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INTEGRATED BIOGAS TECHNOLOGY IN MEETING ENERGY, FOOD, AND SANITATION CONDITION OF RURAL INDIA

Basu, S.
De, G.C.
Nemade, N.H.

Chemical Engineering Department
Indian Institute of Technology
Bombay, India

ABSTRACT - Biogas technology, integrated with water hyacinth (Eichhornia cressipes) based stabilization lagoons, is evaluated as an appropriate technology in meeting the long-standing "energy crisis" along with grave sanitary conditions of rural India. Based on an critical appraisal of different biogas plant models developed in India and in China, inherent defects in the standardized KVIC models have been pinpointed, and improvement in the ASTRA model highlighted. For the optimization of digester height/ diameter ratio in a biogas reactor, an attempt has been to develop a correlationship, which could furnish optimal results in terms of minimum capital costs, and maximization of profits available in the form of cooking/lighting energy, agricultural inputs, and improved sanitary conditions in rural areas.

INTRODUCTION

In a major part of the world, known as Third World countries, conditions in rural areas are dominated by poverty, starvation, and alarming insanitary conditions. Poverty of the rural population in those areas becomes unbearable, and millions of people are compelled to leave their villages, and make for the cities. With an annual growth rate of 4%, around the year 2000, the urban population in agglomeration centres of Third World countries will be increased from the present level of 28% to the level of 41% of the total population (approximately 2000 million people). In September 1978, the World Health Organization stated that the number of undernourished people in developing countries has already reached over 500 million people. In 1979, 16 million people died of starvation or under-nourishment because of lack of medical assistance. The death rate of children before reaching the first year of age amounts to 30-40% in slum areas.

Natural forest reserves of the world diminish daily by 30,000 Ha due to indiscriminate felling of trees for firewood. In India, it has been estimated that over 50% of the energy consumption in the country is needed for cooking, which is mostly met through non-commercial sources of energy like firewood, agricultural wastes, and cow dung. While 56% of energy consumption in urban areas is accounted in household cooking, more than 98% of energy consumption in rural India is met by non-commercial energy sources (mostly by firewood and/or cow dung), contributing considerably to deforestation, and ecological damage to the country. The one-sided efforts towards industrial growth, actively promoted by export-oriented industrialized nations, do benefit only a minor part of the middle and upper classes in developing countries.

The introduction of biogas technology in rural areas is expected to furnish the following benefits :

a) Generation of cooking and lighting energy for domestic needs from a technically simple, and operationally reliable process technology.

b) Increase and improvement of natural fertilizer supply, thereby reducing dependence on the supply of chemical fertilizers.

c) Improvement in hygiene, and thereby better sanitary conditions of the rural population.

d) Preservation of forests.

e) Possibilities of far-reaching employment and encouragement in establishment of artisan businesses with related training facilities.

Figure 1 shows the socio-economic benefits of biogas.

To evaluate the impact of integrated biogas technology on upliftment of socio-economic conditions of rural India, a project was initiated at the Chemical Engineering Department. The Indian Institute of Technology (IIT), Bombay, with the following objectives :

a) To evaluate the cost-effectiveness of a community sewage treatment system, integrated with community biogas plants, as a socio-economically attractive and environmentally sound appropriate rural technology.

b) To evaluate the techno-economic feasibility of enriched biogas production from water hyacinth in admixture with human and animal wastes.

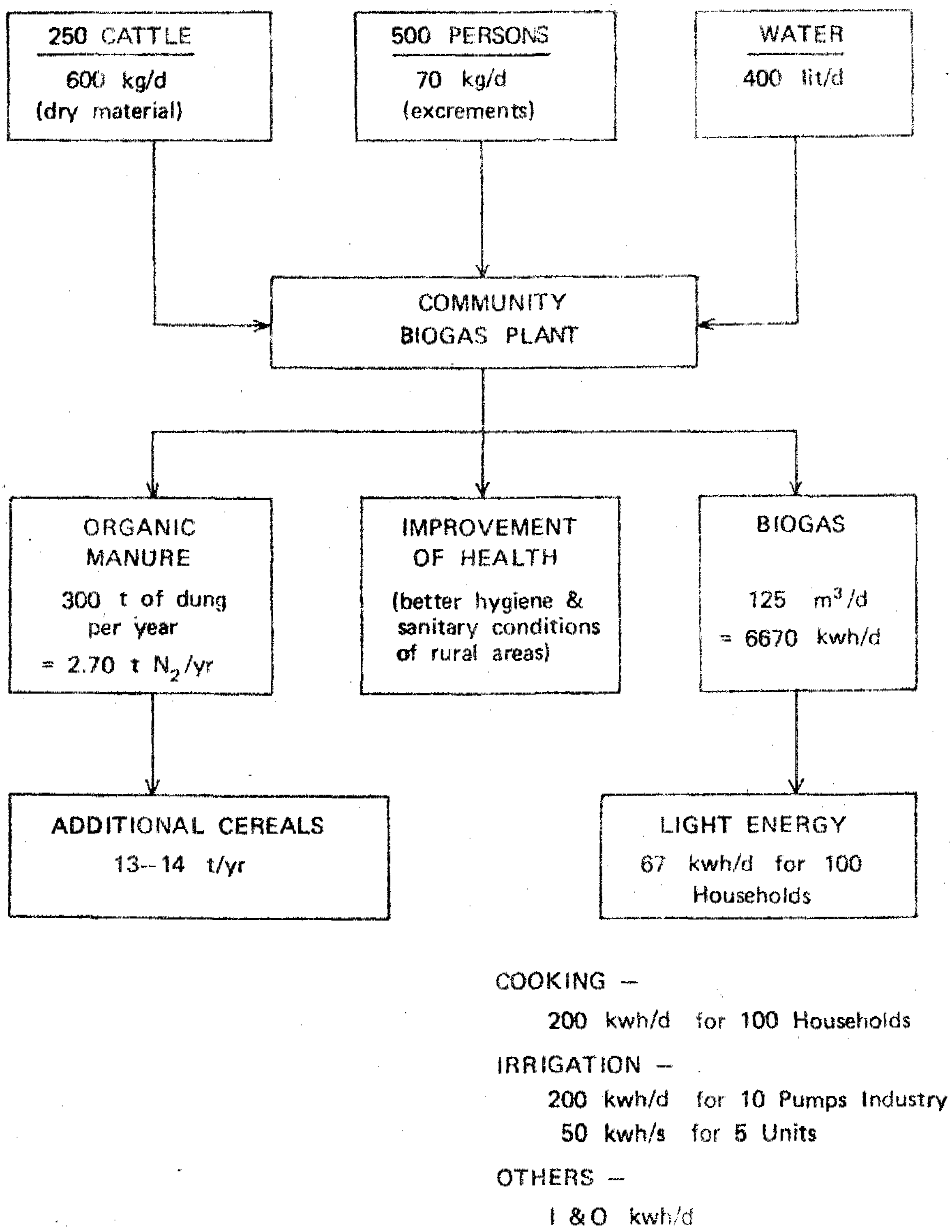

Figure 1. Socio-Economic Benefit of Community Biogas Plant

c) To evaluate and optimize the design parameters (with respect to optimal digester height/digester diameter ratio) for a model biogas reactor, so that capital costs are minimized and profits are maximized, the latter in terms of generation of energy, agricultural inputs, and improvement of sanitation and rural health.

An attempt has been made to highlight the socio-economic benefits of a community biogas plant integrated with a sewage treatment system, and to explore the techno-economic possibilities of improvements for conventional Indian biogas plants, which are developed and popularized by the Khadi and Village Industries Commission (KVIC), the Government of India.

DEVELOPMENT IN BIOGAS TECHNOLOGY - A CRITICAL APPRAISAL OF LITERATURE

Considerable development work was carried out in India during the last four decades on the development of biogas plants for application in rural areas, and different models have been proposed (1, 2, 3).

Some of the operational difficulties in the earlier biogas models have been rectified in the design of KVIC, which started implementation of the biogas scheme (known as the gobar gas scheme) in a planned manner from 1962.

KVIC also undertook development and research work at their centre at Kora Kendra, Bombay, where gobar gas burners with 60% thermal efficiency, a gobar gas lamp, and a gobar gas engine were developed. Reddy et al. (4) at the Indian Institute of Science (IISc), Bangalore, made a further improvemnet in the KVIC biogas model by incorporating a solar water-heater system in the biogas unit.

An analysis of the KVIC biogas model indicates that, due to the requirement of a mild steel gas holder (which accounts for 40% of the capital costs of the biogas unit), and excessive detention times (50 to 60 days), the initial capital cost of the KVIC is very high and beyond the reach of most of the rural population in India.

From an analysis of the reported biogas kinetics, based on human and animal wastes, it is found that keeping the solids content consistency at about 8-10%, the operating pH inside the digester pit at 6.5 to 7.5, and the fermentation temperature within 20 to 30 °C gives pronounced effects on the biogas yield and its stabilization (Figure 2). In KVIC biogas units, biogas yield at 30 °C is stabilized at 0.40 m^3 per kg of dry cow dung with a detention time of 30 days, as compared to yield level of 0.34 m^3/kg in 40 days at 25 °C, and 0.38 m^3/kg at 20 °C with a stabilization time of 50 days.

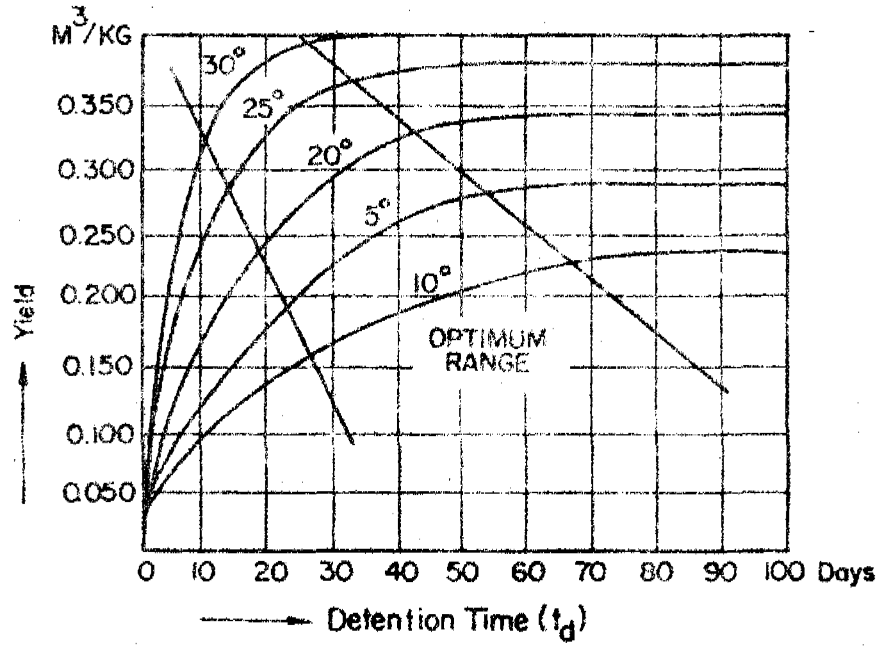

Fig. 2 – Influence of Temperature and Detention Time on Yield of Biogas.

Biogas kinetics data indicates that there is a possibility of considerable reduction of the detention time inside the digester, from the present level of 50-60 days to 30-40 days, when the ambient temperature remains within 25-30 °C.

Assuming a detention time of 40 days at 30 °C (which is expected to give sufficient stabilization with respect to pathogenic bacteria), the size of the biogas reactor could be reduced by the extent of 20-25%, as compared with the KVIC biogas digester, which is designed on the basis of 50-60 days detention time at 30 °C.

Another feature of the KVIC biogas, which is different from the shallower type developed in China, is its high ratio of digester height to digester diameter (around 2.46). The narrow and deep digester pit, as developed and standardized by the KVIC, appears to be optimized based on the minimization of the capital costs of the mild steel gas holder.

At IISc, Bangalore, in connection with their project on the applications of science and technology in rural areas (ASTRA), studies have been undertaken on the optimization of digester height/diameter ratio based on total capital costs of the biogas plant, which indicates that a wide and shallower type of biogas reactor (ratios of the order of 0.95 to 1.10) gives best results in terms of biogas productivity and savings in initial capital investment.

A comparative features of the conventional KVIC and ASTRA biogas plant, each having a capacity of 5.66 m^3/d, is depicted in Table 1.

Table 1. Comparison of Conventional KVIC and Modified Biogas Plant (ASTRA)

		Digester of 5.66 m^3/d		Based on Maximization of Profit/yr
		KVIC	ASTRA	
1.	Gas holder diameter (m)	1.83	2.44	2.165
2.	Gas holder height (m)	1.22	0.61	0.920
3.	Gas holder volume (m^3)	3.21	2.85	3.396
4.	Digester diameter (m)	1.98	2.59	2.175
5.	Digester height (m)	4.88	2.44	1.280
6.	Digester depth/ digester ratio	2.46	0.94	0.590
7.	Capital cost of plant (Rs)	8100	4765	3587
8.	Relative costs	100	58.80	44.30
9.	Gas yield (cm^3/g)	28.3+3.2	32.7+4.0	32.8
10.	Daily loading (kg dung/d)	150	150	172.50
11.	Mean temperature (°C)	27.60	27.60	-
12.	Improvement in gas yield	-	+14.20%	-

*Theoretical value

OPTIMIZATION OF BIOGAS DIMENSIONS BASED ON MAXIMIZATION OF PROFIT

As indicated earlier, most popular biogas units of the KVIC design takes a very high detention time (t_d), which could be changed to a more realistic value for the improvement and optimization of the capital costs and biogas production.

Real benefit could be achieved in rural areas if biogas units are integrated with organic fertilizer production and sewage stabilization ponds, along with fish culture and utilization of biogas in running small-scale village level industries, as presented in Figure 3.

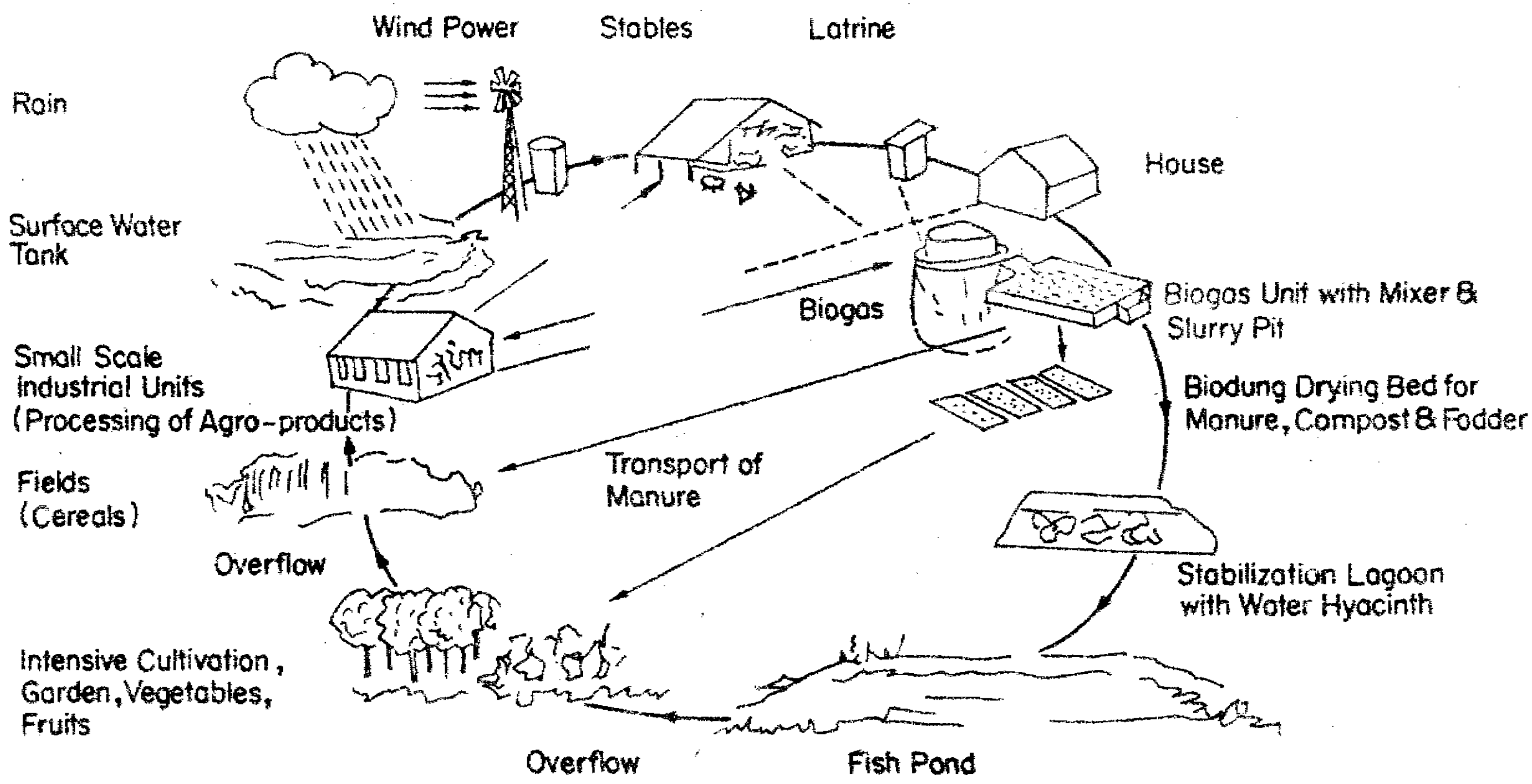

Fig. 3 - Integrated Biogas Technology System with Sewage Treatment, Cultivation & Utilization of Bioenergy for Small Scale Industrial Units.

Therefore, socio-economic benefits of an integrated biogas system could be measured in terms of revenues generated from biogas, fertilizer, and additional crop yields.

If total expenditures incurred in running a biogas plant (including the depreciation, maintenance cost, and cost of feed material) are deducted from the revenues, an expression for profit may be written in the following form:

$$\text{Profit (P)} = f\,(D, Y)$$

where D : Diameter of the digester,
Y : Biogas yield, m^3/kg

When cost data under Indian conditions are incorporated in the profit expression, and optimized by differentiating the objective function (profit) with respect to diameter, an expression for D_{opt} may be expressed in the following form :

$$D_{opt} = \left[\frac{0.075\ (4 . \alpha . \gamma) \ + \ 0.225\ (4 . \delta . c)}{\frac{\P \cdot \alpha}{2} \times 0.075 + 0.225\ \P . \varepsilon / 2} \right]^{1/3} \qquad (1)$$

where, α : a constant (which takes care of the gas holder sheet thickness, density, and unit cost of the material, Rs/kg)
γ : maximum fraction of the daily gas production = 0.60
c : actual biogas plant capacity, m^3/d
δ : a constant (cost factor)
ε : a constant (cost factor)

From Figure 2, by curve fitting approximation, the relationship between t_d and Y could be evaluated as follows :

$$10^8 Y^4 + 10^6 Y^3 + 62.96 \times 10^4 Y^2 - 54125Y - 2.41\ t_d + 983 = 0 \qquad (2)$$

With the help of equation (2), profit expression can be represented as follows :

$$P = K_{1/Y} + K_2 l_1 Y^3 + l_2 Y^2 + l_3 Y + l_4 + l_5 / Y$$

where, l_1 : $10^8/2.41.K_3$
l_2 : $10^6/2.41.K_3$
l_3 : $62.96 \times 10^4/2.41.K_3$
l_4 : $-51425/2.41.K_3$
l_5 : $983/2.41.K_3$

$$\left.\frac{\partial p}{\partial y}\right| D \quad = \quad \text{Constant} \quad = \quad 0, \text{ gives}$$

$$K_i/Y^2 \;+\; 3I_i Y^2 \;+\; 2I_2 Y \;+\; I_3 \;-\; I_5/Y^2 \;=\; 0 \tag{3}$$

The maximum value of P is evaluated by trial-and-error method. A value of Y is assumed, and the corresponding t_d estimated from equation (2), D_{opt} from equation (1), from which P is ascertained.

Based on usual cost data (under Indian conditions), the different K values are estimated. Table 2 gives the relationship between t_d and Y, D_{opt}, and maximum profit.

Table 2. Maximization of Profits

Sr. No.	Y m^3/kg	t_d (days)	D_{opt} (m)	K_2	K_3	P (Rs)	Capital Investment (R)
1.	0.0378	55	2.59	3008	-0.4137	2486	5546
2.	0.0378	50	2.54	3018	-0.4211	2541	5309
3.	0.0378	45	2.49	3028	-0.4289	2598	5068
4.	0.0378	40	2.44	3037	-0.4369	2695	4820
5.	0.0364	30	2.35	3052	-0.4523	2762	4368
6.	0.0332	20	2.245	3066	-0.4718	2873	3922
7.	0.0328	15.03	2.17	3073	-0.4859	2943	3620

From the results based on maximization of profits as presented in Table 2, it can be seen that t_d could be optimized within a range of 20-30 days. Therefore, it could be concluded that when biogas digester dimensions are evaluated based on maximization of profits, more realistic t_d is ascertained which gives optimal benefits from biogas technology, if implemented in rural areas along with sewage treatment systems, intensive cultivation, operation of village-level industries as depicted in Figure 3.

FURTHER IMPROVEMENT IN BIOGAS GENERATION

It has been ascertained that for efficient operation of the anaerobic digestion in a biogas reactor, the carbon (C)/nitrogen (N) ratio of the feed stuff should be within 20-30. From an analysis of different feeds (straws, dung, leaves, grasses, aquatic weeds and others), it is found that grasses and aquatic weeds (water hyacinth) contain C/N ratio of the order of 27. In fact, preliminary experimental work carried out at IIT, Bombay with weeds and grasses indicates that biogas production gets stabilized with a detention time of 20 to 30 days, with biogas generation of over 75% methane content at a rate more than two times of the rate of biogas formation from cow dung. With separation of the two phases during anaerobic digestion process in biogas reactor, a much higher of gas production rate has been observed.

During the last 15 years, extensive work has been carried out with highly encouraging results on the use of aquatic weeds (particularly water hyacinth) in treatment of sewage and industrial wastewaters for pollution control, along with recycling of treated effluents as irrigation water (5-8).

Therefore, the incorporation of a sewage treatment scheme (stacked with water hyacinth) in stabilization lagoons (into which digested slurry after a detention time of 25-30 days could be fed after solids separation in a sand filter bed) - as per the integrated biogas utilization scheme depicted in Figure 3 - is expected to give considerable socio-economic benefits to rural areas of India (and possibly also in other tropical countries of the Third World) in terms of energy generation, fertilizer production, increased crop yield, and improved sanitary conditions of the environment. Since most of the rural population belongs to the weaker, under-privileged group, who live under hopeless poverty and exploitation, integrated biogas technology could benefit the majority of the population, if the scheme is implemented in the form of community biogas scheme as presented in Figure 1.

The cost and gas yield of a community biogas plant directly depend upon location factors. On grounds of social justice, the right location - with requires a sufficient quantity of inputs within an economic distance - is of utmost importance. Due to the domination of poverty, starvation, and hopeless socio-economic conditions in rural areas, and due to the settlement structure in slum areas which are suffering from lack of space and over-population, community biogas plants represent the only possible solution.

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BIOGAS TECHNOLOGY IN DEVELOPING COUNTRIES: FACT OR FICTION ?

D.M. Tam

Senior Information Scientist
Environmental Sanitation Information Center
Asian Institute of Technology
Bangkok, Thailand

ABSTRACT - This is an overview of some salient points and perspectives of biogas technology (BGT). The current literature is reviewed regarding the ecological, social, cultural and economic impacts of BGT. It is suggested that the potential benefits of BGT should not be taken for granted. Depending on local conditions, the benefits may be great or small, one benefit may be a trade-off for another, or may be just a incremental rather a full one. The literature indicates that the failures in biogas programs have reached an alarming rate, and caused dissatisfaction and doubt. In order not to repeat such failures, in-dept studies on local conditions and conscientious planning are urged.

INTRODUCTION

Biogas technology (BGT) has been known for a long time, but the interest in it has just recently arisen - mainly because of the increasing costs and the rapid depletion of local traditional fuel sources and of world fossil fuels. The interest in BGT is further stirred by promotional efforts of various international organizations and foreign aid agencies through their publications, meetings, visits, etc., in which proponents are usually dominant over opponents - if any. As a consequence, implementation programs of biogas have been carried out in various parts of developing countries seemingly without proper planning and studying on feasibility. Impressive successes from a country are taken as a good example to follow, with a hope that a similar result will be replicated elsewhere. Quite often it is not. Bitter failures have been reported at an alarming rate, and together with them, pessimism and doubts. All of these may unduly discourage those who attempt to implement a biogas program.

On the other hand, much expectation - and over-optimism - still prevail. While these attitudes are needed for a good start, they may cause misleading in the perception toward biogas technology and so may engender even more failures.

For the above reasons, the author realizes a need to give a gist on the perspectives of biogas technology. Trying not to be over-pessimistic or negative, the author considers it is vitally important to perceive the technology as objectively as possible, so that processes of planning and decision-making can be properly carried out, and failures will less be prone to happen. Special attention will be given to family-size biogas systems in Asia, due to their inherent complexity and impacts in various respects. Human waste alone is not sufficient to feed a family-sized digester. Other wastes, such as animal dung and agricultural residues, have to be used together with human waste. This paper gives a coverage on this broader scenario.

THE BENEFITS OF BIOGAS TECHNOLOGY

Much has been said with enthusiasm about the numerous benefits of BGT. It is often stated that BGT can offer a great potential to solve various problems. For instance, it has been estimated (Agarval, 1979) that India has a potential of at least 18,750,000 family-size biogas plants and 560,000 community plants with daily capacities of 1.7 and 142 m^3 of gas, respectively. If this potential is realized by 1990, biogas could supply India with an energy amount equivalent to nearly 44% of its projected electricity consumption, and reduce its projected consumption of coal by 15%, and of firewood by 79%. Although the investment required for such a program would be very high, about Rs. 66,000 million (about US$ 7,300 million), the benefits seem to be worth it. Are they? This Section will deal with the main benefits of BGT in their right perspectives.

Biogas as a Substitute for Firewood

In rural Asia, some 50% of the energy requirements of a typical household is for cooking (Skrinde, 1981). A great portion of energy used for cooking purposes comes from firewood. For example, in Sri Lanka (Amaratunga, 1980), Bangladesh (Islam, 1980), and Indonesia (Wiersum, 1979), 60%, 71% and 70-75%, respectively, of the total current energy requirements come from firewood. With the population expansion coupled with the increasing need of fuel per capita, the use of firewood has accelerated deforestation at an alarming rate. Until recent years, forests had completely disappeared from most parts of China because the trees had been cut down for fuel (Revelle, 1976). The forest area of Nepal has declined from 60 to 30% within 30 years, and, at the current rate of destruction, could be completely denuded within 15 years (IDC, 1981). These facts are hardly surprising since the requirement of firewood per capita per year is about 250-300 kg in China (Eggeling & Stephan, 1981), 300 kg in India (Makhijani, 1977), and 0.7-0.86 m^3 in Indonesia (Wiersum, 1979). A hectare of forest supports about 50 tonnes of wood (Prasad et al., 1974), which can therefore supply firewood to about 160 persons. A similar process of deforestation is now also occurring in many other parts of Asia. It is estimated that the present forest reserves of India, at present annual rates of firewood consumption, can supply firewood for only 24 years (Revelle, 1976).

BGT is, therefore, looked upon as a means to at least partially curb the deforestation. It is estimated that a 100-cft (2.8 m^3) biogas digester can save 0.3 acre (about 1,200 m^2) of forest per year. Ironically, deforestation, with the resulting scarcity of firewood, is an incentive for adopting BGT. Thus, where firewood is still readily available to rural people, the development of BGT is slow. This is at least the case for Indonesia (Skrinde, 1981) and Thailand (Sermpol et al., 1979).

But the problem of firewood is a rather complex one. It is suggested (ESCAP, 1979) that the common claim that deforestation is caused by people cutting trees for firewood does not seem to hold everywhere. Villagers in Bangdung, Indonesia, for their fire gather mainly twigs and branches that are found within a few kilometers from their villages. The severe deforestation in Java is primarily caused by the pressing need for more agricultural land to feed an expanding population. Similarly, Makhijani (1977) stated that much - if not most - of the soil erosion caused by cutting trees is the result of the commercial lumber operation of government and industry, which indulge in thoughtless clearance of large areas.

Another aspect in Bangladesh adds to the refute of the positive benefit of forest conservation, where it is found that in Bangladesh (Islam, 1980), there is little possibility of improvement of deforestation, because the households who can afford a biogas plant are also the owners of trees. So the trees which will be saved due to the use of biogas by richer households (who without biogas would not need firewood anyway) would not be available to the poorer households.

The benefit of BGT derived from saving firewood seems, therefore, not to be always clear. The main criticism of BGT is centered on the high cost of the digester relative to the low return from the fuel obtained. Although advocates for BGT estimated that biogas is twice as cheap as firewood (Ansari & Yasin, 1980), a critic evaluated the cost of producing 1,000,000 BTU by biogas at $1.50 and by using firewood at $0.15 (ESCAP, 1975).

In fact, BGT may have a negative effect on deforestation due to the fact that animal dung is traditionally free to those who collect it as a fuel source. With the introduction of BGT, the owners of animals will claim ownership on the dung produced by their animals to produce gas for themselves and this will force poorer people to switch from dung to firewood.

There is even a suggestion (Wiersum, 1979) that investment should be given to measures to ensure a sustained yield of firewood, due to its advantage of general familiarity.

Biogas as a Substitute for Animal Dung

Animal dung constituted 5-10% of the requirements for kitchen fuel in rural areas of India at the beginning of this century. This figure rose to 25% by 1930, 45% by 1950 and 70% at present (Khan, 1980). Prasad et al. (1974) estimated that 45% of the domestic fuel requirements in Indian villages come from burning animal dung. A source as quoted by Revelle (1976) revealed that about 4.68 million tonnes of dried cow dung were burned in India during 1970-71, of which 83% was consumed in rural areas. Another survey, also quoted by Revelle, gave the yearly per capita combustion of dung cakes in rural households as 87 kg during 1963-64. A similar picture can be seen in Pakistan where 70% of the fuel used in the villages is animal dung, and this constitutes about 70% of the cattle and buffalo dung produced (Shah, 1980). The use of animal dung as cooking fuel has an important implication since it is also valued as fertilizer, and the more it is burned in the homes, the less it is applied to the field. Although only about a half of the fed dung is degraded in the generation of gas, the useful heat of the gas is about 20% more than the useful heat obtained by burning directly the entire amount of dung. This is due to the high efficiency (60%) of burning biogas as compared with about 10% efficiency of burning dung. Thus gas conversion offers an efficient use of animal dung as a fuel, while still conserving the nutrients to be applied to crops.

In practice, the belief that using biogas for cooking can significantly alleviate the loss of nutrients from burning dung is likely to be illusory, due to the following factors :

1. The scale of animal dung saving is small as compared with enormous costs. India, for example, has set a target of building 100,000 family-size biogas units each year during the period of 1975-1985, at a cost of US$ 200-400 apiece (Makhijani, 1976). Even if this target were reached (more likely it will not), this would mean that by 1985 only 2-4% of India's cattle herd would be involved.

2. This benefit is meaningless to rural people, since animal dung is normally obtained free, whereas biogas should be obtained at a cost.

3. As stated previously, the saving of animal dung is traded off with aggravated deforestation.

Biogas as a Substitute for Fossil Oil

Oil-importing countries are more and more burdened with their skyrocketing oil bills. A typical situation can be found in Pakistan, where, during the period 1971-1979, the amount of imported crude oil and petroleum products rose by less than 50% whereas the bill increased 22-fold (Shah, 1980). Kerosene is still a main source of energy for lighting in most rural areas of Asia. In Sri Lanka, about 90% of households use kerosene oil lamps for lighting (Amaratunga, 1980). It was hoped that BGT could partly help save the reserve of foreign currency used for importing oil. In this respect, it should be noted that rural families in Asia usually light about 2-3 oil lamps for about 3 hours a day. Such a lighting regime would not require any substantial amount of oil as compared with the amount of oil used for agricultural and industrial purposes, for driving vehicles, and for more sumptuous needs of urban areas. The kerosene consumption for a household in a survey area in Bangladesh is only about 1.06 gallons (less than 5 liters) per month (Islam, 1980). Even if all of the oil used for lighting in the rural areas of Bangladesh could be replaced by biogas, the amount of oil saved would be a small portion of the total amount of oil imported, which was more than 5 million tonnes during 1978-79 (Shah, 1980). The same situation is in India, where Revelle (1976) estimated that the energy used for lighting in 1970-71 was about 4.2% of the total rural energy needs. Comparing with the total energy need of the whole country, the proportion is much less, should be lower than 0.1%.

Biogas to Reduce Drudgery

Where firewood is scarce, the collection and transport of firewood is very time-consuming. In China, this task requires up to 4 hours per day per family. BGT can eliminate this drudgery. Also, using biogas instead of firewood for cooking can reduce cooking time from 4-6 hours to 1.5-3 hours a day (Eggeling & Stephan, 1981). This can lead to more productive work, and is especially beneficial to women who can have more time for educational activities and entertainment.

In other situations where un- or under-employment is still prevalent (about 63% of the population in rural Nepal are jobless, according to Shrestha, 1981), and so people still have much free time, or where conventional fuels are plentiful or readily available, such a benefit of time-saving may not be appreciated. It has also been remarked that the shift from firewood to biogas for cooking is a major change for village housewives. Whether this change - with all the associated problems of safety, handling, cooking practice, etc. - will be acceptable to them is a question which can only be answered in the field (Reddy & Prasad, 1977).

Biogas as a Means of Nutrient Conservation

The nutrient element of concern is nitrogen since this element is lost if the waste is burned as a fuel, or can be depleted through volatilization, leaching, etc. during storage or handling if the waste is used as a fertilizer. Although at a first glance the amounts of nitrogen in various types of wastes seem to be negligible, full recycling of nutrients from wastes gives substantial benefits. Experience in Vietnam (Tuan & Tam, 1981) shows that the feces and urine collected for one year from a family of 4-5 persons - when applied to rice, corn or sweet potato - can offer an extra yield of 130-150 kg.

It is generally believed that in most handling methods of organic wastes today, substantial amounts of nitrogen are lost; but nitrogen is not lost from a biogas digester. In fact, from scanty information it is known that the nitrogen level does reduce during fermentation, and the degree of reduction was reported by Chen & Li (1978) to be 5%, by the Chinese Institute of Soil and Fertilizer (1979) to be 3-10% depending on the input mixtures, and by Iannotti et al. (1979) to be 2.7%. Therefore, the common belief that a biogas digester produces fertilizer should be reconsidered.

First of all, it should be pointed out that a biogas digester does not "produce" nitrogen. Oddly enough, there have been reports of an increase of nitrogen content in the digester effluent as compared with the influent. This must have been due to faulty analyses or calculations (for example, using concentrations instead of total amounts). In a closed digester where there is no known process of nitrogen fixation, an increase of total nitrogen amount is inconceivable. Rather, a digester is just able to increase the amount of nitrogen available to plants. This could also be done with other waste handling methods such as composting.

Then, there have been various reports on impressive crop yield improvements as the result of applying effluents from digesters. Such a methodology in assessing the value of digester effluent as a fertilizer is a debatable matter. The usual comparison of the effects of digester effluents and influents on the yields of short-lived crops is not sound since digested wastes contain more available nutrients and hence should give better effects on short-lived crops. The situation would be different if raw and digested wastes are applied gradually at low loadings to perennial vegetation. In this case, the higher proportion of nitrogen in organic forms in the raw waste may result in some nitrogen being carried over from one season to another (Bhatia, 1977), whereas the nitrogen in ammoniacal form in digester effluent will quickly volatilize within a short time.

Still worse, comparing the yields of crops applied with digester effluent with those of crops receiving no any form of fertilizer is practically meaningless. Unfortunately, this kind of unscientific work has been recommended as a "demonstration" method to show to laymen that BGT has great benefits, which may be misleading.

The evaluation of digester effluent by measuring its nutrient composition right after it comes out of the digester is not appropriate. Application method, storage time and transport distance - among other factors - would have a direct effect on a benefit assessment of the end-product. Unfortunately, data regarding these aspects are not sufficient to determine the benefit. It is said (Eggeling et al., no date) that nitrogen escaping from digested slurry after more than 10 days of storage amounts to about 10-15%. ESCAP (1980) indicates that the "nitrogen effectiveness" of digester effluent which is spread and ploughed is 85% that of dung which is spread and ploughed immediately. No details are given on whether this "effectiveness" is assessed on perenial vegetation or short-lived crops. If this is the case of the later, the effectiveness of fresh dung is very limited, and therefore the figure of 85% does not tell much. Shah (1978) says that if the slurry is dried, essentially all of the ammonia is lost. This is reasonable since digester effluent needs a long drying period due to its high water content, about 90%. Ammonia constitutes 75 to 85% of the total nitrogen in digester effluent (Institute of Soil & Fertilizer, 1979; Iannotti et al., 1979). Hence, according to Shah, the losses of nitrogen from drying of digester effluent could be extremely - and unfavorably - high.

It can be concluded that biogas effluent as a fertilizer should not be construed as a full benefit of BGT. With or without a digester, a comparable amount of plant nutrients could be obtained from a given amount of waste. And if it is desired to convert the nutrients in wastes to the forms more readily available to plants, other methods should also be considered, rather than blindly adopting BGT. This consideration will be dealt with in the Section "Biogas Technology vs Composting".

Biogas as a Pathogen Inactivation Method

Substantial portions of pathogens are removed from the effluent of a biogas digester.

For helminth ova, the physical mechanisms of removal are: (i) floating to the surface where the ova adhere to the scums, and (ii) free settling to the bottom. Thus in the Chinese design without any mixing operation and with the outlet connected to the middle section of the digester chamber, a high removal of helminth ova is obtained (Sichuan Institute, 1979).

Long retention times - usually more than 40 days in the Indian design and several months in the Chinese design - are favorable for pathogen die-off. Schistosomes are observed to live up to 37 days while 99% filarias die within 30 days in summer. The viability rates of Ascaris ova - which is the most resistant of all parasites - from 63 to 93% after 10-90 days is reduced to 20% after 180 days (FAO, 1978). This could cause a concern if (i) human waste is to be used (ii) in the Indian design (iii) when mixing is performed and (iv) the outlet pipe protrudes deep down to the bottom.

Because of anaerobic conditions, aerobic organisms such as Leptospira of hookworm ova are killed quickly in a digester, the latter surviving for no more than 9 days (Sichuan Institute, 1979), and being removed by 90% within 30 days in winter; whereas Shigella and Spirochetes die within 2 days (FAO, 1978). Para-typhoid B bacilli - one of the most persistent enteric bacteria - are observed to survive for a period of 44 days in a digester.

Based on these data and others, it has been claimed that BGT is a method for pathogen destruction and could contribute to sanitation improvement in rural areas of developing countries. It is true that significant improvement in public health is observed in the regions where BGT has been introduced. But building a digester solely for this purpose is not a logical reason, and this will be discussed further in the next Section.

Biogas Technology vs Composting

From the considerations on nutrient conservation and pathogen inactivation above, the matter of importance now is to compare the performance in these respects of waste handling methods that are common in rural areas of Asia. Before the introduction of BGT, composting is probably the only waste recycling option in rural developing countries with the eventual purpose of fertilization.

Nitrogen Conservation

Without going into elaborate details of the composting process, it suffices to say that - based on data from various sources compiled by Gotaas (1956) - a correct composting process can help conserve from 85 to 90, and possibly 95%, of the nitrogen in the raw materials. Also, it has been reported (Tuan & Tam, 1981) that as much as 95% of the nitrogen contained in human waste can be conserved by closed, thermophilic composting in field conditions using soil powder, mud, hay, dead leaves, etc. as bulking agents. These sources of information show that a biogas digester is not superior to a correct composting method as far as nitrogen conservation is concerned. In other respects, BGT has more disadvantages: it is more costly, more difficult to operate and maintain, requires more space more water, and digester effluent is more difficult to handle and transport than compost.

The comparison between digester effluent and compost is not necessarily concerned only with NPK contents. Compost is well known for its beneficial effects in fertilization due to its chelating agents, growth hormones, increasing the ability of the soil medium to retain plant nutrients, increasing the water holding capacity of soil, and improvement of soil structure. Apparently no information is available to indicate whether biogas digester effluent possesses these benefits, and if yes, how much.

Pathogen Inactivation

Gotaas (1956), when analyzing the typical temperature curves of a compost heap and the thermal death points of a number of pathogenic bacteria, parasites and parasitic ova, indicates the unlikelihood of pathogen survival in composting. It is seen that the highest thermal death points of pathogens are appreciably lower than the maximum temperatures found inside the composting pile. The magnitude and duration of the high temperatures (50-60 °C for several days), the populations of microorganisms, the antibiosis which is characteristic of a mixed compost and the low water content (40-50%) - all are very adverse to pathogens - provide a sound basis for believing that no pathogens, parasites, or parasitic ova survive the composting process.

Few data on pathogen destruction in composting at field scales exist in the available literature, except that experiments in China indicate that 96-100% Ascaris eggs are destroyed in aerobic composting (McGarry et al., 1978). This level of inactivation is much higher than that in a biogas digester.

BGT, especially when human waste is used as a feeding material, should be therefore considered as a convenient method of pathogen reduction, rather than an effective means of pathogen destruction.

SOCIO-ECONOMIC ASPECTS

Although BGT may offer various benefits, it does not necessarily mean that it will be accepted with enthusiasm. This Section will give an analysis on the complex socio-economic aspects of BGT.

Economic Feasibility

There is no general answer to the economic feasibility of BGT. Data widely vary from country to country. For example, while it is reported (Sermpol, 1979) that the maintenance cost for a family-size plant in Thailand is about 23% of the capital cost, this percentage rises to about 58% for a digester in the Philippines producing daily 28-42 m^3 of gas (Simpson & Morales, 1980). The payback time of a digester also varies greatly, from as low as 1.25 years in China (Li, 1982) to 7 years in Thailand (Pisit, 1979), and even as high as 16.7 years for India (Moulik & Srivastava, 1975).

Even the economic feasibility of BGT has not reached a general concensus. While many researchers are in favor of BGT, others come to the conclusion that the monetary benefits do not outweigh the costs incurred by an individual household (Makhijani, 1977). It is further claimed that the benefits of BGT will accrue to the society as a whole rather than to the individual household which adopts BGT.

User's Perception Toward Biogas

Due to his lack of knowledge and awareness, a villager cannot be expected to understand the benefits of deforestation control, nutrient conservation, or health improvement. Hard pressed with all the difficulties of his life, an uneducated and poor villager has only one thing in his mind, that is to try to solve his immediate problems, for the sake of survival. A land or animal owner may like to try something new, perhaps only out of curiosity. But a poor rural peasant is very hesitant to enter a new venture. Also, not being familiar with entrepreuneship practice, he is shy to contact a bank for a loan; and not being accustomed with social relations outside his village, he is not eager to ask for technical advice on the operation and maintenance of his digester, or for reparation work when his digester fails.

He even seldom sounds out his opinions and feelings. In an extensive survey in Thailand (Sermpol et al., 1979), more than 50% of biogas users stated that the motive of BGT adoption was to please the government officials who came to them to promote BGT.

The indifferent attitudes as described are more conspicuous with BGT since biogas does not bring in cash, and hence the benefits are hard to perceive. The investment cost for a family-size digester in Thailand (Sermpol et al., 1979) can be used to buy a smaller pump, or for a down payment to acquire a small farm tractor. These machines are considered by the farmer to be more important than BGT since it can bring additional cash within one crop season.

Long-term Benefits vs Short-term Priorities

The average capital investment for a digester in Thailand (Sermpol et al., 1979) is 2,675 Baht. From this investment, the owner can get daily 1.2 m^3 of biogas, which is equivalent to one kg of charcoal, or a mere 3 Baht. Similarly, the investment cost of a digester in India is Rs. 4000 (US$ 500), whereas the return is equivalent to 2-3 liters of gasoline a day. From the villager's viewpoint, these returns are either too low in relation to other uses of handy resources, or hard to quantify, and hence leads to hesitation in adopting BGT. Asian farmers usually have no steady income, let alone a cash reserve. They get their money only twice or three times a year and at the same time they have pressing demands on their available income of a social and agricultural nature. Whichever need comes earlier will get the funds. As a result, the poor will not jeopardize meeting their immediate needs for any long-term goals, even if these may ultimately benefit them.

This attitude is consolidated further when the gas is not valued because of the availability of other sources of energy such as firewood nearby the house, or kerosene at the village market. In Korea, where 90% of the villages are said to be supplied with cheap electricity - about US$ 2 per family per month - the high capital cost of a digester (about US$ 150) and low gas production in the winter both have adverse effects on BGT adoption (Subramanian, 1977).

Again, the cost of a digester is a crucial factor. In China, the construction materials cost a family about US$ 30 whereas the cost of a bicycle is $ 100 (Chen & Li, 1980). This clearly shows the affordability, and acceptability, of BGT to the Chinese peasants.

Unequitable Distribution of Benefits

A family-size digester needs an input from 4-5 head of cattle in order to produce enough gas for cooking and lighting. Realistic data show that to set up a plant of 100 cft (2.8 m^3) gas capacity, one should possess at least 4 cows. This will limit the benefit of biogas to a small number of families who own enough cattle. In India, this number is about 10-12% of the rural population (Agarval, 1979). Another estimate is that less than 5% of the village population in India own 4 or more animals. (Chiranjivi, 1978; Prasad et al., 1978).

Although it has been suggested (Skrinde, 1981) that 2 or 3 cows could support a unit of 2-m^3 gas capacity, such a unit produces an amount of gas sufficient for cooking only. The hope that more people will participate in BGT may not be justified since (i) a plant of such a scale may not be economically attractive, (ii) less benefit (without the benefit of lighting) means less incentive for adopting BGT; and (iii) families owning less animals are more reluctant - or have less resources - to join the scheme.

It is evident that BGT depending solely on animal wastes as input materials will deprive the poor majority a chance for raising their living standards. Using human waste to compensate for the deficit of feeding material cannot substantially increase gas yield, besides brings about various problems of malodors and health harzards, and also social constraints.

Social Acceptance

Acceptability of biogas may be hampered by religious convictions. Muslim societies, on account of their beliefs, oppose the use of pig waste as a feeding material (Sermpol et al., 1979; Subramanian, 1977). For instance, a plant in Indonesia using pig manure had to be abandoned due to the opposition from Muslim villagers. In another case, the use of digested human waste as fertilizer was discontinued when a local witch doctor attributed sickness to the consumption of products grown with the digested slurry (Skrinde, 1981).

There is also much reluctance in Korea, Thailand, and some regions of India to use human waste as a feeding material as well as to use the gas produced from it for cooking. (Mazumdar, 1982; Moulik & Srivastava, 1975; Subramanian, 1977). The negative attitude toward the use of human waste varies from place to place, but when it occurs it is a major obstacle to the implementation of BGT.

Ownership of Waste Materials

Major obstacles can be readily seen from the ownership of waste materials. Traditionally, the institutional structure is arranged in the village such that the wastes are available for those who need them, without regard to the distribution of animal ownership. BGT will provide novel opportunities for the rich in the village to claim ownership of the wastes, and of their product - whether it is gas, electricity, or machine power. This will intimidate the poor from exerting their income rights. From free sources, the wastes will become a priced commodity like land, animals, etc. The loosers will be the poorer families who have to seek alternative sources of energy and fertilizers.

at the rate of 15% can cover the annual expenses even on liquefied petroleum gas.

Administration and Organization

Yadava (1980), when reviewing the working of the biogas plant program in India, analyzed main bottlenecks/problems encountered. Briefly, they are:

* Inadequate technical help;
* Lack of follow-up services, and of monitoring of feedbacks;
* Too much time lag of about one year and a half between the submission of application and actual installation;
* Lack of demonstrative efforts; and
* Lack of proper coordination

CONCLUSION

Biogas technology, more than any other technology, is a delicate and complex issue. This paper just serves as a checklist of the main relevant aspects, to which there is still much to be added. Apparently successes, such as those in the People's Republic of China, have not achieved spontaneously without initial failures. The technology itself is not enough, even if current plaguing technical problems can be solved - and there is much room for improvement. As pointed out in the paper, the benefits of BGT should not be taken for granted. Depending on the economic and social structures, the benefits can be small or great, one benefit may be a trade-off for another, and a benefit may be just an incremental rather than a full one. All of these factors will eventually decide the desirability of BGT. A careful, objective assessment of every aspect is essential during the planning phase. The meaning of "objective" is sometimes hard to define since this depends on individual viewpoint. For example, while there are clamorous praises on biogas as a cooking fuel, an opinion (Makhijani, 1977) is that using biogas for cooking in India is a basically uneconomic proposition. The argument is that making a per capita investment of over Rs. 100 to produce a high-grade fuel for cooking while pumps are idle for want of energy is an unaffordable luxury.

On the other hand, many parameters can be quantitatively assessed, and all of them should be assessed. Overlooking an essential factor may cause irreversible damage. After some years of implementation, it was discovered that more than 50% of the total digesters built in a country could have been abandoned. 50% of the owners interviewed said that the reason of non-use was the unavailability of input materials. In another country, most of the digesters were abandoned mainly due to their low performance in winter. These costly failures could have been avoided if the planning phase had been carefully worked out.

When a technology that is appropriate to local situations has been identified and the economic affordability has been proved, some other heavy tasks still lie ahead. These are - to cite only some of them - community education and motivation, good organization and administration, and possibly re-structuring the whole socio-cultural-economic set-up (such as changes in living habits and productive conduct, decentralization of the production of materials, rearrangement of dwellings, etc.).

Collecting feed-back and correcting any problem that pops up during implementation is no less important. In the People's Republic of China, technical progress has been made not before but during the implementation stage (Thery, 1981). This must have resulted from watchful follow-ups and a preparedness for problem-shooting. In some other regions, promotionals officials come to villages with all "friendly persuasion" and go when the work is finished, leaving behind them a lot of problems that the users do not know whom to turn to for assistance; and finally when the officials revisit the sites, all they can do is to say something about "biogas technology reconsidered"!

Feedback monitoring requires an assessment of the whole scenario, besides a study on each component of this scenario. It has been pointed out that analyses in the past have often disregarded those effects that took place in parts of the system not immediately surrounding the project. Such effects have been called "second-round" or "linkage" effects (Qurashi, 1980). As previously mentioned, an increase in the demand for animal wastes as a result of the introduction of BGT can induce the second round effects of reducing the availability of animal wastes to other existing users, and/or increasing the prices of the wastes. Here exist "chain reactions", with the subsequent results of accelerated deforestation, a wider gap between the rich and the poor, etc.

The limited length of this paper does not allow for an elaboration of remedial measures and recommendations for actions to be taken - features which have been intensively covered in the literature anyway. It suffices to say that strong will and dedication - but not with a fanatic attitude - is badly needed for undertaking such a difficult endeavor. Only then can biogas technology be well accepted and well run, and fully show its potential benefits.

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HUMAN WASTE MANAGEMENT IN LOW-INCOME SETTLEMENTS IN LAE, PAPUA NEW GUINEA

Thomas Popuei Gabriel

INTRODUCTION

Just below the Equator, to the Southeast of Indonesia, is the Island of New Guinea, which except for Greenland is the largest island in the world. It is divided politically into two sections : the Indonesian-administered West New Guinea, and the eastern section, which makes up most of the independent state of Papua New Guinea. This paper will discuss the methods and problems of human waste management in low-income settlements in Papua New Guinea in general with illustrations; and in particular details drawn from those methods and problems existing in Lae, the second largest urban centre and a foremost industrial town in Papua New Guinea.

Lae, with its population of 60,000, is situated on the Huon Gulf at 7° Latitude. The city of Lae is presently experiencing a population growth rate of more than 5% per annum. This is mostly due to the migration of people from the highlands where the population density is too high to sustain a reasonable living standard with existing agronomic methods (1). Thus to seek employment which often proves to be elusive, the highlanders come, via the highlands highway (the longest all-weather highway in the country and to which they have easy access) to the city of Lae. These new arrivals face the same problems that any displaced group faces anywhere in the world. They settle down in self-help settlement areas on the outskirts of the city, build their makeshift houses, and try to solve their problems of existence and survival. At present there are 13 settlements in Lae.

A BIT OF HISTORY

Before the first missionaries came to Papua New Guinea in the beginning of the 19th century, the local people did not use systematic methods of human waste disposal. Coastal people were using overhung toilets, whereas the people of the mainland used bushes and shrubs.

The earliest method of human waste disposal introduced after the missionaries came was the pit latrine. But, as is the case anywhere - when a new though better and more hygienic method, but drastically different from the one that has been handed down from generation to generation is introduced by outsiders - the use of the pit latrine was not readily accepted. As the early Papua New Guineans lived in villages, the pits were mostly communal. And because the people regard waste disposal as a secret, they were hesitant to walk in front of their village elders to go to the toilets. Also, a common belief was that anyone in the family of the person digging a toilet would die soon. Here again the mores and traditions of a culture were interferring with the health and sanitation of the people. It was not until the end of the second World War that the pit latrine acquired a semblance of acceptability. By that time, more and more people had been to schools, became more receptive to the new methods of sanitation and came to realize the importance of maintaining hygienic conditions.

IN LOW-INCOME SETTLEMENTS

In a comparative nutritional study in 1980 (2) in Lae, it was discovered that a high percentage of families in two of the thirteen settlements were using reasonably sanitary methods of waste disposal. The number and percent of families using septic tanks, pit latrines and none of these two systems of disposal are given in Table 1.

Table 1 : Human Waste Disposal Methods
Used in Buimo Roads and Taraka Settlements, Lae in 1980.

Method	Buimo Road		Taraka	
	Number	%	Number	%
Septic tank	4	4	36	17
Pit latrine	99	95	172	81
None	1	1	4	2
Total	104	100	212	100

However, the popularity of the pit latrine in both settlements was deplored by the researchers (3). In the report of the nutritional study, the researcher wrote:

> "Pit methods are the usual form of sanitation. This method is not successful, as the ground water table is high and part of the settlement is often flooded during the rain".

It was hypothesized further that the failure of these pit latrines could have affected the health of the settlement dwellers. For example, the research found a high incidence of intestinal parasites and diarrhoea in the pre-school children in both settlement.

In Taraka, out of 213 stool samples, 54% had larvae or eggs of intestinal parasites present. In 12% the counts were moderately high and in 12% the counts were very high. Out of 352 school children, 76% did not have diarrhoea at the time they were examined, 5% had diarrhoea during that week, 11% had diarrhoea in the previous week and 8% had diarrhoea for both weeks (2).

The results (3) for the pre-school children in the Buimo Road settlement are as follows.

> "Larvae or eggs of intestinal parasites were found to be present in 52% of the 96 stool samples taken during the course of the survey. These included 36% which were infested with hookworm and 16% with both hookworm and ascaris. In 19% of the samples the counts were high (greater than 5000), 11% were medium (2000-5000) and 16% low (under 2000)".
>
> "15% of the children surveyed had diarrhoea near the time of the survey. Of these, 4% had diarrhoea the week before the survey and 6% during the survey week. These two groups (10% of the sample) are likely to be the children suffering from acute diarrhoea. A further 5% had diarrhoea during both weeks. These can be considered chronic cases".

CONCLUSIONS

Clearly, the high rainfall of Lae (annual rainfall is 4800 mm) and the poor underground drainage - which results in quick flooding in the settlements - render the pit latrine unsuitable as far as hygiene and sanitation is concerned. But, the settlement dwellers cannot afford more sanitary methods. To be able to develop a more sanitary and more hygienic method, yet financially within the means of the people (if possible with help from the local government), would be an ideal solution to this situation.

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IMPLEMENTATION ASPECTS

E.K. Simbeye

Principal Health Officer
Ministry of Health
Dar es Salaam, Tanzania

ABSTRACT - Human waste management is a subject that has received global attention. It is a daily topic. It is no wonder that the United Nations has declared the 1980's as the International Drinking Water Supply and Sanitation Decade. One of the objectives of the Decade is that each household should be provided with a sanitation (excreta disposal) facility. It has been realised that many diseases of man are of faecal origin. Diseases like cholera, typhoid fever, dysentry, gastroenterities and ankylostomiasis are spread by man ingesting food or water or trodding on soil that has been contaminated with excreta. Fortunately, about 80% of these diseases are easily prevented. One method of preventing the spread of faecal-related diseases is by properly disposing of excreta, that is, use of latrines. The provision of latrines in households is certainly a good idea. However, the implementation of programmes of this nature is not without constraints.

IMPLEMENTATION ASPECTS OF HUMAN WASTE MANAGEMENT

This subject has four points to be considered. These are:

1. Acceptability
2. Affordability
3. Extension work
4. Training needs

1. Acceptability

People will accept good things, things that are to their liking and conform to their cultural values. This is equally true with latrines. A flush toilet, for instance, being decent and convenient to use, and despite its high construction costs, is readily acceptable. On the other hand, a pit latrine with its disadvantages of bad smell, fly breeding and collapsing, is not readily accepted.

Tribal customes, taboos, and beliefs have played a big role in the rejection of latrines. Parents-in-laws, for instance, would not share the same latrine with sons- or daughters-in-laws. Elders (men) were believed not to defaecate and it was shameful to be seen doing so by children. Defaecation was therefore done in secrecy. The bush served as a good hiding place for this purpose. Men went out to the bush or forest to fell trees for building purposes and women went to fetch water or firewood from the nearby river, dug well or bush. While they were doing these works, they eased themselves in the nearby bush or in the forest.

Fear of falling into a pit latrine - the most commonly used facility - was another reason for not accepting to use a latrine. Pregnant mothers would not use a latrine for fear of abortion. In fact it was the fear of falling into the pit. People felt unsafe to use latrines that collapsed too often. They therefore opted to use the bush which, despite of not being convenient, was safer.

It is to be observed, however, that when people come to live together in cities and townships, the need for a toilet becomes apparent. Bushes are not easily available in these areas to provide a cover. Hence privacy and convenience dictate acceptability. The provision of latrines in urban centres is a legal requirement, at least in Tanzania. No house shall be occupied if it does not have a latrine and it is therefore a legal offense under Public Health Rules. Therefore, people must invariably accept the use of latrines.

Even in rural areas, people who have come to live together in villages as observed in Tanzania (as a result of civilisation policy of the country) have cultivated the habit of using latrines. In some villages a latrinisation culture has existed for a long time. Hence, indiscriminate defaecation is usually rare.

As indicated earlier, there are cultural factors and beliefs that negate the use of latrine. These, however, can be accommodated in project implementation. For people who cannot share same latrine, two latrines can be constructed; one for use by parents, and one by children. Alternatively, the same latrine could serve both men and women if two separate doors are placed on opposite direction.

Health education has a role to play in fostering acceptability. If people understand and imbibe the idea and reasons of using latrines, they will no doubt accept to use latrines. The construction of safe and durable latrines will encourage people to use latrines. Privacy and convenience, including the desire to prevent spread of diseases, are conducive to the acceptance of the use of latrines. In this country, and the author believes in other countries as well, mass public health education campaigns are amounted through news media such as the radio, newspapers and public meetings. Constraints relating to news media range from unavailability of radio sets, batteries and newspapers. This deficit normally occurs in remote rural areas. In Tanzania between 1973 and 1975 the news media, mainly the radio, was instrumental to the successful campaigns of Mtu ni

Afya (Man is health) and Chakula ni Uhai (Food is life) which were jointly launched by the Ministries of Health, Agriculture and Adult Education.

2. Affordability

This will vary from place to place and between individuals. It will also depend on the technology chosen, material used and the level of wealth the people have. Conventional sewerage is an attractive sanitary facility but certainly it is out of the reach of many people. Even septic tank would be expensive to most rural people. Indeed very few people can afford this technology. Pit latrines and pour-flush latrines, on the other hand, are low-cost technologies that a big proportion of people both in urban and rural areas could afford. The choice of building materials also does matter. For example, concrete blocks, burnt bricks or corrugated iron roofing sheets would be too expensive to many people. But a good latrine could be made from materials that are locally available. Such materials would include adobe, treepoles, mud and thatch. It is certainly advantageous to use durable construction materials for durable latrines. The author is convinced that if people are educated so that they can grasp the importance of using latrines, they will be easily convinced and motivated to spend some money to construct latrines that should last at least more than five years. This would be a saving to them as they will not require a new latrine every two or three years as they do now. For poor people, the author thinks they will require some external assistance. This may come from village government or central government. Such assistance could also come from foreign agencies. This assistance, however, will have to go along with people's contributions in materials, labour and financial forms. The Wanging'ombe sanitation project in Iringa Region which complements the water supply project is a good example where a donor agency interacts with the villagers to produce good and durable ventilated improved pit latrines. UNICEF supports the project by giving two bags of cement, a vent pipe and wire screen for each latrine built. In addition to this, UNICEF also provides squatting plates. The level of UNICEF subsidy in this respect is comparatively low. It is about Tsh. 300 (Or about US$ 36) per latrine whereas UNICEF subsidy and indeed other donor agencies on water is higher; about 50% higher than that provided for a sanitation facility.

The provision of cement, squatting slabs, etc. constitutes a big motivation for the people to construct latrines. It is also a policy that each household shall built its own latrines. This can b9e done on an individual or co-operative basis. In the Wanging'ombe Sanitation project, for instance, each 10-cell leadership makes out burnt bricks that would be enough to build a latrine for every household in that leadership, irrespective of whether the owner of the household is a poor or well-to-do person. The use of local fundis (artisans) has become a common practice. These local artisans are normally required to work on this latrine building project as a contribution to the village development. They are usually exempted from other village communal activities.

3. Extension Work

While it is essential that each household should have and use a latrine, it is equally important that public places and institutions such as dispensaries, health centres, schools, offices and recreation places should be provided with latrine facilities. The omission of latrines in these places would encourage people to find other alternatives such as sanitary lanes and other obscure places. The spread of faecal-borne diseases would thus be enhanced. Public latrines are normally constructed by urban authorities in these areas. In rural areas, such facilities are usually built on a self-help basis by people's participation. School pupils could also build their own latrines if they are well guided. Latrines in schools would be a good teaching material for children who would later on influence their parents or the very young ones at home on the use of latrines. Sanitary facilities in hotels and restaurants are usually indicated in building plans. These plans cannot be passed if they do not show the provision of sanitary accommodation.

Maintenance and sanitary upkeep of public latrines require very close supervision, otherwise they will become an eyesore and indeed a threat to the health of the public. This would necessitate assigning full-time duty personnel in charge of keeping public latrines clean all the time.

4. Training Needs

There is a need to train craftmen such as mansons and carpenters who are able to construct latrines with much expertise. Untrained workers usually mess about and provide low-quality structures that will become unsafe and collapse at anytime. A badly built latrine is as bad as having no latrine at all. It would repel people from using it because of fear. On-the-job training is a best approach.

The question of motivation also applies in this case. While users could be motivated to construct and use latrine by giving them minimal help as indicated in the case of the Wanging'ombe Sanitation Project, craftmen or mansons could be motivated by providing them with construction tools such as trowels, spirit levels and tape measures. They could also be motivated by giving them some refresher courses on their specialties. There is also a great need to train supervisors, who will oversee the work of the mansons or carpenters. More experienced artisans could be selected for such training. Also health staff such as health officers or health assistants - who are normally project staff - could be given an orientation course on latrine construction. They should be motivated by being admitted to continuing education programmes.

Study tours overseas would be an excellent incentive. Likewise, the provision of transportation would motivate project staff to work better and with more interest.

For more intricate systems such as sewerage schemes and flush toilets, including aqua-privies, we would need to train sanitary engineers, architects, designers, draftmen and perhaps planners. Good salaries and opportunities to promotion would be excellent incentives for such cadres to work diligently.

CONCLUSION

The implementation of human waste programmes could be met with problems, especially if it is accompanied by tribal customes, taboos, beliefs and fear. Poverty and ignorance of diseases - and of their cause and how they are spread - are constraints. The author is convinced, however, that if people are educated and are motivated well on the importance of latrines and their use, such constraints can be surmounted. Both users and supervisory staff require motivation of some kind. Health education for all remains a sole reliable weapon that can be used to change people attitudes towards better health, and thereby facilitates very much the implementation of human waste programmes which are vital in improving the quality of life of mankind.

KINETICS OF ORGANIC, BACTERIAL, NUTRIENT AND PARASITE REMOVAL IN A SERIES OF WASTE STABILIZATION PONDS IN NORTH-EAST BRAZIL

Malwila G. Dissanayake
Visiting Professor

Salomao A. Silva
Professor Titular

Experimental Station for the
Biological Treatment of Sanitary Wastes
Federal University of Paraiba
Caixa Postal 306
58.100 Campina Grande
Paraiba, Brazil

ABSTRACT - Waste stabilization ponds have been used as a means to reduce organic pollution and bacterial contamination in wastewater prior to discharge to the receiving waters. However, research findings reported in the literature differ from region to region. This paper discusses the performance criteria of five ponds in series under tropical conditions. The organic loading was adjusted to 1874 kg BOD_5/ha-d so that the first pond in the series was anaerobic, and the subsequent ponds acted as facultative or maturation ponds. The results indicated that the five ponds in series performed satisfactorily with regard to organic, bacterial, nutrient and parasite removals. The net average BOD_5, COD and feacal coliforms removals were 89%, 79% and 99%, respectively. The overall ammonia-N and phosphorus removals were 32% and 36%, respectively, while the parasite removal exceeded 99%.

INTRODUCTION

Waste stabilization ponds are being used increasingly for sewage treatment in many developing countries, where they have economic and technological advantages over conventional treatment systems. The climates in many of these countries are ideally suited to the waste stabilization and treatment. Pond design methods remain largely empirical; various methods emphasizing either temperature or solar radiation as the limiting factor in waste treatment.

Since the performance of waste stabilization ponds also depends upon meteorological factors such as temperature, sunlight energy, sunlight duration, rainfall and seasonal changes, research findings reported in the literature differ from region to region (1-7). It was this lack of reliable information - especially in the tropical regions of Asia, Latin America and Africa - that prompted this investigation on the performance criteria of waste stabilization ponds with emphasis on organic, bacterial, nutrient and parasite removals.

This paper outlines the results obtained from a comprehensive study of the behaviour of five pilot-scale waste stabilization ponds in series under tropical conditions in North-East Brazil.

RESEARCH OUTLINE AND EXPERIMENTAL INVESTIGATION

Five waste stabilization ponds treating domestic sewage from the city of Campina Grande, Paraiba, were investigated for an eighteen-month period, in tropical North-East Brazil. A high organic loading was applied so that the first pond (A1) was anaerobic, and the second (F1) and the subsequent three ponds (M1, M2 and M3) functioned as facultative or maturation ponds. The layout of the five ponds is shown in Figure 1. Campina Grande is located at 7° 13' 11", South, 35° 53' longitude West, and 547.7 meters above MSL. The temperature varied from a low of 20°C to a high of 30°, with an average value of 25°C. The average sunlight intensity, duration, rainfall and evaporation are given in Table 1.

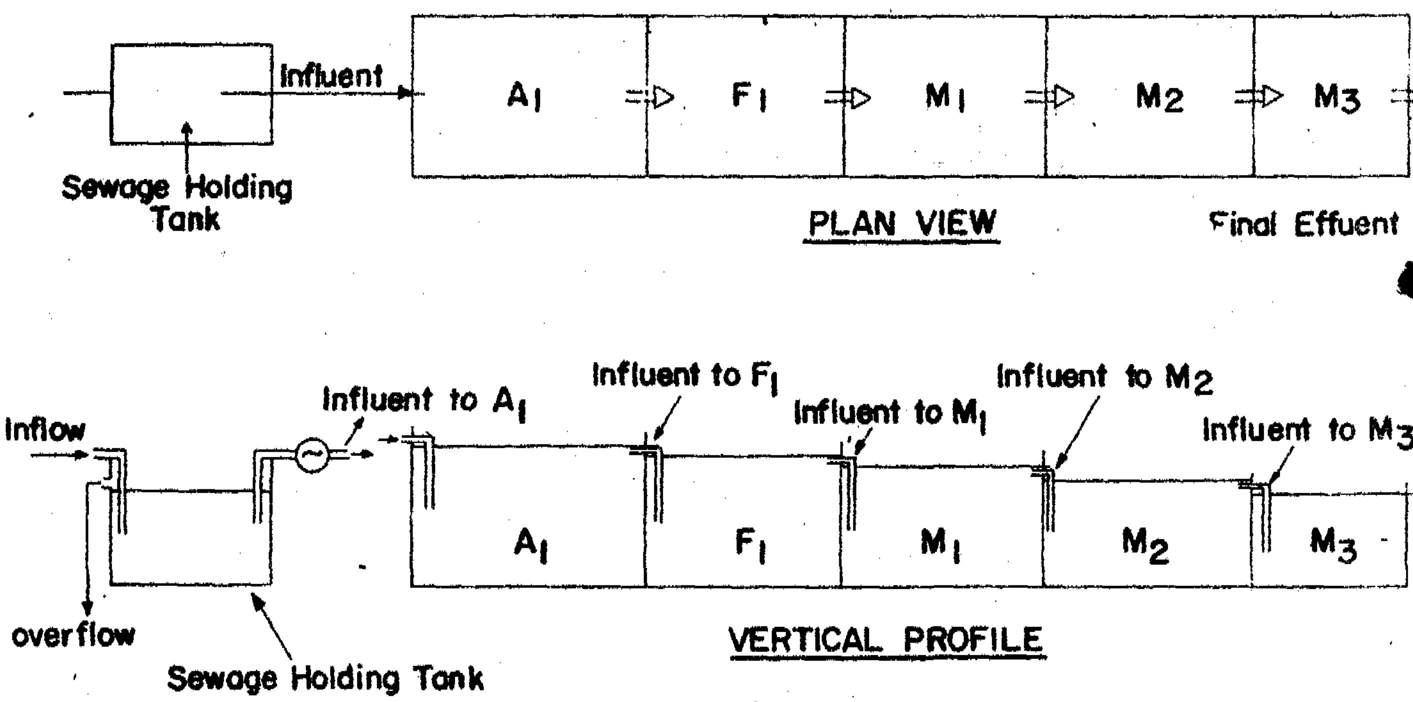

Fig. 1. Layout of Five Ponds in Series

Table 1. Meteorological Parameters

Parameter	Monthly Average
Total rainfall, mm	57.42 (2.7-115.4)
Total evaporation, mm	177.02 (121.2-238.1)
Solar radiation, Langleys	603.83 (415.0-707.0)
Sunshine hours	196.35 (104.3-267.2)

The average sewage characteristics with lower and upper ranges are given in Table 2 for the 18-month experimental period. The pond dimensions and operating parameters and summarised in Table 3.

Table 2. Raw Sewage Characteristics

Parameter	Mean and Range (Minima & Maxima)
BOD_5, mg/l	249 (105-358)
COD, mg/l	192 (399-827)
Ammonia N, mg/l	43.0 (29.2-54.5)
Nitrate N, mg/l	0.29 (0.02-1.65)
Fecal coliforms, No/100 ml	4.0×10^7 (0.2×10^7-8.4×10^7)
Total solids, mg/l	1146 (945-1336)
Suspended solids, mg/l	297 (160-405)
Temperature, °C	26.5 (24.2-28.1)
pH	7.44 (7.35-8.06)
Phosphorus, total, mg/l	6.84 (4.50-9.70)

The following parameters were daily monitored during the experimental period: pH, temperature, BOD_5, COD, fecal coliforms, ammonia and nitrate nitrogen, total and suspended solids, total phosphorus, chlorophyll-a, and some parasite species.

Chemical and bacteriological analysis were carried out according to Standard Methods (8). The parasites were determined by successive centrifugation and subsequent identification under the microscope at a magnification of 100x. The experiments reported in this paper were carried out for 18 months from June 1979 to November 1980.

Table 3. Pond Dimensions and Operating Parameters

Parameter	A1	F1	M1	M2	M3
Dimensions m	10.00 x 3.36 x 1.25	10.00 x 3.35 x 1.00	10.00 x 3.35 x 1.00	10.00 x 3.35 x 1.00	10.7 x 3.35 x 1.00
Area, m^2	34.0	34.0	34.0	34.0	34.0
Volume, m^3	42.0	34.0	34.0	34.0	36.0
Raw Sewage Flow Rate, m^3/d	21.24	21.24	21.24	21.24	21.24
Mean Hydraulic Ret. Time, d	2.0	1.6	1.6	1.6	1.7
Areal BOD_5* Loading, Kg BOD_5/ha-d	1874.0	–	–	–	–
Volumetric BOD_5 Loading g BOD_5/m^3-d	150.0	–	–	–	–

** Raw sewage influent BOD_5 was assumed to be 300 mg/l.*

RESULTS AND DISCUSSION

Waste stabilization pond kinetics involve a complex process encompassing several climatological and physical parameters. Existing models of Marais & Shaw (9), Marais (3), and Aguirre & Gloyna (10) were based on first order kinetics and consisted of only temperature and detention time as major parameters. However, Dissanayake (11), Bowles et al. (12) and Uhlmann (5) pointed out the need to improve the above models to include the parameters such as algal concentration, light intensity, light duration, dispersion number and organic loading, which were also found to affect the bacterial die-off.

There are many conflicting claims regarding the efficiency primary and subsequent ponds. This paper discusses the merits of each pond in the series. The results showed that, under tropical conditions, the five waste stabilization ponds in series performed satisfactorily with regard to organic, bacterial, nutrient and parasite removal, even under a relatively high organic loading and low detention time. Percentage removals of various parameters are summarised in Table 4 for the pond series.

Table 4. Percentage Removals of Major Parameters

Parameter	A1	F1	M1	M2	M3	Overall
BOD_5	75	10	23	22	19	89
COD	69	9	10	9	7	79
Ammonia - N	26	-1	4	3	3	32
Nitrate - N	22	-6	11	0	0	26
Fecal coliforms	85	40	45	54	50	99
Total solids	23	1	-5	1	3	23
Suspended solids	79	13	6	2	-4	83
Phosphorus, total	37	-4	-3	3	2	36

Organic Matter Removal

As seen from Table 4, the net average BOD_5 and COD removals of the pond series were 89% and 79%, respectively. However, of this amount, the anaerobic pond A1 was responsible for the reduction of 75% influent BOD and 69% of influent COD. Each of ponds M1, M2 and M3 was responsible for an average reduction of only 20% BOD and 10% COD. This confirms the wide-spread belief that tertiary and subsequent ponds are not very effective in removing the organic matter of primary pond effluents. One reasons for this may be that the major portion of BOD_5 coming into these ponds contains non-biodegradable organic matter.

Pond F1, which acted as a transition pond between anaerobic and facultative ponds, was responsible for the removal of 10% BOD_5 and 9% COD. This was mainly because of the high organic loading (468 kg BOD_5/ha-d) and low detention time (1-6 days). The pond series was in fact loaded heavily and operated with low detention times to investigate the effect of these extreme operating conditions on organic and bacterial removal kinetics. The ponds M1, M2 and M3, though normally considered as maturation ponds, in fact achieved facultative conditions. Hence, it is evident that ponds do not behave according to a set pattern, but rather depends on operating parameters and prevailing environmental conditions. Therefore, the results of this study shows that a comprehensive mathematical model describing the kinetics of waste stabilization ponds should include operating and environmental parameters.

Fecal Coliform Removal

The overall fecal coliform bacterial reduction in the pond series was 99%, while the individual percentage removals of subsequent ponds ranged from 40 to 85%. These findings confirm the fact that subsequent ponds in a series are capable of removing fecal coliforms in substantial amounts (3), though marginally effective in organic matter removal. The average fecal coliform removals in pond A1 of this study is, however, compatible with the results of Dissanayake (11), Marais (3) and Mara et al. (2). However, the results contradict the belief that each subsequent pond in a series achieves a fecal coliform removal in the range of 90% or more.

In fact, this study reveals that the actual removal of fecal coliforms in each secondary and subsequent ponds depends on a number of factors such as organic loading, detention time, sunlight intensity and sunlight duration. The low fecal coliform removal values reported in this paper (Table 4) are mainly due to the high influent organic loadings (F1 - 468.5, M1 - 421.5, M2 - 324 kg BOD_5/ha-d) and low hydraulic detention time.

Dissanayake (11) showed that when the detention time increased from 2 to 10 days, the fecal coliform removal increased from 78% to 92%. Marais and Shaw (9) tabulated results of ponds in USA and South Africa, where E. coli and total coliform percentage removals in secondary and subsequent ponds varied substantially as the organic loading and detention time varied. Hence, the results of this study further confirms that fecal coliform removal in secondary and subsequent ponds does not lie in a constant range (as widely believed to be over 90%) but depends on a number of parameters such as temperature, detention time, organic loading, pond dispersion number, sunlight intensity and sunlight duration.

In the pond series, the overall total solids, total volatile solids, suspended solids, volatile suspended solids and settleable solids percentage removals were 23, 56, 83 and 98, respectively. Pond A1 achieved major portions of these removals, while the efficiencies of solids removal in other ponds were marginal.

Nutrient Removal

The overall ammonia-N and nitrate-N reductions were 32% and 22%, respectively. However, major portions of ammonia-N (26%) and nitrate-N (22%) were removed in pond A1 which was anaerobic. These amounts are compatible with those reported by Gann et al. (13). The overall total phosphorus removal was 36% and virtually all of this was achieved in pond A1. This shows that in a series of ponds, secondary facultative and subsequent ponds are not effective in the further removal of nutrients. Since nitrogen and phosphorus act as limiting factors to phytoplankton growth, their reductions in higher amounts are necessary to completely inhibit eutrophication. However, in designing a series of ponds, consideration should be given to the fact that secondary facultative and subsequent ponds are only marginally effective in removing nutrients.

Parasite Removal

Certain parasite species were measured in the raw sewage and the effluents of the five ponds. These results are summarized in Table 5.

Table 5. Parasite Counts in the Influent and Pond Effluents

Parasites	Mean and Range (Number/litre)					
	Influent	A1	F1	M1	M2	M3
Ascaris lumbricoides	588(192-1757)	20(0-40)	1(0-20)	0	1(0-5)	8(0-120)
Ancilostomideo sp.	895(102-3050)	25(0-95)	10(0-60)	2(0-10)	6(0-60)	4(0-50)
Entamoeba coli	1269(79-5087)	33(0-215)	17(0-117)	1(0-15)	5(0-60)	8(0-120)
Entamoeba histolityca	191(0-1414)	8(0-70)	5(0-60)	1(0-5)	3(0-20)	1(0-20)
Trichuris trichiura	23(0-57)	0	0	0	0	0
Hyménolepis nana	4(0-19)	0(0-3)	0	0	0	0
Taenia sp.	2(0-7)	0	0	0	0	0
Iodamoeba butschlii	43(0-443)	0(0-7)	2(0-10)	2(0-10)	0	1(0-20)

The overall parasite removal in the pond series exceeded 99%; pond A1 achieved 90% of this reduction while the efficiency in other ponds varied from one pond to the other for each parasite species. Therefore, the usefulness of subsequent ponds in a series stem from the removal of bacteria and parasites.

Algae Genera in Ponds

In the secondary facultative pond and the three maturation ponds, Euglena, Chlorella and Phacus were the predominating algal species. Algal concentrations were measured in the form of chlorophyll-a. The average chlorophyll-a concentrations during the 18 month period in F1, M1, M2 and m3 were 33, 84, 132 and 142 mg/l, respectively.

In order to have a broaden knowledge about the various algal general present in facultative and maturation ponds, 22 algal species were observed

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BIOGAS, COMPOST COMMUNITY LATRINE FOR LOW-INCOME SETTLEMENTS

Shri. Moreshwar Bhau Navrekar
Voluntary Social Worker and Bio-gas Technologist

Shri. Shrikant Navrekar
Biogas Expert

ABSTRACT - Several low-cost sanitary alternatives - like the trench latrine, composting latrine, single tank septic latrine, etc. - have been developed in recent years for low-income housing areas. The authors have recently developed a composting latrine biogas plant with much success. The garbage of the locality can be composted together with the outcome slurry from the gas plant in the adjoining pits. Every latrine chamber is provided with water with the tank on siphon principle, so wastage of water is completely avoided. We can get best quality organic manure rich in N, P, K, and other trace elements, and also the valuable biogas, the value of which will compensate for the salary of the worker employed for the maintenance of the unit. It has been found that any community latrine is beyond the approach of the children, old persons and disabled persons of the families in the community and they cover nearly half of the population of the community. The 'Box Latrine' has been found to be the best solution for this problem. From experience in the operation and maintenance of the community latrine, we can say that this community latrine must be operated on a co-operative basis. This system will prove most beneficial for the low-income settlements as :

1. the users will look after the unit carefully and hence there is no chance of damages;

2. the latrines will be used cleanly and sanitarily;

3. the community can employ a biogas and compost technician, whose salary will be compensated for by the value of biogas produced in the unit;

4. the value of the manure will be a bonus for the community; and

5. the garbage in the locality is to be collected for composting.

INTRODUCTION

The importance of rural sanitation in India was identified by Mahatma Gandhi and he brought it to the notice of village social workers and insisted them to emphasize on the same. Gandhiji's main object of rural sanitation programmes was total cleanliness of villages, with special attention to the disposal of nightsoil by a means that villagers would afford by their low incomes. Naturally from the beginning, efforts were aimed to find out suitable alternatives for the low-income groups in the villages. Secondly, besides sanitation Gandhiji laid equal stress on securing the manure from the nightsoil. He was against the Western methods of nightsoil disposal which totally ingnored the manure. The philosophy of Mahatma Gandhi gave inspiration to many and devoted workers emerged out in a large number. Such inspiration and devoted workers are important for initiating sanitation programmes. Mere scientific and technical viewpoints would not suffice. To achieve his aims, Gandhiji started with a simple trench system for the disposal of nightsoil; and, with more and more experience and experiments with it, several improved and modified designs were worked out.

Since 1945, the programme got a momentum and many government and non-government institutions got themselves involved in the same. As a result, several types of sanitary latrines were evolved. At present in India, many types of nightsoil disposal systems are operating like bore hole, pit, trench, the Wardha type, the Gopuri, the Castle, the PRAI, etc., and some modified designs of these types. Every type has its merits and demerits.

'NAIGAON KHATGHA' (A Family Latrine Unit)

In early fifties, the authors studied and tried many of the above-said types and finally - on the basic principle of biogas plant - we worked out a cheaper and most scientific design of latrine which can technically be called "single-tank mini septic compost latrine". It is well known that the septic action - anaerobic digestion - is the best method for the disposal of nightsoil. Our design is based on the same principle. In India this type is known as 'NAIGAON KHATGHAR' (Khat - manure, Ghar - house) - a family unit producing organic manure. This type has been proved to be very successful as a family unit both in rural as well as urban areas.

It is very convenient to convert service latrines (basket type) into this type in urban areas. Hundreds of service latrines were converted into the 'Naigaon' type in cities. Similarly municipal community latrines were also converted into the 'Naigaon' type within a short time. Besides conversion, new erections were also done on an individual as well as community basis. Later, in mid sixties, the 'Gandhi Smarak Nidhi' - an institution working on the Gandhian principles in rural areas - adopted this type for extension work and is now still propagating the type.

COMMUNITY LATRINE BIOGAS PLANT

Nearly all the workers involved in the sanitation programme had come to the conclusion that, as far as possible, the community latrine should not be encouraged. Instead, family units should be advocated. This resulted in the negligence of the community latrines. The misplaced defecation in the open was continued, and due to this fact the environment used to become filthier and unhygienic.

Then onwards we directed our research and extension work towards Gobar (cow-dung) gas plant-cum-latrine for the villagers. With the experience of the same, we have designed a community biogas plant utilizing only human waste as a feeding material which has been proved to be much cheaper, aesthetic and sanitary than the conventional community latrine. The unit is known as the 'biogas compost community latrine', the details of which are given in the succeeding paragraphs.

The unit is welcomed by the public because of its outstanding features of giving a valuable biogas and rich organic manure - hitherto neglected in any other type of community latrine - the benefits of which are well known. Besides, the unit is popular because :

a. it is free from foul odour;

b. there are no fly and mosquito nuisances;

c. the garbage of the community can be composted; and

d. the outcoming effluent helps in keeping the community surroundings clean and sanitary.

The unit can be conveniently said to serve for a long period since :

a. The excreta from the basin flow immediately to the digester unit; and there are least chances of the corrosion of the complete latrine unit as well as of the squatting plates.

b. The gas plant attached is a modified fixed-dome type, constructed in brick masonary work and nowhere steel is used. Naturally the whole design is least corrosive and long lasting.

From the economic point-of-view, this type is found to be cheaper than any other sanitary community latrines. Naturally affordability is no problem.

As per our experience, unlike any other type of community latrines, we have found no difficulty in receiving public acceptance of this type as it is cheaper, aesthetic, sanitary, easy to maintain, and producing biogas and richly organic manure.

WHY COMMUNITY LATRINE BIOGAS PLANTS?

The agriculture throughout the world is suffering from the serious disadvantages of synthetic fertilizers. The only remedy to avoid these hazards is to replace these fertilizers with appropriate organic manures. Fortunately, developing countries can handle every source, which will give abundant organic manure. Human waste is the never-ending source of the best quality organic manure.

Besides the fertilizer issue, the world is also facing an energy crisis. Biogas is one of the alternatives which can alleviate the energy crisis to a great extent and that too can be had from human waste. By implementing a proper disposal system, we can get organic manure and biogas from human waste at the same time.

In this way human waste does not remain a waste, but becomes a national wealth; and the issue of its management - hitherto supposed to be a time-consuming and tedious task - becomes a wealthy, productive and lively national activity.

The design under discussion in capable of giving the two main advantages discussed above. Besides, the unit does not contaminate surface soil, surface water or ground water. It is free from odour and inaccessible to flies and other animals. There is no handling of fresh excreta and the construction, materials and methods are simple and inexpensive.

DESCRIPTION OF THE DESIGN

The design consists of a modified fixed-dome type latrine biogas plant, having an expected gas capacity (say 500 cft). The required number of latrines with specially prepared basins (having sufficient slope) are attached to the inlet or feeding chamber of the plant by a pipe line having a sufficient gradient. The number of latrines to be attached depends upon the number of users. One latrine can be considered sufficient for twenty five persons. Each latrine is provided with a small water tank inside at hand. It is constantly filled with water, which is supplied on the siphoning principle from the a main water tank outside. This method of water supply avoids the misuse of water and helps the user keep the basins clean easily.

A community latrine biogas plant of 500 cft capacity will consist of 20 latrines. This will be sufficient for 500 users.

BENEFITS OF THE DESIGN

This plant will give 500 cft of biogas per day. A gas engine of 5 HP capacity can be run for 6 to 7 hours by using this gas (@ 15 cft gas per Hp-hour). Devices like floor mill, generator, etc., can be operated with the help of this engine. The biogas can also be utilized directly for street lighting. 500 cft of biogas will light 25 gas lamps of 40-candle power each for 8 hours.

In addition to the biogas, at least 500 tonnes of compost is obtained per annum from the unit. The compost is rich in nitrogen, phosphorus and potassium, and contains trace elements as well. When added to the soil, it helps in building up humus content and all the physical properties of the soil are improved. The population of beneficial microflora and macroflora is increased, which in turn results in healthy and bumper crops.

MAINTENANCE OF THE UNIT

The community can employ a biogas and compost technician, whose salary will be compensated for by the value of biogas produced in the unit. The value of the manure will also be a bonus for the community.

THE 'BOX LATRINE'

It has been found that any community latrine is beyond the approach of the children, old persons and disabled persons of the families in the community and they cover nearly half of the population of the community. There must be some provision for the disposal of human waste for this category of users, which should be convenient and cheap. In the absence of such a provision, environmental conditions will remain filthy and unhealthy - a source of suffering and disease.

The 'Box Latrine' (costing Rs. 30 to 50 in India), which we have organised, has been found to be the best solution for this problem. The box latrine is a handy device, most convenient even for a child. Being cheap, every family can keep it at home. Besides, the box has been proved to be a multipurpose sanitary facility. It can be emptied at any time at leisure in an emptying tank specially provided in the community latrine unit.

PRACTICAL AND LOW-COST TECHNOLOGY FOR HUMAN WASTE MANAGEMENT

Yu-Si Fok

Professor
Department of Civil Engineering

Researcher
Water Resources Research Center

University of Hawaii at Manoa
Honolulu, Hawaii 96822, U.S.A.

ABSTRACT - This paper first discusses several practical methods for low-cost human waste management. Among these waste management methods, the double-vault composting latrine was selected for modification. The second discussion centers the modifications of the double-vault composting latrine, so that additional features can be incorporated in this system to improve its efficiency without too much added-on cost. A new system called the Vault Wheel-Box Latrine is introduced in this paper. Finally, the disposal of the decomposed human waste as fertilizer to crop land is also discussed.

ASSESSMENT OF LOW-COST TECHNOLOGY FOR HUMAN WASTE MANAGEMENT

According to UNICEF News (1), in the industrialized countries, the cost of installing a modern household water supply system is about US$ 500 per person, and of a waste disposal system connected to a sewer, an additional US$ 500 per person is needed. Such high costs cannot possibly be borne in developing countries, in many of which the gross national product is only US$ 200 to US$ 300 per person. Therefore, technologies for water and sanitation in the developing countries must be kept as low as possible, between US$ 5 and US$ 75 per person.

Several low-cost human waste management systems are frequently promoted. Four of which were reported in the UNICEF News (1), namely:

1. The "long drop" latrine,
2. The "ROEC": Reed odorless earth closet,

3. The pour-flush toilet, and
4. The double-vault composting latrine.

The simplified designs of these systems are reproduced in Figures 1 to 4. Among these four low-cost human waste management systems, the "long drop" latrine was utilized in Sanna, Yemen, a hundred years ago. However, its present applicability is limited because modern construction practice will no longer support the "long drop" latrine. In other words, this systems is no longer cost-effective in taller buildings.

The "ROEC" system requires a pit in the ground. The underground waste holding pit is harder to maintain and the waste cannot be easily removed from the pit. Furthermore, if the pit is not lined with impervious material, liquid waste leakage from the pit could contaminate groundwater supply.

The pour-flush toilet system was designed to use water to flush the toilet. In places where water is also a limited resource, the usefulness of this system will be limited.

As pointed out by UN officials, the double-vault composting latrine system has merits to be promoted because it requires no water, and the decomposed human waste can be utilized as fertilizer. This system will not create the waste disposal problem since liquid waste and solid waste are separated and recycled safely. In other words, the double-vault composting latrine system has met the criteria of low cost, recycling waste without inducing disposal problem, and sanitation without the use of water.

MODIFICATION OF THE DOUBLE-VAULT COMPOSTING LATRINE

The applicability of the double-vault composting latrine system has been discussed above. However, in order to fully utilize this system, some improvements of this system are suggested in the following. As shown in Figure 4, this system should have better ventilation by using the screened vent pipe set-up as showed in Figure 2. The urine collection system and the storage pot should be covered. Also the feces receptor holes should be covered when they are not in use. In other words, the system should cover the waste collection systems to prevent the odor release and insect intrusion to human waste.

The idea of the double-vault composting latrine is to separate liquid human waste (urine) from solid human waste (feces); and storing these wastes in tightly closed containers. Furthermore, the use of double-vault is to use one of the vaults for storing the solid human waste for an extended period (45 days minimum) in order to allow the human waste to complete the decomposition process. The decomposed human waste will then become a useful fertilizer. The dimensions and capacity of each vault have not been shown in any of the newsletters distributed by the United

Nations. However, judging from the photographs from UNICEF News (1), the minimum dimensions of a double-vault composting latrine are approximately 2 m in length, 1 m in width and 1 m in depth. Since one of the double vaults is used for waste decomposition process and would be sealed for at least 45 days, the volume of each vault can be designed subjected to the number of users. If each user produces 2 liters of solid waste per day and there are eight users for the latrine, the minimum dimensions estimated previously in this discussion should be adequate.

The other advantage of the double-vault composing latrine design is its above ground placement which makes operation and maintenance of the latrine easier. That is, the decomposed human waste can be removed from the vault more conveniently than from a pit which is located below ground level. As showed in UNICEF News (1), the compost in a double vault composting latrine was removed by a boy using a shovel and baskets. This practice can be modified and a new system is introduced in the following.

THE FOK VAULT WHEELED-BOX LATRINE (An Significant Improvement of the Double-Vault Composting Latrine)

The removal of human waste from the double-vault latrine is laborous. In order to simplify the waste removal process, the access doors of the double vaults can be redesigned to accommodate a suitable sized wheel box, which can be fitted in each vault like a drawer (see Figure 5). Since the waste is deposited in the wheel box, the capacity of the double-vault latrine will have great flexibility because a filled wheel box can be removed. With this new improvement, the double-vault latrine may also be redesigned as a single-vault latrine. The construction and design of the wheel box can use local materials. If the wheel box is removed from the air-tight vault, it should be covered air-tight during transportation to a decomposing site to complete the minimum 45 days decomposing process. If the wheel box is lined with non-biodegradable plastic sheets or other local water-seal material, the vault wheel box can be sealed for the completion of the 45 days decomposing period. There are many alternatives that can be suggested to this operation; however, the concepts should be maintained in order that sanitation has the first priority in all operations. The use of plastic or similar products for the vault wheel box has potential. In developed countries, plastic or other petro-materials are used for non-returnable containers.

DISPOSAL OF THE DECOMPOSED HUMAN WASTE AS FERTILIZER TO CROP LAND

As promoted by UNDP, the decomposed human waste from the double-vault latrine is used to fertilize crop land, a practice in many countries for thousands of years. Kitchen ashes added to the vault would help to deodorize the human waste and add plant nutrients. In high rainfall areas where crop land soils tend to be acid, the addition of kitchen ashes with lime would be beneficial. The decomposed human waste has been claimed to be free of pathogenic bacteria and intestinal worm ova but viruses are a concern. The virus problems should be investigated.

CONCLUSIONS

According to the discussions presented in this paper, the following conclusions can be made :

1. The double-vault latrine system has many advantages over other systems in practical and low cost for human waste management. It will cost little to built (US$ 50), it requires no water and hence groundwater contamination is not a problem, kitchen ashes can be used for deodorizing, urine is separated from feces, and the waste can be stored in one sealed vault for decomposition.

2. Improvements of the double-vault latrine can be made so that with slight additional cost, the latrine can be made more effective. Some improvements suggested in this paper are :

   a. The receptor holes for liquid (urine) and solid (feces) wastes should be covered when the latrine is not in use to prevent odor release and insect intrusion to the waste.

   b. The capacities and dimensions of the vault should be designed to suit the number of intended users.

   c. The double-vault latrine should be provided with a standpipe for ventilation purposes.

3. A new system called the Vault Wheeled-Box Latrine is introduced in this paper. In this new system, the vault is fitted with a drawer-like wheeled box will provide capacity flexibility because the waste collected from the latrine can be removed and stored in another location for the sealed decomposition process.

4. Decomposed human waste has been used as fertilizer in many countries for centuries. Human waste sealed in a container for a minimum 45 days will be decomposed into an organic compost which will be odorless, free of pathogenic bacteria and intestinal ova. However, the problem of virus should be investigated so that viral diseases can be controlled.

ACKNOWLEDGEMENTS

The writer wishes to express his appreciation to Mr. Edwin T. Murabayashi, Research Associate, Water Resources Research Center, University of Hawaii at Manoa, for reviewing the manuscript of this paper.

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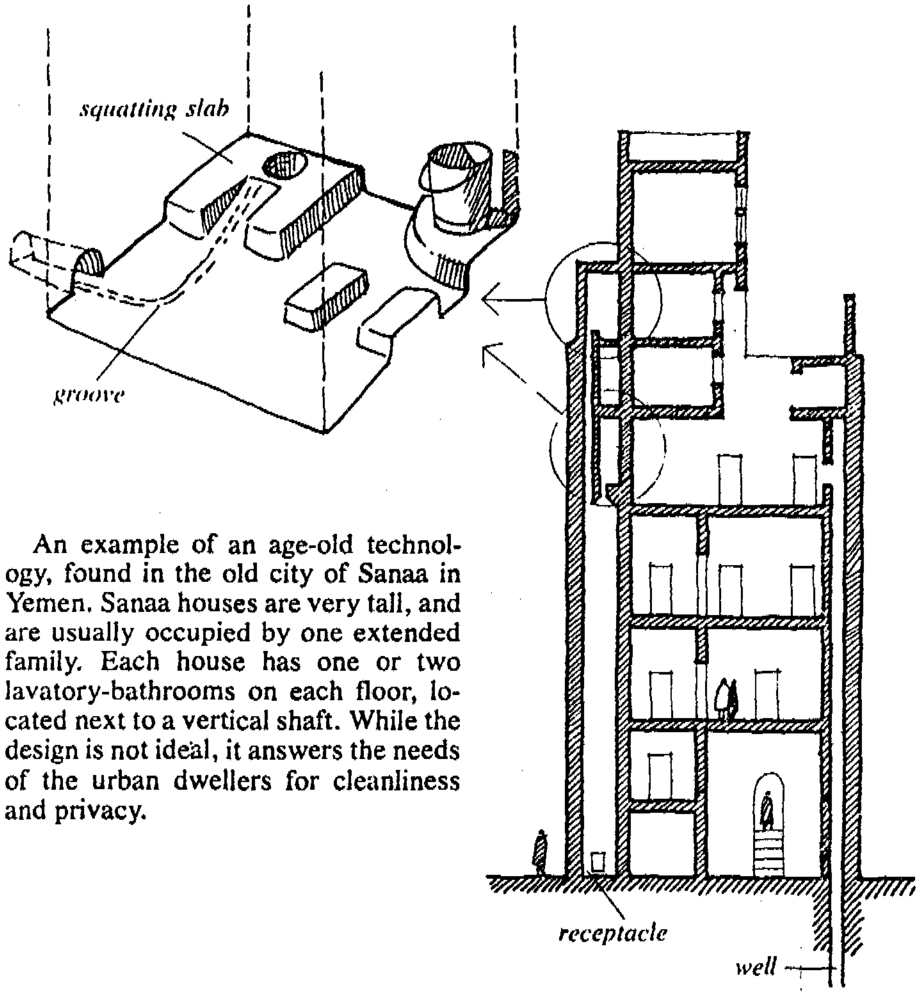
Figure
1. The "long drop" latrine



An example of an age-old technology, found in the old city of Sanaa in Yemen. Sanaa houses are very tall, and are usually occupied by one extended family. Each house has one or two lavatory-bathrooms on each floor, located next to a vertical shaft. While the design is not ideal, it answers the needs of the urban dwellers for cleanliness and privacy.

Source: Winbad and Kilama, **Sanitation without Water,** *SIDA, Stockholm.*

Figure
2. The "ROEC": Reed Odorless Earth Closet

This is an improved version of the simple pit latrine. The ventilation is improved by the pipe, 200 mm diameter, painted black and put on the sunny side so that the air will heat and create an updraught. The cap with a screen on the top is to prevent flies entering and spreading infection. The ROEC, which has been introduced in Botswana, Philippines, and elsewhere, is mainly constructed from local materials, but the pipe and some cement need to be bought. Depending on construction method, cost: $100-$150.

Source: Winbad and Kilama, **Sanitation without Water,** *SIDA, Stockholm.*

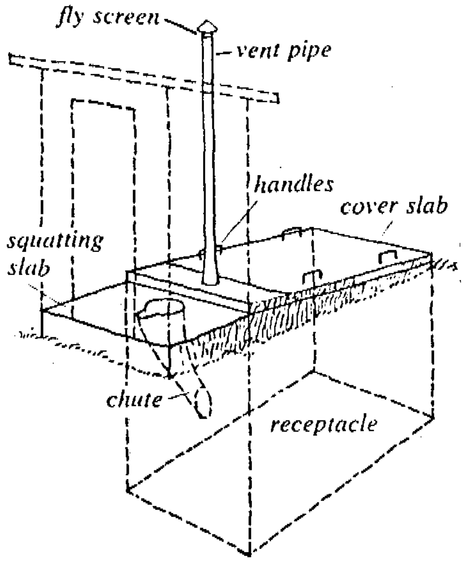
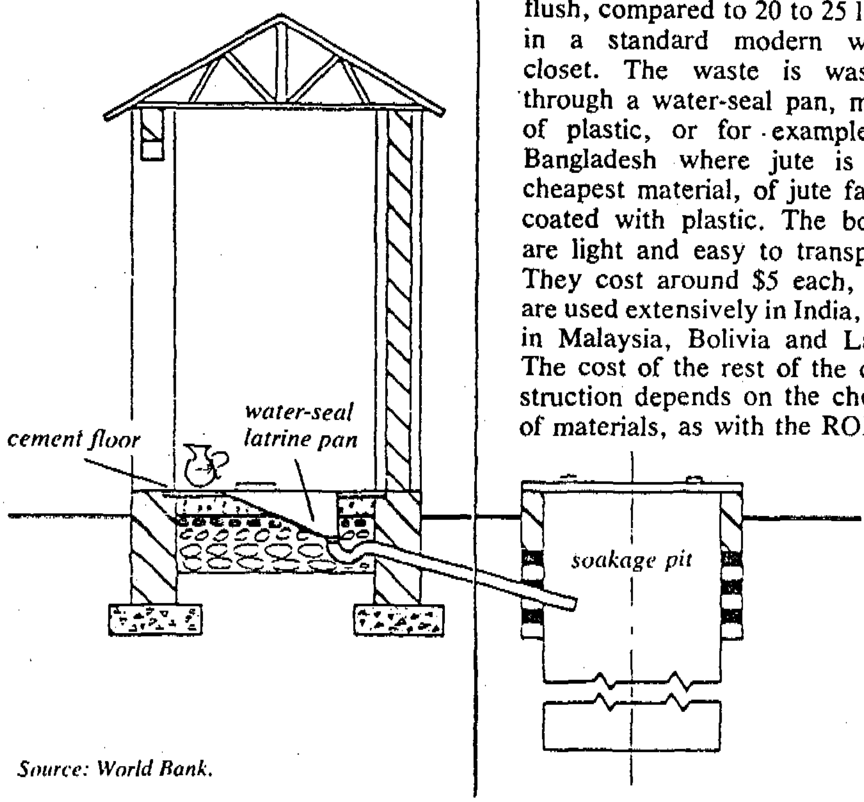


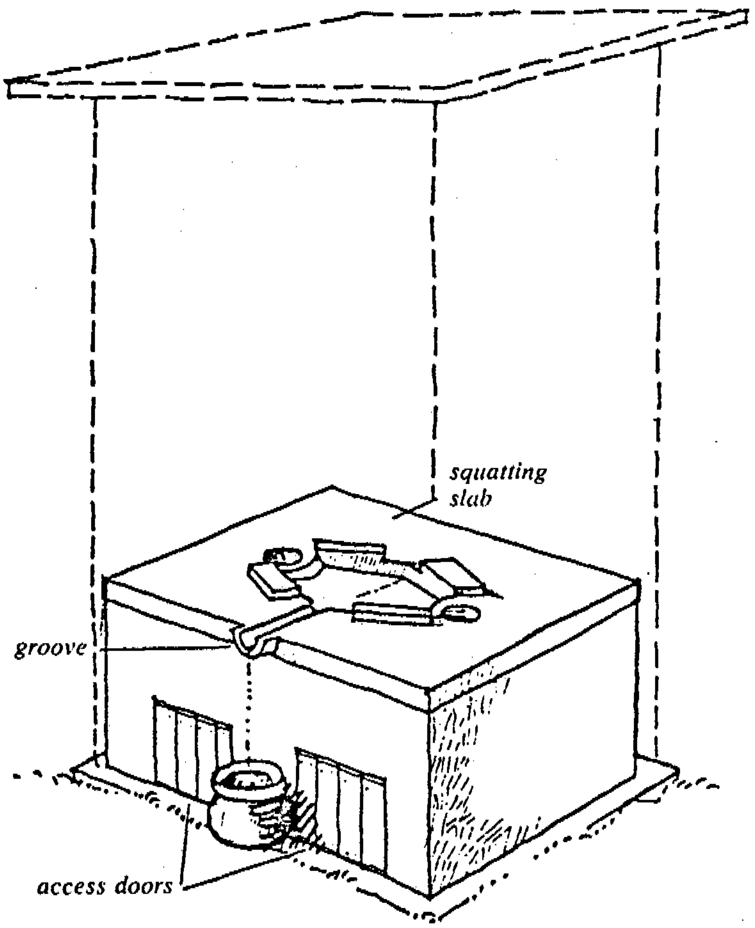
Figure
3. The pour-flush toilet

This simple toilet requires only one or two litres of water to flush, compared to 20 to 25 litres in a standard modern water closet. The waste is washed through a water-seal pan, made of plastic, or for example in Bangladesh where jute is the cheapest material, of jute fabric coated with plastic. The bowls are light and easy to transport. They cost around $5 each, and are used extensively in India, and in Malaysia, Bolivia and Laos. The cost of the rest of the construction depends on the choice of materials, as with the ROEC.



Source: World Bank.

Figure 4. Double vault composting latrine



This latrine is principally found in Vietnam and to some extent in China. It is particularly suited to densely-populated areas, where the water table is high, and the use of ordinary unsealed pit latrines pollutes the ground water. In the "double vault" latrine, there are two cement-lined vaults or boxes above ground level. These are used alternately, and the one not in use is sealed so as to create anaerobic conditions in which harmful bacteria are neutralized. Urine is separated from fecal matter by the use of a groove in the floor, and a run-off into a separate container. The fecal matter is composted, and after a minimum sealed-off period of 45 days, rendered into a dark grey, harmless, odourless, nitrogen-rich fertilizer, which is then removed. The cost of construction of the double vault latrine is very low because only a small amount of cement is needed: $50. The fertilizer produced also has a value. The double vault latrine is now being promoted by UNICEF in Bangladesh, Burma and Egypt.

Source: Winbad and Kilama, **Sanitation without Water,** *Sida, Stockholm.*

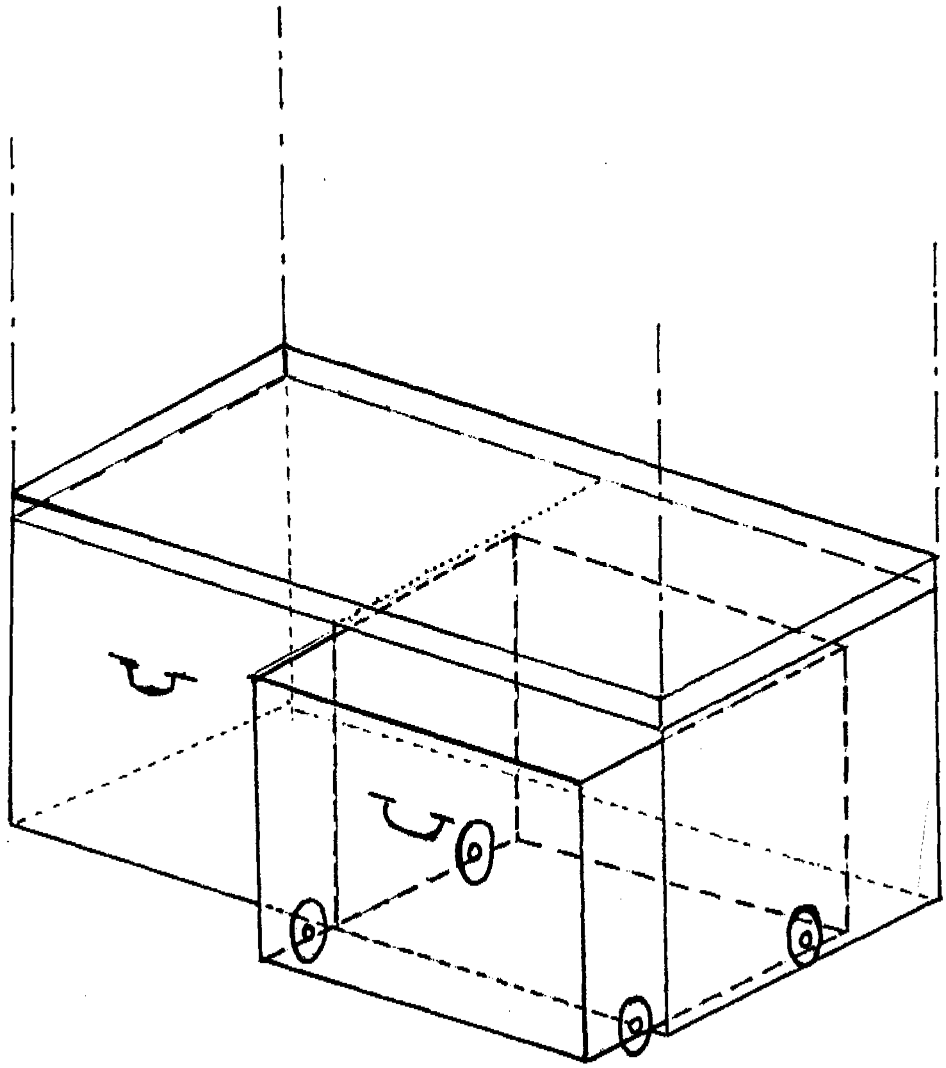


Figure 5. Schematic Design of Vault Wheel-Box Latrine

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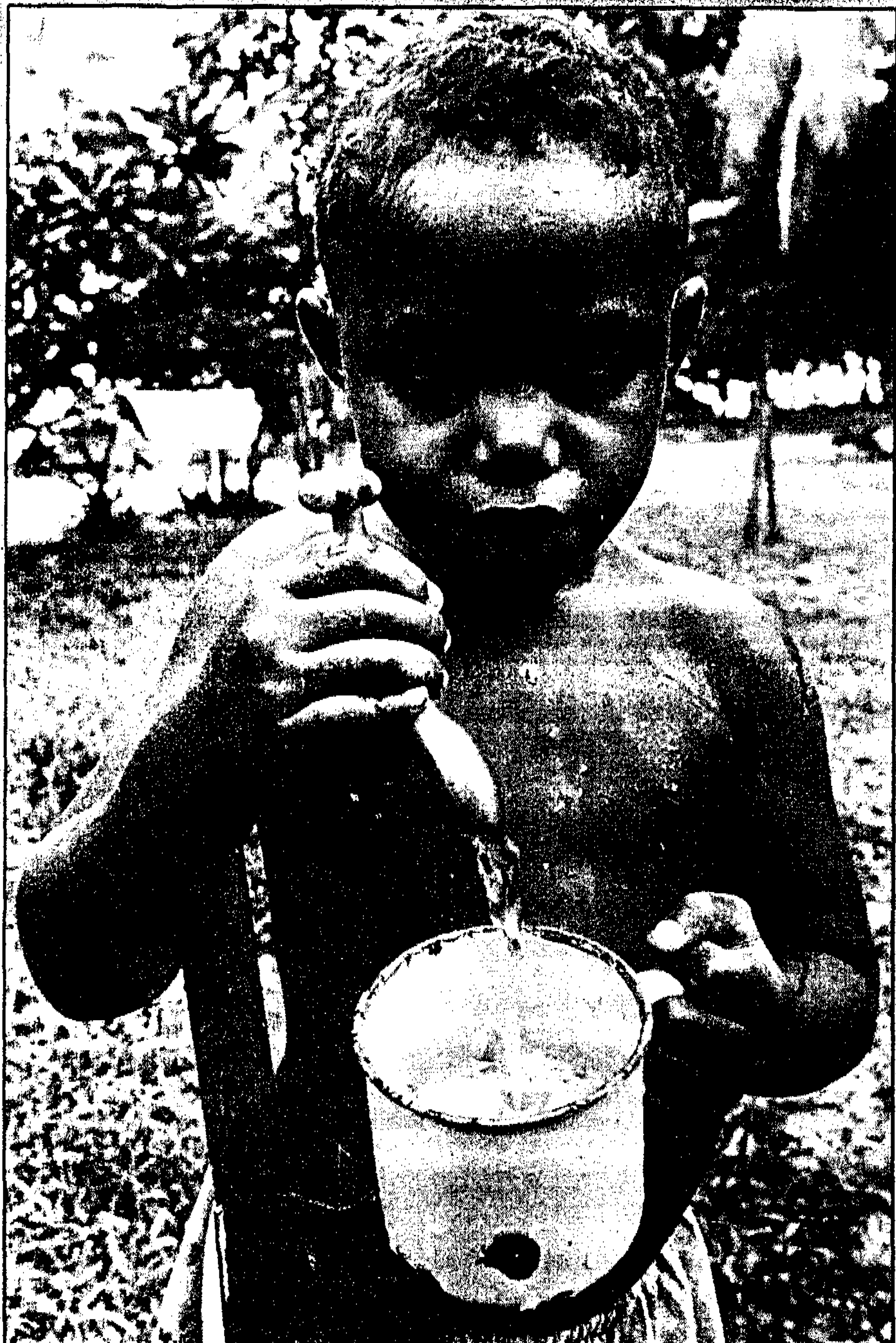
WATER AND SANITATION: The pure and the impure



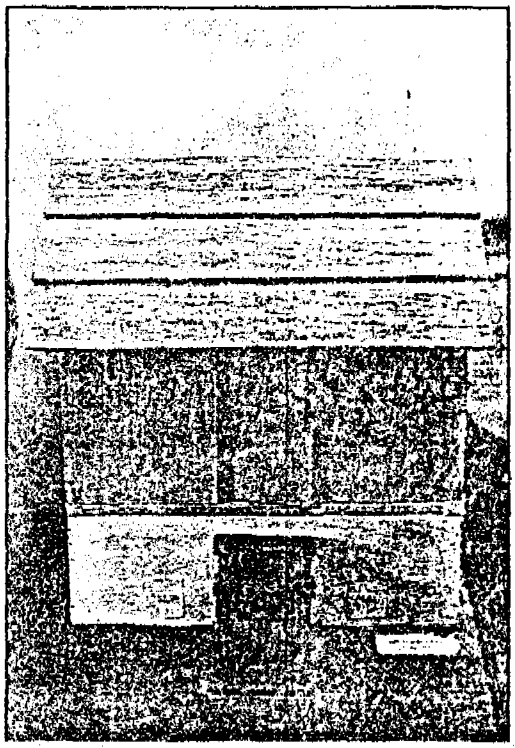
- The water-boys of Ouagadougou
- Low-cost technologies for cleanliness
- Nepal: life at the water tap

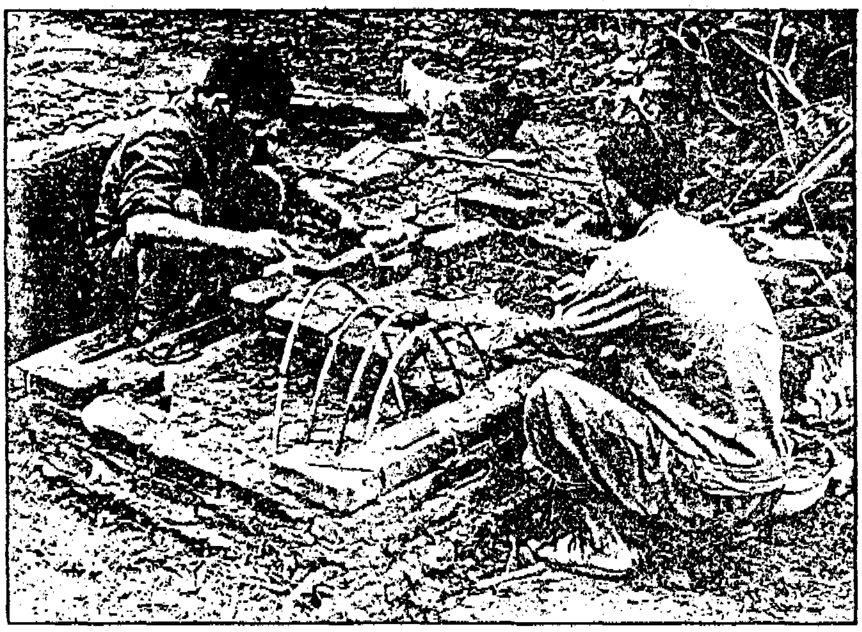
APPENDIX

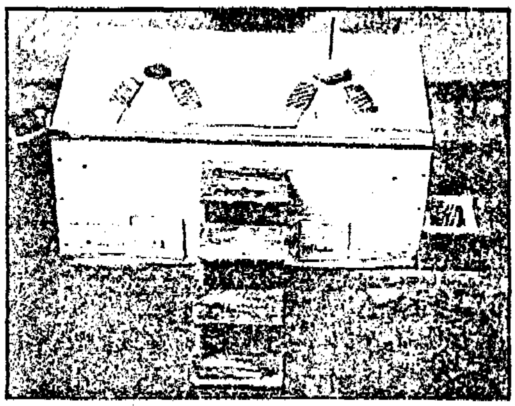
Building a Latrine, Quang Ba Style

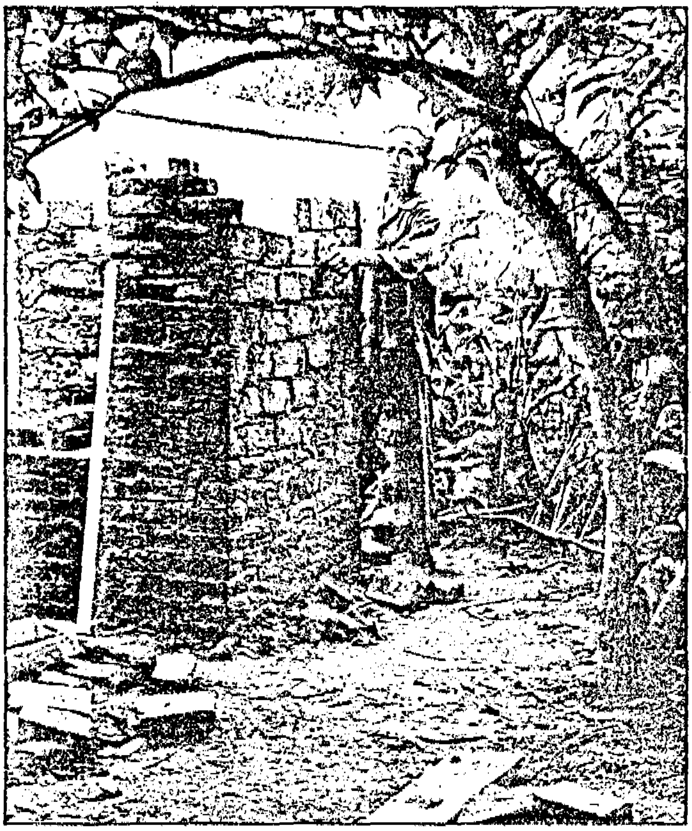
Many people around the world live in densely-populated river deltas, where the high water table means that ground water easily becomes polluted if unsealed pit latrines are used. The "double vault" latrine* commonly used in Vietnam and China overcomes this problem, and also provides a valuable side-benefit: fertilizer. This latrine, shown here at different stages of construction, is being built in Quang Ba, a village in Vietnam which the President once described as the dirtiest in the whole country. The villagers, under the guidance of the local doctor, made such a determined effort to clean up the village that they eventually won his approval as an example to other communities. Photos by JACQUES DANOIS, UNICEF's Senior Information Officer in East Asia.

*A diagram of this latrine is shown on page 21.









1. The unimproved pit latrine: the human waste, deposited below ground level, can easily contaminate the ground water, especially if the pit is unlined. Those who go barefoot are easy prey to hookworm and other parasites.

2. Early construction: the basic shell of the "double vault" latrine is made of sun-baked bricks. The twin "vaults" are above ground and the bamboo scaffolding for the ceiling of one is already in place. They are divided by a wall, and are completely lined with cement to create anaerobic or oxygen-free conditions, in which harmful germs are organically destroyed.

3. and 4. The models, exterior and interior: these are used as teaching aids to explain to villagers the benefits of the latrine's design. When one "vault" is in use, the other is sealed. When composted, the contents are rendered into a harmless, odourless, removable fertilizer. Urine is separately collected, in the groove which leads into the receptacle at right (see 4).

5. Nearing completion: the outer walls are rising. The latrine is conveniently situated near the owner's house, which pleases the local doctor, because people used to build them much further away from their homes.

6. The finished latrine: its total building costs have come to less than $50—mostly on cement for the "vault" lining and the floor. The doctor reports that parasitical diseases among children have all but disappeared in Quang Ba since the latrines were introduced.

7. Harmless, odourless fertilizer: this is shovelled out after a minimum of 45 days through the door at the front. Human waste is a traditional fertilizer in this part of the world, and once reduced into this totally innocuous material, it retains all its nitrogen-rich properties without any risk to public health. UNICEF is now promoting this kind of latrine in Bangladesh, Egypt and Burma.

ROLE OF SULABH SHAUCHALAYA IN HUMAN WASTE MANAGEMENT
- AN INDIAN EXPERIENCE -

B. Pathak

"Sanitation is infinitely ennobling"
- Mahatma Gandhiji.

INTRODUCTION

Management of the exit of food is as important as its intake. Although this is a significant subject and can be discerned as a vital source of energy and higher production, this was never considered in India as much important as irrigation, transportation, electricity, etc. Delving into the past, we find that people in ancient India, due to easy availability of land, used open spaces for defecation. In our Vedic literature, we do not find any mention about particular design of latrine. In some of the literature - like the Code of Conduct, chapter of "Daivi Bhagwat Puran" - it was mentioned that one must ease away from dwelling apartments before sunrise by digging a hole in the earth and filling up the same with dry leaves, grass or soil, etc., before and after defecation. Our great economist, Kautilya, too touched upon the subject, but he was not able to give a clear idea about the types of latrines used for defecation.

There are references of baths and bathing in the Indus Valley civilization in India, but no details of the types are found. Till the 19th Century, no serious effort was made for a passionate search for an economical, safe and hygienic system - other than the sewerage and septic tank - for the proper disposal of human wastes. A random sampling reveals that over 70 percent of the urban population in India is bereft of the sewerage and septic tank facility. People use either service latrines, drains, roads or open spaces for defecation, which pollute the atmosphere and give birth to a number of diseases. The lamentable fact is that service latrines need the services of a particular section of the people to clean manually them and that section is treated as untouchable in our country.

While the origin of scavenging in India is still shrouded in mystery, researchers say that the sub-human practice of carrying nightsoil on head started after the Mughal invasion of India. Now we have come to know that the English and Americans were also acquainted with the system of scavenging. To quote Christopher Hamlin 91), who mentioned in his article "Sewage Waste or Resource" in the monthly journal "Scavenger" (July, 1982) :

> "Before the coming of the water closet, the sewage of European cities was disposed of by "scavengers", men who made nightly rounds of the cities (hence "nightsoil"), collect the contents of

> privy vaults and cart these to nearby farming areas. Often the farmer who brought his produce to the city returned home with a load of fertilisers. This was also a custom in America, where the widespread introduction of water closets and sewage systems occurred only late in the century. But by the mid-19th Century, the scavenging system broke down in many places. As cities grew, so did the supply of sewage. The laws of supply and demand prevailed and the bottom fell out of the nightsoil market. Farmers living near cities were saturated, while for those living further away, transportation costs were too high".

According to the survey of housing conditions conducted by the National Sample Survey in 1973-74 (2), a one-third of the urban population of 120 million in India - accounting for 40 millions - was still using service latrines, although the sewerage and septic tank systems came into existence in 1400 A.D. and 1460 A.D., respectively. Then where does the missing link lie? Certainly it is predominantly the economic constraints which have barred the mass adoption of sewerage and septic tank systems.

In India from 1930 onwards, a dynamic search for a safe and economical alternative to the sewerage and septic tank systems for the disposal of nightsoil started. Trench latrine, dug-well latrine and bore-hole latrines were tried, but failed. They could not satisfy the conditions laid down for a sanitary latrine. Then came the one-pit hand-flush water-seal latrine which was adopted in Gujarat, Kerala, Madras and Uttar Pradesh. In India, organisations like the All India Institute of Health & Hygiene, Calcutta; the Rockfeller Foundation; the National Environmental Engineering Research Institute, Nagpur; the Planning Research & Action, Lucknow (U.P.); Nagafgarh, Delhi; the Research-Cum-Action Institute, Poonamali; the Environmental Sanitation Project, Kerala; the Safai Vidyalaya, Gujarat; and international organisations like WHO, UNICEF, and UNDP, have played an important role in establishing the technology of hand-flush water-seal latrine in India.

In India, although some people talked about - and gave a concept to - the two-pit hand-flush water-seal latrine, at first they did not give due attention to it.

On the basis of the designs suggested by Wagner & Lanoix of WHO, the Ministry of Works & Housing, Government of India; the Harijan Sewak Sangh; the Gandhi Smarak Nidhi; and the National Gandhi Centenary Committee, India; the author developed a design of a two-pit hand-flush water-seal toilet which is popularly known as the "Sulabh Shauchalaya" in India. So far, about 80,000 Sulabh Shauchalayas have been installed in different states of India like Bihar, WEst Bengal, Tripura, Orissa and Uttar Pradesh. The installation of a large number of the two-pit hand-flush water-seal toilet is the contribution of the Sulabh International.

It was during the Gandhi Centenary year 1969 when, with a view to do away with the demeaning practice of manual handling of human excreta, the Government of Bihar, with the concurrence of the Ministry of Works & Housing, Government of India, directed all the local bodies of the State to convert all the existing dry latrines into water-flush latrines. The Stage Government provided the entire cost of construction by giving half of the amount as subsidy and the rest as loan to the house-owners. From 1967 to 1974, the State Government allotted a sum of Rs. 3.4 million to different local bodies for the conversion programme, but with no tangible results. In 1974, the State Government recognised the Sulabh Shauchalaya Sansthan, now the Sulabh International, and since then the programme has been widely acclaimed.

Sulabh Shauchalaya is a hand-flush water-seal compost toilet, or pour-flush toilet, which is cheaper in construction than the sewerage and septic tank systems. Even a petty amount of Rs. 100 can suffice for construction, which shows that it is equally good for rich and poor people. Only two litres of water is required to flush the nightsoil from the pan to the leaching pit. The design of the Sulabh Shauchalaya is such that the gases produced in the pits are absorbed by the soil. Hence, it is odourless and this cachet has led to the installation of the Sulabh Shauchalayas even in bedrooms and in the vicinity of kitchens. As the nightsoil in this system is converted into a good manure, any - even the house-owner himself - can clean the pit.

This striking feature of the system does not necessitate the services of scavengers. The manure obtained can be used in fields or kitchen gardens as fertilizer, which can increase the productivity of the field and correct the deficiencies of chemical fertilizers when put together. Moreover, it fulfills all the seven conditions for a sanitary latrine laid down by Wagner and Lanoix in their book 'Excreta Disposal for Rural Areas and Small Communities' which are as follows (3) :

1. The surface soil should not be contaminated.

2. There should be no contamination of ground water that may enter springs or wells.

3. There should be no contamination of surface water.

4. Excreta should not be accessible to flies or animals.

5. There should be no handling of fresh excreta; or, when this is indispensable, it should be kept to a strict minimum.

6. There should be freedom from odours or unsightly conditions.

7. The method used should be simple and inexpensive in construction and operation.

DESIGN OF THE SULABH SHAUCHALAYA

It would be useful to describe briefly the design of the Sulabh Shauchalaya which has been developed by the author (4). The Sulabh Shauchalaya mainly consists of a paltform, footrest, water seal, pan, drain, tanks and tank covers.

The platform, made of bricks in cement mortar, is 3 ft (900 mm) long, 3 ft (900 mm) wide, and about 1 ft (300 mm) above the ground level. Footrests, made of bricks in cement mortar, are placed slightly higher over the platform.

The maximum depth of the pan - which is 400 to 600 mm long, and its front and rear portions are circular having radii of about 50 mm and 125 mm, respectively - is up to 225 mm. The front depth is 12.5 mm and it slopes at an angle of 33° towards the point of opening at the bottom, which is about 75 mm in diameter. It is made of white cement, marble chips and marble dust in the proportion of 1:1:0.25. Its exposed surface is rubbed with carborandum stone.

The pan is fixed on a water-seal made of c-c-1:2:4 and has an opening of 75 mm in diameter. The water-seal is made in such a way that its passage is circular tapering at the bottom from both sides.

Our specially designed V-shaped water-seal plays a very important role as it requires only a minimum amount of water - say a litre or two - for flushing the excreta into the tank, and always keeps the pan and the surroundings completely odourless, thereby making the Sulabh Shauchalaya psychologically and practically acceptable to all.

There is a brick surface drain connecting the water-seal with tanks for the passage of sullage.

Two circular tanks, 100 mm in diameter and 1000 mm deep - or two rectangular tanks (825 mm x 750 mm), 1200 mm deep - are provided in the system. Circular tanks consume more space than the rectangular ones. The side walls of the tanks are provided with honey combs, while the bottom is left earth-based to facilitate the percolation of water. The honey comb can, however, be eliminated if the site conditions are favourable. Only one tank is put to use at a time while the other is kept closed. The second is opened for use only after the first gets filled up. While the second tank is in use, the human excreta get transformed into manure in the first tank. One pit is filled up in about 4-5 years when used daily by 5-6 persons. The tanks are covered with pre-cast RCC slabs with iron rings on the top for handling if and when needed.

Five typical designs have been enclosed to illustrate the functioning of the Sulabh Shauchalayas in different conditions.

FUNCTIONING OF THE SCHEME

Adoption in different soil conditions : The Sulabh Shauchalayas have been constructed in different types of soil ranging from laterite soil found in India : parts of WEst Bengal, Uttar Pradesh, Madhya Pradesh, Karnataka, Tamil Nadu, Orissa and Andhra Pradesh, to alluvial deposits spread over the Indo-Gangetic basin found in parts of Bihar, U.P., Assam and WEst Bengal. This system covers both the saline and alkaline soils and thus it has been found suitable in soils with appreciable variations in genetics and morphological, physical, chemical and biological characteristics associated with changing physiography, climate and vegetation.

IMPROVEMENT OF DESIGN

Honey combs in the side walls of the pits are provided primarily for distribution of earth pressure, absorption of gases and percolation of water through the side walls. In practice, it has been found that the pits function well even without the honey comb. Rather, it helps reduce the possibility of pollution and also in warding off the rat menace, without adversely affecting in any way the structural stability.

The next improvement is in the RCC slabs, used as tank covers. These are now being plastered on the inner surface with cement to prevent corrosion of the reinforcement in the slab. At the same time, the slabs become more durable.

The adopters of the system were apprehensive that the foundation would become weak due to the accumulation of water in sub-soil. But no such phenomenon has been noticed so far, even after the installation of 80,000 Sulabh Shauchalayas in various parts of the country in different soil and water-table conditions. In conditions of high humidity and temperature, the process of decomposition is accelerated which is conducive to the transformation of excreta into manure. But for the cleaning operation the summer season, in India, i.e., from March to May, is preferable to other seasons.

The Sulabh Shauchalaya has been found successful in household installations where the number of users is limited. In public conveniences, the system of leaching pits has not been functioning very satisfactorily because of a large number of users, which necessitates a frequent cleaning of the tanks. This experience of the author has been corroborated by the findings of Macdonal in 1952 (5), who observed that water-seal latrines should be constructed only in family installations and they were not suitable for use in public conveniences. Hence, for community latrines, we have now switched over to the septic tank system. Biogas has also been introduced of late in community latrine complexes.

FILLING OF PITS

It is envisaged that filling of leaching pits provided in the system would be in the order of 2 cft per person per year. Factual observations have now been made and the results in a nutshell are summarised below (4).

Period

The rate of filling is 1.2 cft per person per year in pits of 2-year old, which gradually reduces to 0.644 cft for pits which have been functioning efficiently for more than 5 years. The results are shown in Table 1.

Table 1. Average Rate of Filling of Pits of Different Age-Groups

Age of the pit	Average volume filled cft/person/year
2 years	1.214
3 years	1.036
4 years	0.854
5 years	0.829
More than 5 years	0.844

Soil Conditions

The type of soil has a significant effect on the rate of filling as shown by Table 2.

Table 2. Average Rate of Filling of Pits in Different Soil Conditions

Sl. No.	Age of the pit	Volume in cft per person/year				
		Soil Type 1	Soil Type 2	Soil Type 3	Soil Type 4	Soil Type 5
1.	2 years	1.333	1.138	1.024	-	0.915
2.	3 years	0.963	1.200	0.725	-	1.137
3.	4 years	0.820	0.744	0.733	1.023	1.010
4.	5 years	0.825	-	-	-	0.840
5.	More than 5 years	0.664	0.587	0.642	-	-

Type 1 : Clayer soil up to 1.8 m depth.
Type 2 : Light soil on top followed by clayey soil up to 1.8 m depth.
Type 3 : Heterogeneous soil up to 1.8 m depth.
Type 4 : Light soil up to 1.8 m depth.
Type 5 : Clayey soil at top followed by light soil up to 1.8 m depth.

In clayey soil, which is of semi-impervious nature, the percolation of water through the walls and the bottom of pits provided with pour-flush latrines is restricted, resulting in accumulation of sludge in pits at the initial stage. The volume filled per person per year, therefore, is higher in such areas. But with time, the soil is saturated with water and, due to its structural improvements on account of granulation in the presence of organic or decaying matter, the percolation is improved which is depicted by a reduction in the rate of filling. The behaviour of filling is different in sandy soils having a higher infiltration capacity. The depth of filling in the initial stage is low, with a tendency to increase after a year. After constant use, the sandy soil gets stabilised with the deposition of organic matter found in the nightsoil, resulting in a reduction in the rate of filling per person per year.

Water Table Conditions

Observations have been made at various depths ranging from 3 feet to 10 feet below the ground level. The results presented in Table 3 show that high water table has practically no significant effect on the rate of filling.

Table 3. Average Rate of Filling of Pits in Different Water-Table Conditions

Sl. No.	Water table category	Average volume filled (in cft per person/year)
1.	I (up to 0.9 m)	0.926
2.	II (1.2 m to 2.10 m)	0.931
3.	III (2.10 m to 3.00 m and below)	0.918

IMPLEMENTATION

The Sulabh International, a voluntary social organisation registered in 1970 under the Societies Registration Act 1860, carries out a house-to-house survey of dry latrines and motivates the house-owners to undertake the conversion of dry latrines into Sulabh Shauchalayas. It has a general body consisting of members having faith in the principle of result-oriented work including some workers of the organisation itself. The general body elects a managing committee, and the managing committee elects the office-bearers. The main objective of the organisation is to impress upon different municipal authorities the top-priority need for the implementation of the conversion programme. Half of the cost of the conversion is provided by the concerned government and the rest is given as loan to the house-owner through the municipal committee of the area concerned. The loan is repayable in easy installments.

The construction work is done by the Sulabh International on behalf of the beneficiaries so that the common people may not face difficulty. After completing, work guarantee cards are issued to the beneficiaries for a period of five years. Constructional defects, if any found within the guarantee period, are corrected free-of-charge. It also takes follow-up actions and supervises the functioning of the Sulabh Shauchalayas.

Thus the Sulabh International has succeeded in maintaining a rapport between the house-owners and municipal authorities before and after the introduction of the system. About 75,000 service latrines in the State of Bihar alone have already been converted into Sulabh Shauchalayas through this organisation.

The Sulabh Shauchalaya has made its dent in West Bengal where 5,000 service latrines have already been converted into Sulabh Shauchalayas and 50,000 more are likely to be converted within the next 2-3 years. In Andhra Pradesh and Orissa, nearly 1,000 Sulabh Shauchalayas have been constructed in each State. A similar endeavour is on in the States of Tripura, Uttar Pradesh, Madhya Pradesh, Haryana and Jammu and Kashmir.

This clearly indicates the system has been gaining ground gradually, but steadily, in various parts of the country.

PUBLIC LATRINES

The organisation constructs and maintains public latrines in various public places like railway stations, bus stands, market areas, hospitals and office compounds, etc. These public conveniences have become very popular among the masses, particularly the floating population, rickshaw pullers, residents of the towns, pavement dwellers and labour classes. The Sulabh International maintains round-the-clock public latrines, baths and urinals. The charge is very nominal, only 10 paise per head, for using the latrine and bath facilities. Women and children are exempted even from this nominal payment. Soap powder is provided to clean hands after using the toilet. In Patna alone, about 50,000 people are daily using the facilities. Similar facilities have been provided to the masses in several other towns of Bihar. Due to the fine performance of community Sulabh Shauchalayas, there has been a consistent demand for their construction in various parts of the country. In the metropolitan city of Calcutta, three public latrine and bath complexes comprising 60 seats have been constructed and about 3,000 persons are using this facility daily. More public conveniences are also being constructed there. Similar facilities have been provided in some other states also, like Orissa, Madhya Pradesh, Uttar Pradesh and karnataka.

The maintenance of the community toilets and baths on the pay-and-use system has caught the attention of the people of India, and now they are thinking of maintaining these community toilets and baths on the pattern developed by the Sulabh International.

LIBERATION OF SCAVENGERS

The Ministry of Home Affairs, Government of India, has taken up a programme of liberation of scavengers under the Protection of Civil Rights Act, 1955. The Home Ministry had given financial assistance to the Government of Bihar for converting all the existing dry latrines into Sulabh Shauchalayas in two towns of Bihar. Hundreds of scavengers have been freed from the demeaning practice of carrying nightsoil on head and provided alternative employments like cleaning of roads and drains. Attempts are being made to train them in other occupations like typing, nursing, driving, dairy farming, carpentry, etc. Three more towns of Bihar are also going to be declared free of scavengers by the end of this financial year, with the financial assistance of the Ministry of Home Affairs, Government of India.

Encouraged by the success achieved in Bihar, the Ministry has also taken up similar programmes in other States.

The Government of Bihar, with its own funds, has freed three more towns, and 12 more will be declared free of scavengers by the end of this financial year. The crusade is on to eradicate this evil practice of carrying nightsoil on head by the end of the Seventh Five-Year Plan in India.

EVALUATION

In 1979, a socio-economic survey (6) of the Sulabh Shauchalayas installed in the Ranchi Municipal area was conducted by the X'viers Institute of Social Services. The beneficiaries expressed their full satisfaction and most of them were convinced that the vulnerability of epidemic diseases had decreased considerably after the installation of the Sulabh Shauchalayas.

An evaluation study (7) recently made in Bihar by UNDP through Dr. Z. Ahmen - Professor and Head of the Department of Sociology, University of Patna, Bihar - reveals that the Sulabh Shauchalayas have been found, by and large, to function satisfactorily in different socio-economic, geological and hydrogeological conditions; and so the users were satisfied with the units installed in their premises. The scheme has been favoured by a cross-section of the society. It has been acceptable to people belonging to different castes, communities, religious groups and occupational categories. However, it has been found to be most popular among the weaker sections.

In his latest evaluation study (8), the author has made an attempt to find out the process of diffusion of this particular innovation. The adoption seems to have occurred in an orderly time sequence. There has been no concentration of the beneficiaries in a particular socio-economic group. However, it has found more acceptability among the old, poor and backward caste people. At the same time, the illiterate people have embraced the scheme.

Literacy also appears to be an important variable affecting the degree of innovativeness in the adoption of the Sulabh Shauchalaya scheme. In the process of diffusion, the change agent, as the representation of personal media of communication, has played the most vital role.

POLLUTION OF SOIL AND WATER

For a mass adoption of the Sulabh Shauchalaya system, the possibility of soil and water pollution arising from the leaching pits has been the subject of research. Dr. T.R. Bhaskaran and Sampathkumaran have made the following observations (9) :

"If the soil at the bottom of the pit is composed of clay or sand with an effective size of 2 mm or less and the velocity of flow of ground water is up to 3 ft per day, the latrine can be placed even as close as 20 ft from the well. If the soil is coarser than 0.2 mm but less than 0.3 mm of effective size, the latrine should be placed 50 ft away from the well. In areas where the soil composition is coarser than 0.3 mm of effective size, and the subsoil velocity is greater than 3 ft per day, a careful study of the conditions must be made in deciding the distance between the latrine and the well. In such extreme cases, 1 ft to 2 ft envelop of fine sand of effective size 0.2 mm can be placed all round the latrine pit and at the bottom to protect the ground water pollution resulting from the flow from the latrine".

The recent investigations made by UNDP in Gujarat, Bihar and Tamil Nadu show that there is no evidence of bacterial pollution in this system in alluvial soils having predominance of silt and clay and low range of probability, even in wells 8 m away from the leaching pits. In rocky regions with rock outcrops where the overlying strata is coarse and highly permeable, an envelop of fine sand around the leaching pits and about 0.3 m below can be used as a protective measure against contamination.

INTRODUCTION OF NIGHTSOIL BIOGAS PLANT

The next milestone in the pioneering career of the Sulabh International is its organising aspect in the field of improvement in the living standard of people by providing a solution to the problem of fuel shortage with the provision of an integrated scheme of nightsoil digester system with facilities of collection and utilisation of gas and digested sludge. The work in this connection is in full swing and three nightsoil biogas plants are already functioning well in Patna, the capital city of Bihar.

Two of them are of lower capacity, i.e. of 100 cft, each designed for a family of 5-10 persons. The bigger one, having a capacity of about 2000 cft, has been installed in a public Sulabh Shauchalaya complex which is used by 1000-1500 persons a day. Thus the nightsoil is available enough to feed the biogas plant.

In this way, the Sulabh Shauchalaya scheme foresees more and more work in the total environment within which the masses live. Certainly, the biggest intended and manifest consequence of the scheme is the eclipse of dry latrines prevalent for a considerable period of time. The Sulabh Shauchalaya appears to be capable of catering to the needs of the biggest chunk of the masses. This holds a wide range of potentials to solve the problem of human waste removal. The system works creatively as a waste disposal system; and energy, particularly in form of biogas, is evolved. Necessity is the mother of invention and the environmental necessities, which are so apparent among the masses, will give rise to inventions which will definitely help meet the needs of mankind and, at the same time, have a significance for the larger society.

CONCLUSION

The author believes that his organisation is doing a yeomen's service quite on a par with the compendium of the letter of the Minister of parliamentary Affairs and Works and Housing, Govt. of India, which was received by the Chief Minister of Bihar and read :

> "I am extremely happy to know that your State Government, in collaboration with the Sulabh International, has been successfully implementing the low-cost sanitation programme in Bihar and that your community latrines are a model for other States to follow".

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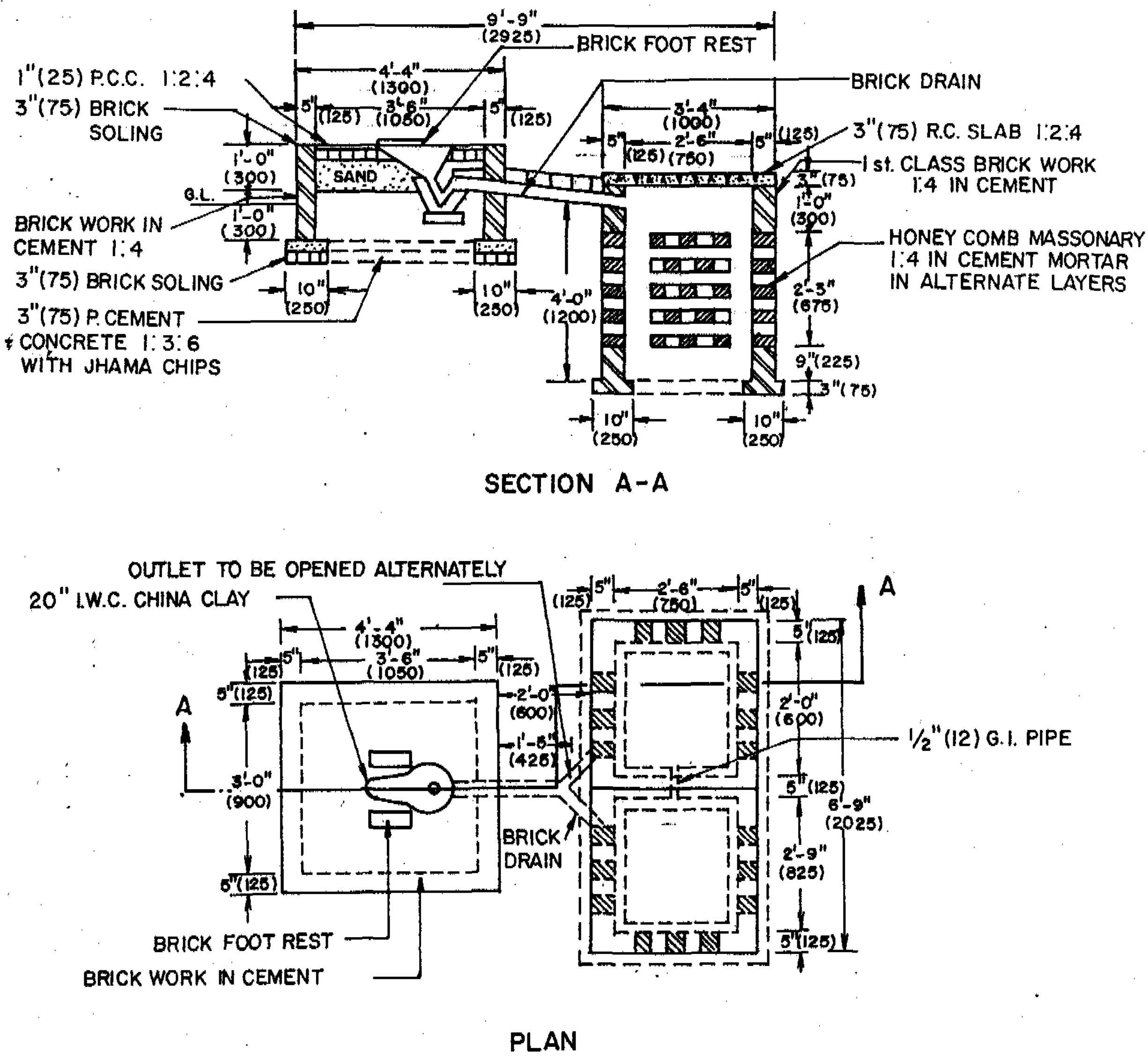
Appendix A

DESIGNS OF THE SULABH SHAUCHALAYA



(All Dimensions in the Bracket are Millimeters)

Figure 1 Design of Sulabh Shauchalaya with Rectangular Tank

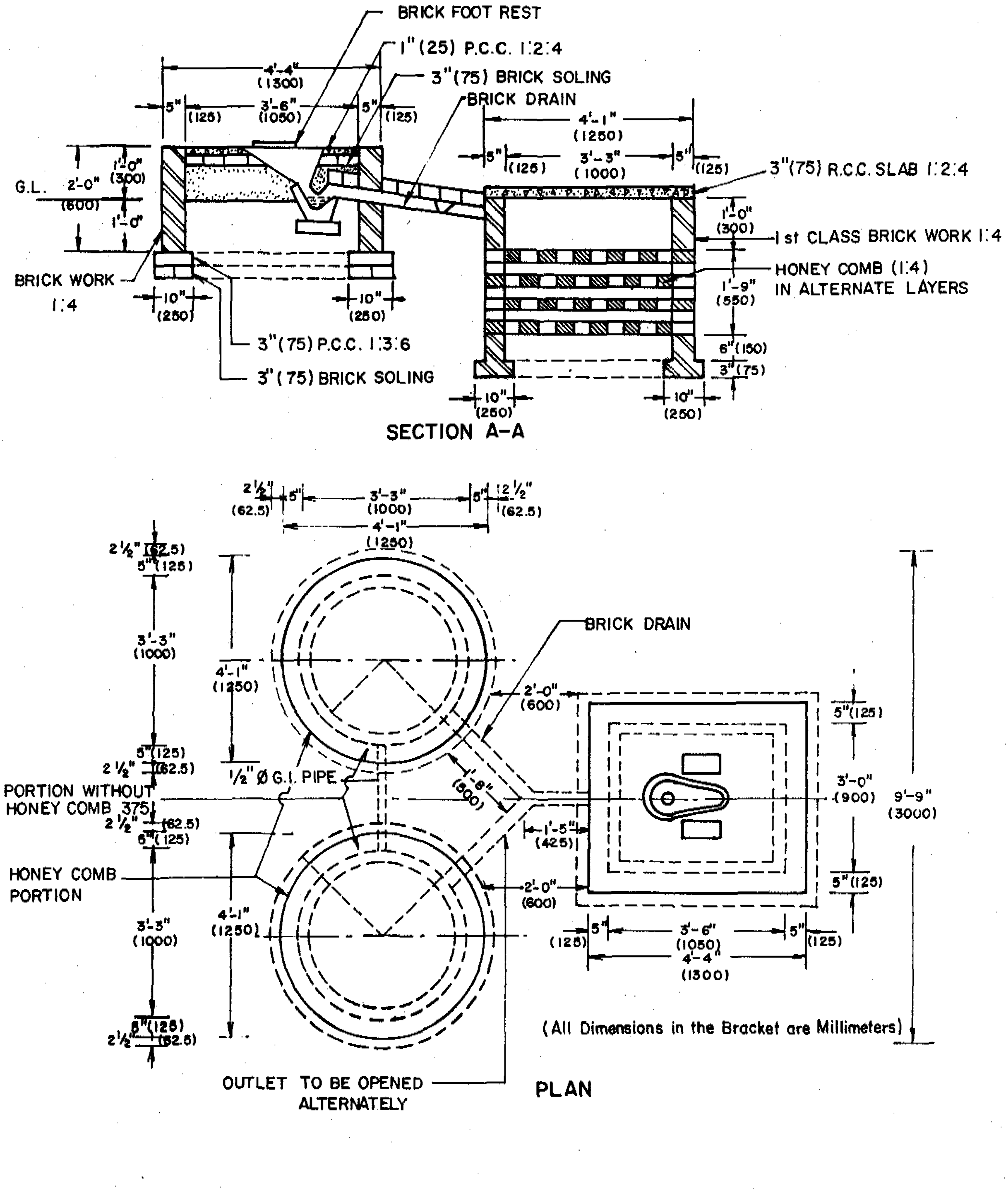


Figure 2 Design of Sulabh Shauchalaya with Circular Tank

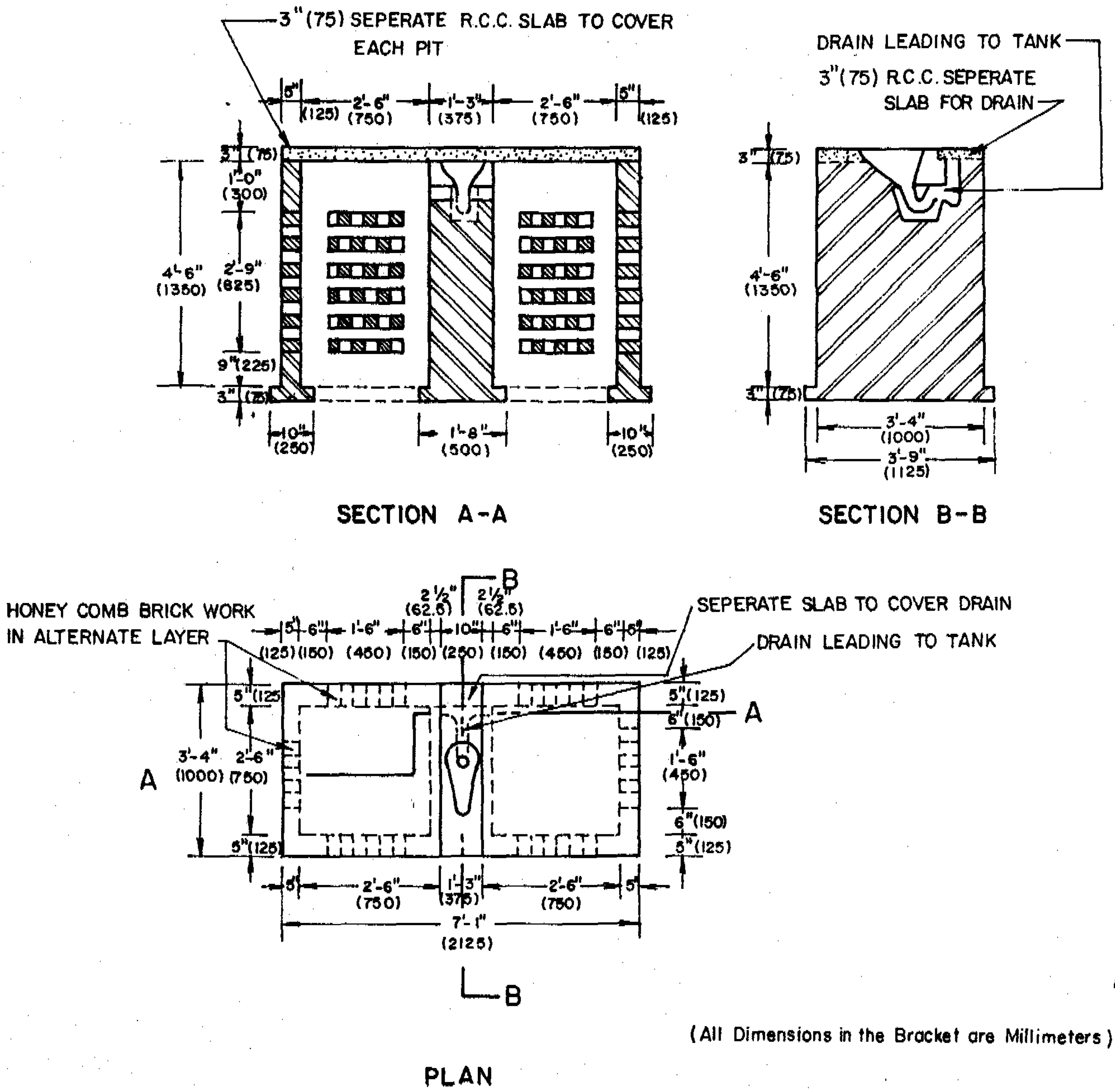


Figure 3 Design of Sulabh Shauchalaya in Limited Space

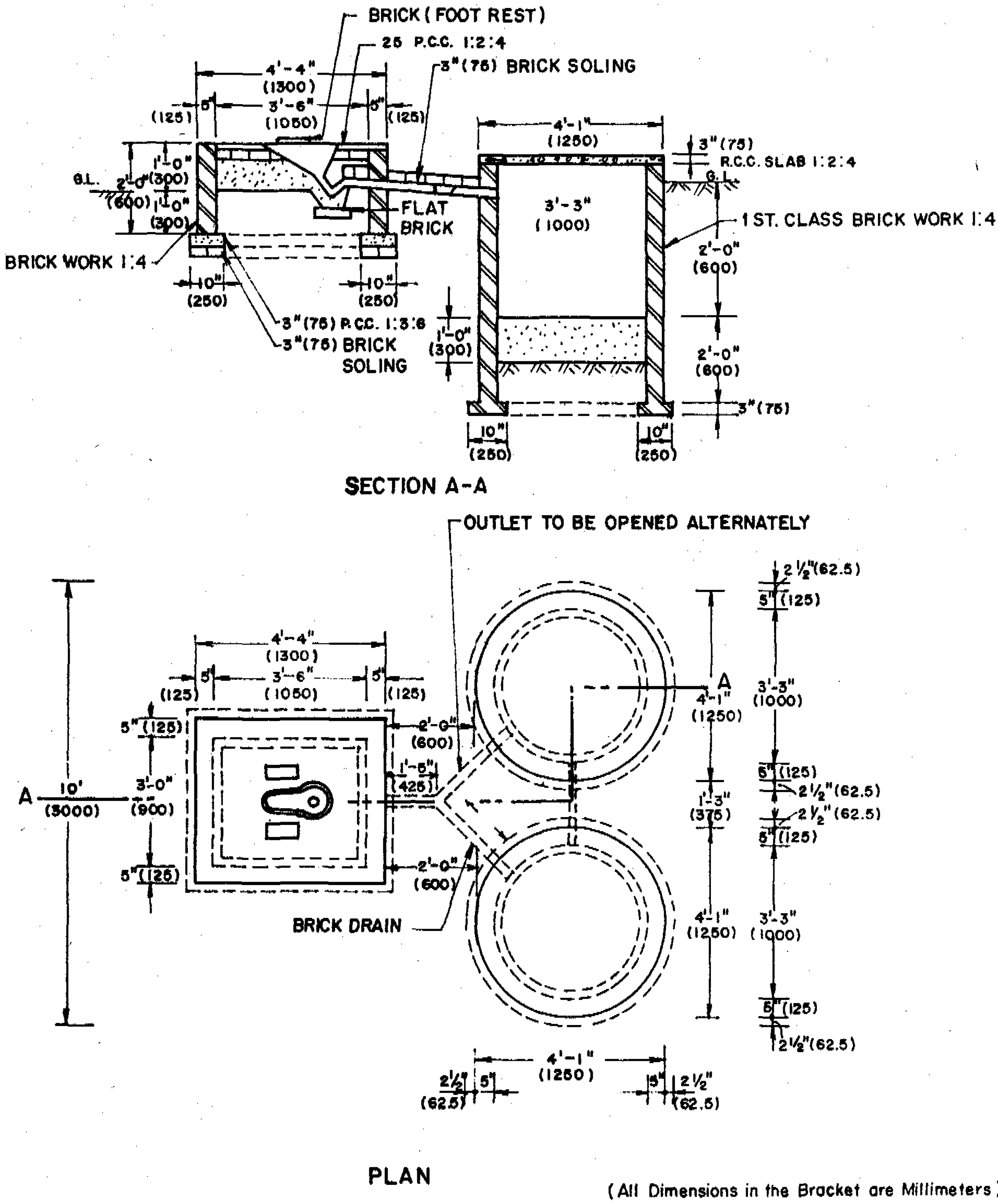


Figure 4 Design of Sulabh Shauchalaya Suitable near Water Source

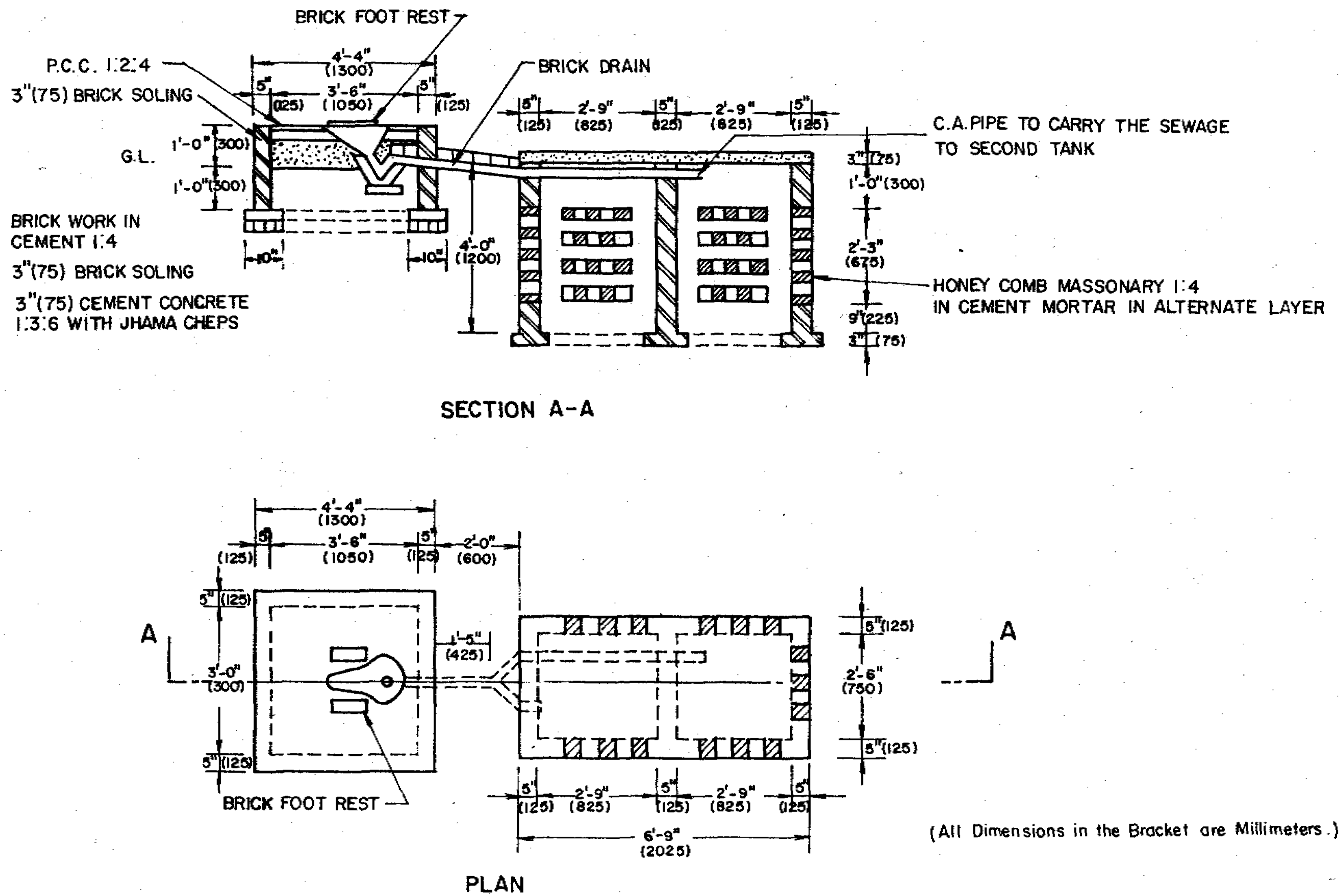


Figure 5 Design of Sulabh Shauchalaya with Rectangular Tank Provided with C.A. Pipe to Carry the Sewage

SANITATION ASPECTS IN SARVODAYA PROJECTS
IN SRI LANKA

Weera Jinadasa

I wish to express my sincere thanks to the Organizing Committee for inviting me to be present at this Seminar, the theme of which is of profound importance especially to those of us living in the Third World. In a world today where medical science and all other sciences have reached almost the summit of advancement, it is insettling to hear of a large percentage of children not living to see their fifth birthday, every of them a victim of contaminated diseases which is contacted through - call it whatever one may deem it fit irresponsible disposal of human waste or any other wastes of most we are aware for that matter. It is my intention here not to provide statistics and analysis of the so-called diseases and their fatalities, but to create a humble concensus for practical actions to completely eradicate or wipe off such fatalities, and this is the fundamental goal of human rights as embodied in the UN Charter. In a meaningful way, I feel that this Seminar with honesty of purpose and honesty of conduct has that ideal.

In the second instance, I would like to enumerate here that the subject has appeals to me and has a special significance as long age I have chosen it as my career. Briefly, with your permission to speak in a personal note that during the period 1961-1976, while I was in the United Kingdom working as a Technical Assistant for a local authority where my last assignment as Senior Assistant Engineer to a District Council was four-fold by main tasks and pre-occupations :

1. To make preliminary house-to-house inspection of existing house drainage systems;

2. To design technically and environmentally acceptable safe disposal methods;

3. To satisfy the Central Government Authorities the needs in order to get financial support; and

4. To satisfy river authorities and other statutory bodies in discharging final effluents.

Back in Sri Lanka with Sarvodaya since 1976, I faced a completely new set of circumstances and problems in a completely fresh social and economic milieu, driven to desperation with exponential population growth and the inherent consequential factors. Some of the main features of my new role with Sarvodaya and Community on the topic of waste management are :

1. To create public opinion and awareness among local peasants on the importance and the imperative need for the safe disposal of human wastes of all types and origins by showing the vicious circle of the bug theory.

2. To design, with the local participation, safe (but not the best) possible disposal systems, using local available skills and materials according to circumstances;

3. To promote conditions, co-ordinating services and activities with trained Sarvodaya Volunteers on sanitation at the village level; and

4. To integrate the sanitation program with that of other basic human needs, e.g., food, clothing, shelter, water, etc.

To contrast a little of my new role with that of the same role I was assigned in Europe, some very differentiating circumstances flash back to my mind. I am to state some here, in Europe at private, governmental, institutional and university levels there is always continuing research on on-going process which is pursued in this discipline always with an eye for seeking and gaining improvements. So I always had access to a wide-ranging choice of materials - for example, host of new treatment processes, varied choices of material and many techniques for adoption - to complement and supplement my tasks. Another predominant factor was a good communicating link-up with an easy and fast access to all sorts of information. Furthermore, the statutory regulations are such that in the United Kingdom, The Public Health Act - Section 15, has given wide powers for municipal engineers and allied officers to enforce the law embodying the Act and force the public to accept them, explaining to them that any impringement or violation would cause health hazards detrimental to their own well-being and society as a whole. As a case in point, the response and co-operation from the public is excellent. The various institutions, private organisations, engineering and manufacturing firms too play a worthwhile supporting role in providing material needs and technical needs for waste management as their tasks are well identified. Hence, all are very easy and pleasant, from personnel to finance, planning, designing, implementation and maintenance, much easier and pleasant.

In my new task with Sarvodaya and the public of Sri Lanka, I am facing new dimensions in the related fields of human waste management. Principally such lethargy and apathy are seen around with a sense of indifference, and this is coupled with ignorance over the whole vital field of public health care. People take it for granted that it is another human chore least to be concerned with once released from the burden and act. Hence, a large percentage of Sri Lanka peasants have much to learn in these fields. So back here the same tasks are complex. In addition, a series of bottlenecks and breakdowns too thwart and hamper the efficient handling of related criteria. Much of the planned work remains stalled and shelved because :

(a) there is no whatsoever research on the on-going problems of waste and waste management;

(b) the plan and design for a task are not identified at all to suit specific local conditions;

(c) the choice of material and information is limited;

(d) the communication links are poor; and

(e) there are in-built restrictions on finance and personnel and bureaucratic controls.

Also, the backlog of accumulations left unattended is alarming. To emphasise a point here, a single public health inspector has to cover more than 200-300 villages - an area physically too large to cope with. Here, I feel the Sarvodaya 'Shramadana Ideal' Voluntarism and the gift of labour as it implies can only come to the rescue. As the old farmers adage goes 'Go to the people, learn from them, try to built from what they have, at the end they will say we did it'. There is more practicality and rationale in this approach if we are to move forward from stagnancy to progress on sanitation and health.

With the above presentation as I am entrusted with the task of speaking to you on the 'Sanitation Aspect of Sarvodaya in Sri Lanka', I think it is my foremost duty of briefly give this distinguished gathering a general overview of the Sarvodaya Movement of Sri Lanka. It is not my intention to take your time off by dealing in-depth with the origin, theory, methodology and practices of the Sarvodaya Movement. I simply have a duty to make you understand our most successful approach and experience during the last quarter century in our struggle for the total development of man and his environment. The Sarvodaya Shramadana Movement (Sarvodaya: Awakening of all, Shramadana: Sharing of Labour; a Movement dedicated to the awakening of all 'Sarvodaya' through gift of time, thought and energy 'Shramadana') is an indigenous effort by the people of Sri Lanka, particularly in rural areas, to bring about self-development. It draws up on a cultural and philosophical base familiar to the people of the country. It is non-power seeking and non-party political in nature, and devotes its entire efforts towards the development of man and society by non-violent methods of change.

Sarvodaya Sharmadana believes that the development of man - as a family, village or urban group member - should be the foundation on which national development activities and efforts are built. Therefore, all the programs and projects of the Movement have built - in spiritual cum cultural cum social elements - as a pre-requisite to material development.

All Sarvodaya programmes are originated from the grass-root level and extend upwards with the self-reliant and co-operative effort from the immediate beneficiaries of the programme. The Movement has thus succeeded in achieving a national character and becoming the largest non-governmental voluntary organisation in the country today with the following messages to the human being : Paurushodaya (Personality awakening); to the village: Gramodaya (Village re-awakening), Deshodaya (National awakening) and to the world: Vishvodaya (World awakening).

The first ten years of the Movement, 1958-1968, were devoted entirely to Shramadana (Sharing of Labour) camps, which were organised in all parts of the country, enabling hundreds of people - including school children - to participate in labour-intensive village reconstruction projects, resulting in direct benefits to the people. However, the major objectives of the organisers of the Sarvodaya Shramadana Movement during this period were as follows :

1. To exploit - by concrete development actions - the development potential of rural people through self-help and self-reliance;

2. To bring about a general recognition regarding the value of utilising labour resources, which the people are voluntarily prepared to give for the development of the nation;

3. To evolve in the country a grass-root development leadership which is inspired by the people's traditional and cultural values, and to gain knowledge through participatory experience in the science of village development;

4. To pave the way for development theory and practice, in which an integrated approach is made towards the development of the human person, of his or her community, nation and the world. This may be termed a 'Non-Violent Revolutionary Movement of Changing Man and Society'.

The second ten years of the Movement began with the 100-village development scheme, which was later extended to a 1,000-village development scheme. During this phase of activities of the Movement, strategies for people's participation in self-development (such as Shramadana Camps, family gatherings, group formation at grass-roots, international village-to-village link-up programmes, self-employment schemes and development education programmes, etc.) were developed. Through such methods, an integrated approach was evolved by which changes in ideas and attitudes, in methods and techniques in village development, and instructural life at the grass-root are brought about.

When we study the evolution of the Movement during the past twenty four years, we can now easily discern, step by step, individuals, villages, social leaders such as Buddhist monks, etc., joined in the efforts of the Movement and played an active role, thus resulting in the establishment of the existing institutionalised formations such as the Development Educational Institutes. Presently in the 24 districts of Sri Lanka, 24 Sarvodaya Development Education Institutes are at built-up stages, 14 of which have already completed and established. There are also 170 Gramodaya Centres spanning the Island, which means that every electorate in Sri Lanka is represented with one Gramodaya Centre. In addition to the above-mentioned regional centres, at present there are more than 3,000 children's services village centres spanning nearly 5,000 villages (i.e. approximately 15% of the national population). These centres are run by the Sarvodaya trained local staff and maintained by local village mothers' groups. These are our most vital links for the promotion of health and sanitation in the villages. All programs at these centres have spiritual, moral, educational, social and economic elements integrated into a total approach to the development of man's personality and his social situation.

From what have been said so far, it should be quite apparent that the 'Sarvodaya Serviced Villages' do not face most of the common barriers to an effective sanitation programme which the rest of the country in general is faced with. Some of the barriers are concerned with :

1. Lack of knowledge on the etiology of diseases and failure to realise the need to stop fecal-born diseases through proper conducts and right attitudes;

2. The design, construction and maintenance of safe human waste disposal systems; and

3. Manpower requirements to built pit latrines.

However, constraints are also encountered in the implementation of sanitation projects in the villages. Some major ones are ;

1. Lack of financial support for the very basic essential building materials for construction of a safe squatting slab, e.g. cement;

2. Lack of established governmental or institutional research in this field with a regional orientation to give us new leads to update our techniques;

3. Lack of co-ordination, solidarity activity and good response from local governmental bodies to promote health education and planning at grass-root levels;

4. Lack of an effective statutory act covering public health hazards and the laxity in the enforcement of the existing law for sympathetic consideration by the authorities;

5. Budgetory expenditure and state allocation being more oriented to curative functions in the field of health and health care rather than in the more important functional area of taking effective means for disease prevention.

Much has been spoken of human waste management over the last quarter of the century, which is also the life span of my organisation 'Sarvodaya Movement of Sri Lanka'. Numerous proposals, theories, technicalities have arrived from time to time. Similarly, debates, discussions, seminars, workshops and conferences have also taken place from time to time within this period. While emphasising here that in a way all of them have been contributory to an extent - for example, in the areas of adding new vistas of knowledge on the subject and most importantly in the function of 'Consciousness Raising' in a vital aspect effecting human living - with all humbleness, I should say here that the Sarvodaya Experience clearly points out that little has been achieved and much remains to be achieved. It is also pointless now here to lay the blame for that matter on anybody concerned, person-wise or institution-wise. It is my hope that this Seminar, through its deliberations, moves forward with zeal and courage to learn from whatever past mistakes we have dwelled upon and gained experience thereof, and takes right steps in an integrated approach to bring right solutions to problems we are facing today in the sanitary aspect of human waste management for a qualitative life style for all.

In conclusion, may I quote from the founding member and present President of the Sarvodaya Movement, Dr. A.T. Ariyaratne, a word of 'Integrated Approach' which I referred to above :

> "As far as the Sarvodaya Shramadana Movement is concerned, its most apparent characteristics is its mass nature. This eliminates a weakness that most government programmes have. People cultivate a belonging to what happens around them with their participation. An intelligent and democratic governmental programme can easily incorporate itself into this mass approach to self-development without trying to dominate it. Similarly, even international establishments - I would not even rule out the World Bank or even UNDP - can integrate themselves into a people's programme of this nature if they truly believe in what they have publicly pronounced as development precepts.

TOWARDS A SANITATION MASTER PLAN: A BRIEF DISCUSSION ON THE METHODS OF EXCRETA DISPOSAL IN ADDIS ABABA

Kassaye Betre

Civil Engineer
Housing and Savings Bank
Addis Ababa, Ethiopia

INTRODUCTION

Ethiopia, being a developing country, is faced with a problem of improving her overall environmental sanitation where mortality and morbidity rates rank high among the people. Lack of adequate control of human wastes are the major causes of diseases. Ethiopia, being a member of the international community, government institutions and agencies, have realized her share of responsibilities in the International Drinking Water and Sanitation Decade. The Addis Ababa Water Supply and Sewerage, Authority, the Urban Water Supply and Sewerage, and the Ministry of Public Health are the major institutions responsible for implementing the programmes on water supply and sanitation. The Ministry of Urban Development and Housing, and the Housing and Savings Bank are the institutions responsible for housing provision.

In lieu of the responsibilities entrusted to the institutions, the Addis Ababa Water Supply and Sewerage Authority has been actively involved in providing potable water to a majority of the city residents, but equal effort is not allotted for a better excreta disposal method, particularly to the urban low-income sector of the population. The authorities have recently conducted a survey on the performance of the existing excreta disposal systems with more emphasis on low-cost sanitation technology.

This paper is more or less based on the survey conducted by the authorities. It tries to discuss the excreta disposal methods in Addis Ababa from the viewpoints of affordability and acceptability by the low-income majority. Some of the proposals and views of this paper might not reflect the views of the concerned authorities mentioned above.

BACKGROUND INFORMATION

Ethiopia is situated in north eastern Africa, along the Equator, and covers an area of 1,225,000 km². The altitude varies from 90 m below sea level at the depression to 4,550 m at the peak of highest mountain. Climatic conditions vary from hot desert to cold mountains. The total population of the country is estimated at 31,065,000 in July 1980 (*). The population is expected to reach 41.1 and 54.6 million in 1990 and in 2000, respectively.

Addis Ababa, the capital city, is situated in the middle of the country and covers an area of 218 km². Its altitudes vary from 2,200 to 2,700 m above sea level, and its annual rainfall is on an average 1,200 m. The city population is estimated to be 1.2 million in 1980, with an annual growth rate of 6%.

HOUSING AND SANITATION

Before the Ethiopian Revolution, most of urban land and houses were owned by individuals or private organizations. The transfer of the ownership of the urban land and extra houses from the private sector to the government has entitled all Ethiopians to own urban land and build their own houses in accordance with the urban development master plan. The total number of housing units in Addis Ababa is estimated to be over 213,000, 92% of which are of wood and chicka (mud houses). 10.5% of the population are found to live in shared housing units, with an average of 4.5 person per household. 62% of houses for rent, and others are under private ownership. The majority of the population who live in squatters or slums use communal dry pit latrines or have no toilet facilities. Tables 1 and 2 show statistics on water supply and construction materials of toilet floor, respectively, of different toilet facilities in housing units.

The Ministry of Urban Development and Housing encourages self-help construction by providing technical assistance for co-operatives of the low-income sector of the population. Effort is being given to relocate people from squatters to planned, serviced, low-cost settlements.

The Housing and Savings Bank has granted loans repayable through long-term installments for individuals, co-operatives and state projects - from single dwelling units to big villas - depending on their loan capacities. Proper disposal of excreta, being one of the important element in housing construction, is closely inspected by the bank engineers. It is understood by both parties that a water supply connection, a properly built cesspool

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* Population Census has never been conducted

Table 1. Manpower and Housing Sample Survey – Addis Ababa – Dec. 1976
Housing Units by Toilet Facilities and Water Supply

Toilet Facilities	Water Supply Piped Water					Total
	Inside Housing Unit	Within Compound	Outside Compound	Coupon Purchase	Other	
Dry pit, private	3462	17603	4041	1923	1107	28129
Dry pit, common	2183	67843	17132	27296	6458	120912
Flush, private	4212	2998	–	–	–	7210
Flush, common	659	1960	224	–	226	3069
None	868	9249	14837	16017	11534	52505
Other	227	430	225	644	435	1961
Total	11601	100086	36459	45880	19760	213786

Table 2. Manpower and Housing Sample Survey – Addis Ababa – Dec. 1976
Housing Units by Toilet Facilities and Materials Used
in the Construction of Floor

Toilet Facilities	Material Used for Floor					Total
	Earthen	Wood	Cement	Tiles	Other	
Dry pit, private	9800	13014	1395	1094	2826	28129
Dry pit, common	76448	38271	3774	1547	872	120912
Flush, private	426	4317	1590	217	660	7210
Flush, common	224	1082	675	1088	–	3069
None	48400	3032	209	–	864	52505
Other	1084	877	–	–	–	1961
Total	136382	58593	7643	3946	5222	213786

or septic tank, and an electric line are among the specifications in house building that make a house habitable.

STATE OF PUBLIC HEALTH

In Ethiopia, as in other developing countries, water-associated diseases rank high among the communicable diseases. According to a public health experts report, most health problems can be solved if measures are taken to improve the environment. The problem has greatly affected the densely populated squatters of the low-income majority. Table 3 lists all diagnosed illnesses from 3 major hospitals and 14 clinics in Addis Ababa during September 1977 to August 1980. From this Table, it can be seen that 23.0% of diagnoses are water- or food-associated diseases.

Table 3. Food and Water-Associated Diseases in Addis Ababa

No.	Diagnosis	1970 E.C. Sept. 1977 – Aug. 1978		1971 E.C. Sept. 1978 – Aug. 1979		1972 E.C. Sept. 1979 – Aug. 1980	
		Number	%	Number	%	Number	%
	All Diagnoses	137,972	100.00	250,669	100.00	260,186	100.00
1.	All types of dysentery	3,180	2.31	11,603	4.6	12,991	5.00
2.	Infectious hepatits	100	0.07	370	0.15	173	0.07
3.	All types of schisto - somiasis	99	0.07	157	0.06	14	0.01
4.	Hook worm (more soil-	75	0.05	185	0.07	95	0.04
5.	All types of helminthic infectations	12,269	8.89	28,894	11.53	26,439	10.16
6.	Gastro-enteritis	16,055	11.64	33,580	13.40	28,469	10.94
	Total of six diseases	31,778	23.03	74,789	29.84	68,181	26.22

* *E.C. = Ethiopian Calender*

SOCIO-POLITICAL SET-UP

The dominant socio-political organization governing the city of Addis Ababa is the "Urban Dwellers Association" or the "Kebeles". The city is divided into 25 highers and 289 Kebeles, and is run by the city council. The number of housing stocks and number of residents are registered in all Kebeles. Houses whose rents are less than US$ 50.00 are under the administration of the Kebeles. They are responsible for the collection or rents, maintenance and improvement works.

The Kebeles has much influence among the people, and it is capable of organizing the masses for any large-scale community activities, like cleaning ditches, planting trees, conducting literacy campaign, building public toilets, running schools and shops, etc. In general, the Kebeles plays an important role in the socio-political life of the urban dwellers.

WATER-BORNE SANITATION

The New Sewerage System

Most of the urban centres in Ethiopia have no sewerage system. Phase 1 construction of the new sanitary sewers and treatment plants for the city is to be completed, and it is assumed to be necessary due to the following major reasons :

1. Pollution of streams and rivers, as the result of discharging raw sewage or effluents from septic tanks of industrial and commercial buildings, has brought hazard to the down-stream users for domestic purposes.

2. Main rivers, which are used as major water sources for agricultural development and cattle breading, are being heavily polluted by toxic industrial wastes.

3. During dry seasons, streams become a severe environmental hazard when they are inadequate to dilute the waste discharged.

4. In big institutions, high rising buildings, hospitals and hotels, which generate large amounts of wastes, septic tanks are ineffective and the effluents are discharged to storm sewers or streams.

5. Modern residential units which use flush toilets have the problem of leaching effluent from their septic tanks or cesspools due to the impermeability of the soil. Effluents overflow and run on the surface of the ground, causing health hazard to the surrounding habitants.

Based on the above reasons, it was realized the importance of a sewerage system combined with other low-cost sanitation options to serve best the city residents.

Stage I of the construction, which comprises of a treatment plant and interceptors, is near completion. The water-borne sewage is to be treated by a series of oxidation ponds preceded by screens and grit chamber and followed by digestion tanks and drying beds. Nightsoil is to be delivered by vacuum trucks to the plant. The treatment plant is designed to serve 110,000 inhabitants and, later on, will be converted to aerated lagoons to serve a population of 200,000. The plant, including 50 km length of main lines and tributaries, will cost US$ 21 million.

Stage II, whose construction contract has not been awarded, comprises Eastern interceptors and miscellaneous house connection sewers.

The sewerage system has become a financial burden to the state and the project has the following drawbacks :

a) The project cannot serve the majority of the population. It is estimated to serve only 1/6 of the urban population.

b) It is meant for commercial, public, industrial building and upper-class villas, and cannot reach the worst problem areas.

c) The total cost is exorbitantly high.

d) The poor will not benefit from the project.

e) The economic cost cannot be recovered by the beneficiaries.

f) The majority of chicka houses (mud houses) have no plumbing installation to provide water required to flush solids to the sewers.

On the above ground, a low-cost sanitation alternative is found indispensable to the majority urban population.

Septic Tanks

Septic tanks are observed in most big residential areas, schools, and commercial and public buildings. There is no standard design for septic tanks in the city. A few of them use leaching fields or seepage pits for the soak-away of the effluent. Septic tanks built in places where the soil is permeable function properly. Since a city-wide percolation test has not yet been properly done, the effluents of the septic tanks - which were built without the knowledge of soil permeability - overflow and spread on the surface of the ground. The effluents from commercial and public buildings are mostly connected to storm sewers.

Plot areas for residential units (*) are not sufficient to dig seepage pits or to form leaching fields. As a result, septic tanks function like cesspools and need frequent desludging by vacuum trucks (one to two times a year). However, septic tanks are affordable to the upper-class residential units.

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* A maximum of 500 m^2/housing unit

Public Toilets

The Municipality of Addis Ababa (the City Council) is responsible for the construction and maintenance of public toilets. There are 50 public toilets in the city where 16 were built 15 years ago and the rest are relatively new. They are located at places of public congregations. The facilities are generally kept open from 6 a.m. to 10 p.m. They are staffed with municipal employees during hours of operation. The toilets are made of brick walls of concrete structure with corrugated iron sheets or concrete roofs and a septic tank, which is frequently desludged by vacuum trucks (an average of once a month). They are equipped with flash tanks and Turkish-type squatting plates. All the cast iron flash tanks are enclosed inside a metal grill which prevents the plumbing fittings from being stolen.

As recently observed, most of the public toilets are adequately clean and properly functioning as long as there is a water supply.

The general set up of a toilet consists of :

1. a set of water closet for males, from 4 to 8 in number, all enclosed in metal stall;

2. a set of water closet for females, from 2 to 4 in number, all enclosed in metal stall;

3. wash basins of ceramic or precast concrete for males, from 1-6 in number;

4. not more than 2 wash basins for females;

5. urinal troughs for males, from 4 to 8 units; and sometimes

6. a set of shawers and deep sinks for washing clothes.

The multi-purpose facilities with shawers and deep sinks are small in number and are usually built at spots where people were previously using polluted streams for cleaning or washing purposes. Commonly a few of the old designs are directly connected to streams, whereas the new ones have septic tanks. A public toilet serves 150-600 users per day. The heavily used toilets are those located at shopping centres. They are found to serve mostly :

a) people who live in the vicinity but do not have their own toilets or have a filthy communal toilet;

b) passers-by who come for shopping;

c) people who wait at bus terminals; and

d) people who gather to attend rallies or other services.

Typical public toilet designs are shown in Figures 1 & 2. In the design shown in Figure 2, the cast iron water closet is hidden from the users sight. It is covered with iron sheet supported on a 10-cm thick reinforced concrete slab. Only a rope or wire is left for flushing.

The toilet in Figure 1 costs more than 35,000 birr (US$ 17,500), whereas the one in Figure 2 costs more than 20,000 birr (US$ 7,500). The costs are based on the contractors' unit rates.

SANITATION WITHOUT WATER

As figured in Table 1, the majority at the low-income sector of the population - particularly those residing in the slums or squatters - have no house water connections and hence use disposal methods that operate without water carriage, namely the dry pit latrine.

Most of the pit latrines cannot meet minimal standards from the viewpoints of providing protection of the public health, comfort or safety to the patrons. They are unclean, some are full, yet they continue to be in use while waiting for vacuum trucks to be emptied. Most common latrines suffer severely due to lack of responsibilities by the sharing families. These are common scene in the squatters or slums.

Dry Pit Latrines

Dry pit latrines are the cheapest, affordable and appropriate to the majority low-income sector, provided major improvements are made to the existing latrines. For the ventilated improved pit latrine, the following improvements are proposed :

1. The pit is vented to reduce the odor.

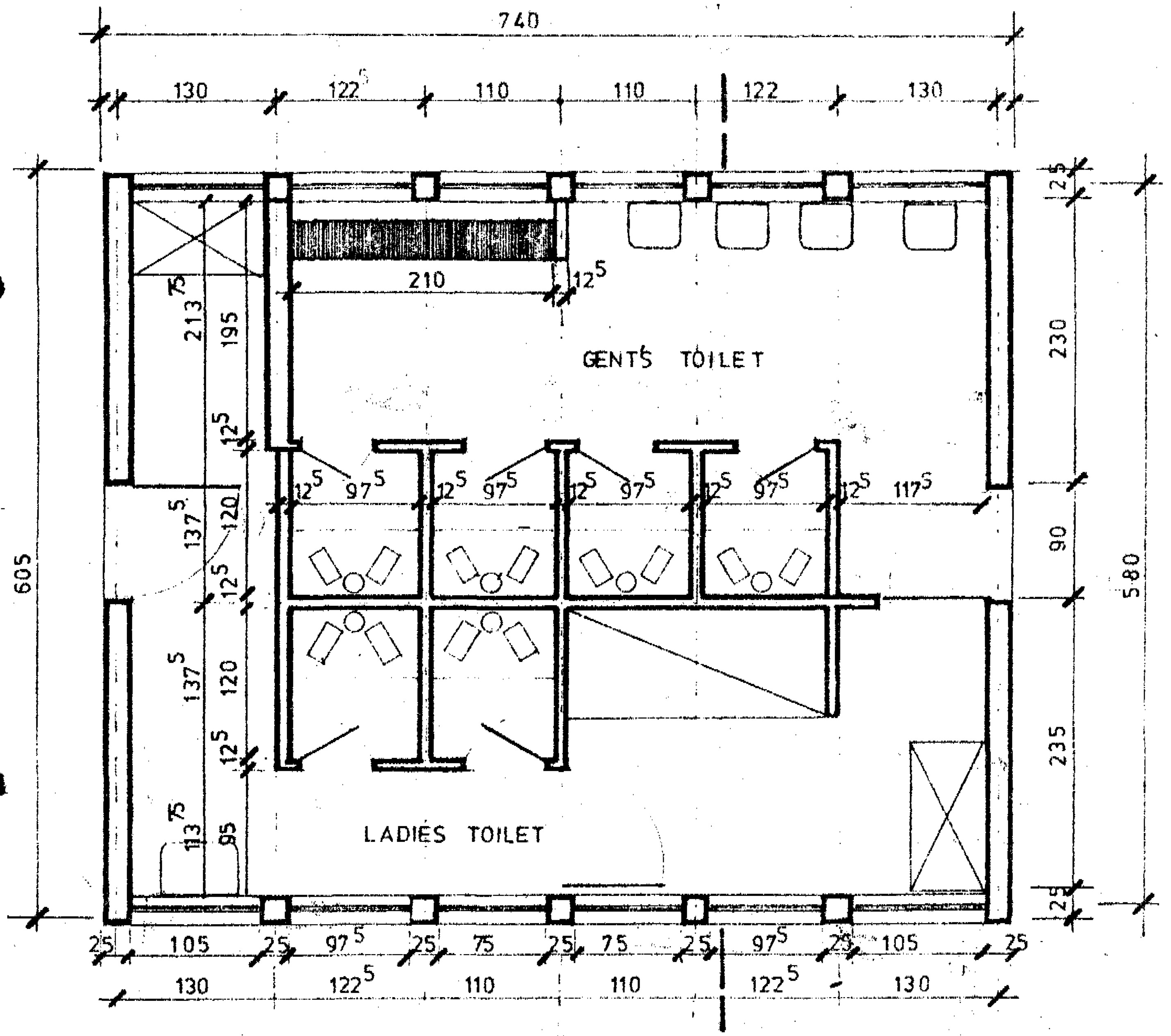
2. A hinged flap is put on the slot to reduce breeding of flies on the pit.

3. A reinforced concrete slab is placed over the pit in order to minimize infiltration by storm water, and is sloped to drain away from the slot.

4. The superstructure is furnished with sufficient siding to afford adequate privacy for the user.

5. The latrine is lighted to encourage night-time use.

6. The pit is lined so as to preclude caving.



FLOOR PLAN

FIGURE N°1 SCALE 1:50

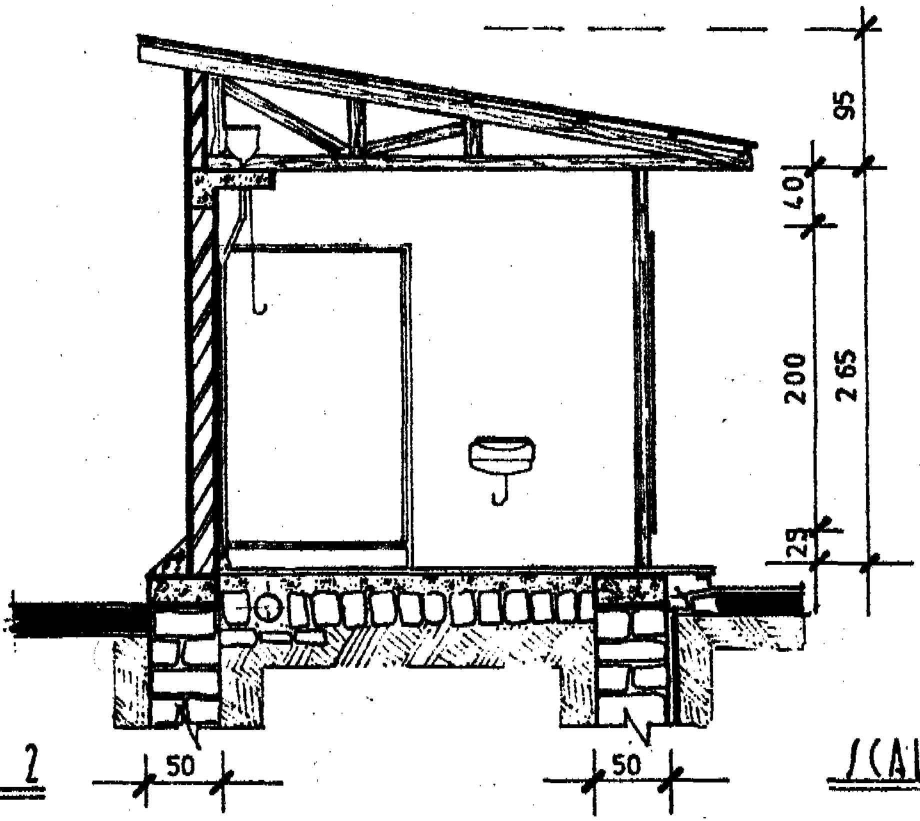
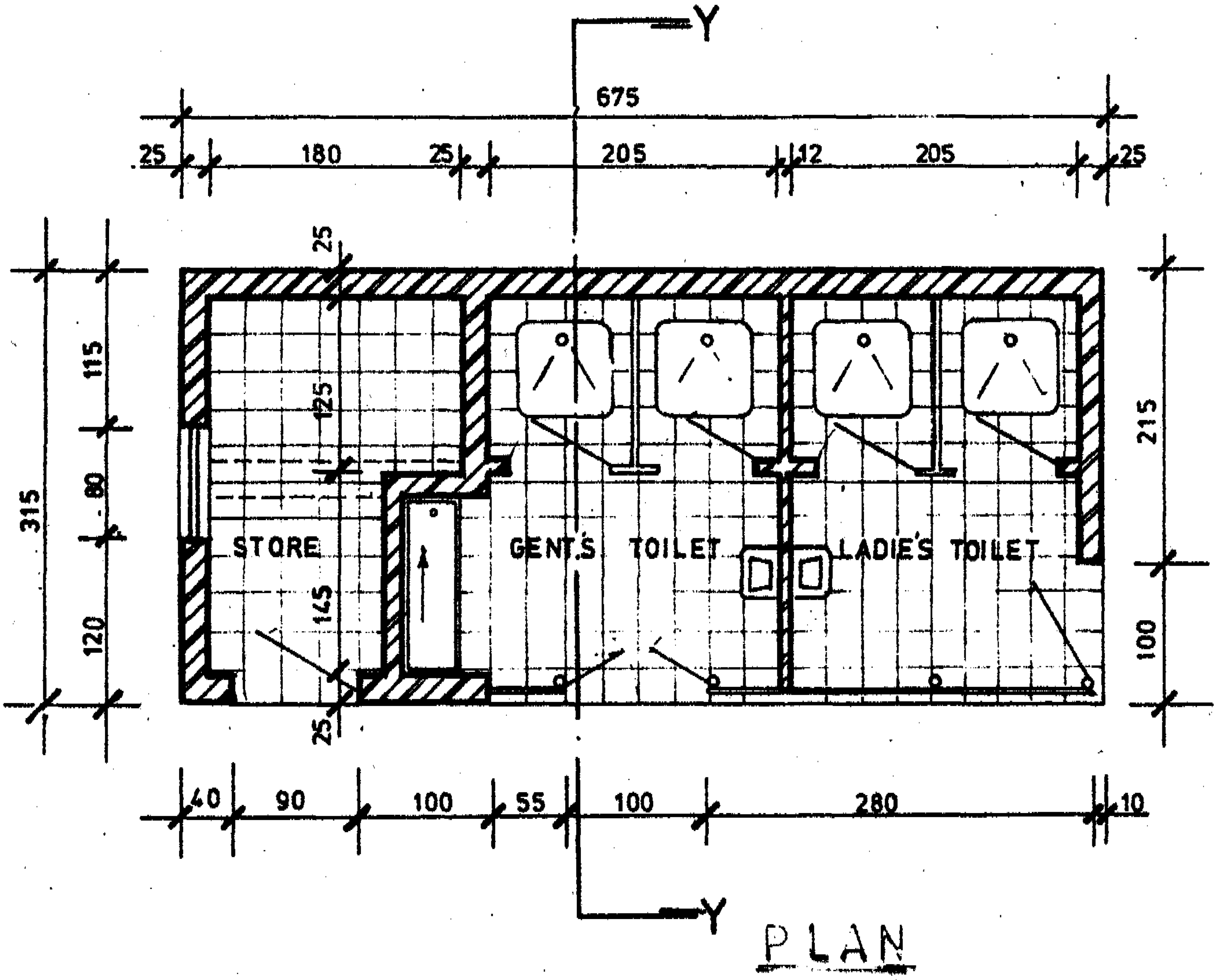


FIGURE No 2

SCALE 1:50

SECTION Y-Y



PLAN

Aqua-Privies and Composting Latrines

They are not widely used in Addis Ababa or in other cities. In places where there is a water shortage, there is a problem in maintaining the water seal, besides high construction costs. Particularly in the squatters using communal toilet facilities, where daily washing is not practised due to water shortage and individual responsibility does not exist, the aqua-privy will be not practical.

Composting toilets - like the Vietnamese toilet or the Swedish Multrum toilet - even though are used elsewhere in the world, are not popular in Addis Ababa due to the following reasons :

1. Lack of market for humus.
2. Unavailability of garden areas in the squatters.
3. Cultural bias against handling human excreta.
4. Fly breeding during removal of pit contents.
5. Construction cost is expensive for the urban poor who lives in slums depleted house.

SEWERAGE SYSTEM COMBINED WITH LOW-COST SANITATION

The existing excreta disposal methods and the various alternatives need proper evaluation. Since the new sewerage system cannot serve the majority of the population, it will be unwise to invest in a project where the beneficiaries are small in number and where there are many competing development projects. On the other hand, large quantities of wastes generated by industrial and commercial buildings have no any better solution than the sewerage system. A small number of upper-class residential units, who benefit from the project, cannot afford to cover the economic cost. As the result, the Government will be forced to subsidize the whole cost of the project. Of course, care has to be taken not to touch the poor who do not benefit from the project, and it is worth noting that economic benefits might carry more weight to the poor than social benefits.

The improved pit latrine, even though an acceptable standard, might not be affordable to the majority low-income group. It is assumed to reach an affordable level if local materials are used and the construction is based on self-help, where all unskilled labour is to be provided by the user and with some degree of subsidy by the government. In a large-scale construction, it requires standardization as well as prefabrication of elements.

In squatters of densely populated regions, the improved (private) pit latrine might not work due to the unavailability of space and inaccessibility to vacuum trucks. In Addis Ababa, where the number of vacuum trucks is inadequate and maintenance and operation costs are high, desludging of pit latrines is time-consuming and difficult. The other alternative which could possibly save cost is the communal improved pit latrine, which could be shared between families. Since families are used to sharing latrines, there is no cultural bias against this, but as to the responsibility it could be improved through education on health and sanitation, and direct control or supervision by the community organizations (like the Kebeles or Women and Youth Associations).

In the poor housing areas where the improved pit latrine is not affordable, the communal public toilet is the only solution. In the case of Addis Ababa where public toilets are administered by the city council and are successfully operating, the service could be extended to serve family units among the slums and the cost can be tremendously reduced if community participation is fully utilized at the construction as well as at the decision-making stage.

The other option which could serve high residential units is the septic tank. It has been suggested that a city-wide percolation test be carried out to locate regions suitable for septic tanks and leaching fields so that it can be effectively utilized.

CONCLUSION

For the formulation of a sanitation master plan which is intended to reach the majority urban dwellers, one should consider in detail alternative options from the viewpoint of cost-effectiveness in conformity with socio-economic conditions of the users. In the case of Addis Ababa, the improved pit latrine, and communal public toilet facilities on one hand are considered as the low-cost excreta disposal systems, and on the other the conventional sewerage system and septic tanks are found to be desirable options. The status of housing stocks in the squatters are generally deteriorating and need urgent action. Most of them are unable to provide basic shelter, let alone to promote other environmental well-beings of the inhabitants. The infrastructural facilities are least maintained in these areas. Among these problems, the objective of the first phase study is (i) eventually to construct various prototypes of dry pit latrine and communal multi-purpose toilet facilities in the densely populated low-income areas, and (ii) in the mean time to conduct health education campaigns by public health experts in collaboration with Urban Dwellers Associations. However, the upgrading of squatters and resettlement of inhabitants to a better site-serviced areas should be planned in conjunction with the improvement in water supply and sanitation, since housing, water supply and sanitation are interrelated in the socio-economic and health status of the people.

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TRAINING OF VILLAGE MASONS ON A LOW COST BIOGAS TECHNOLOGY

Raymond M. Myles

Senior Specialist-Cum-Head
Appropriate Technology Action for
Food Production (AFPRO)
New Delhi - 110016, India

ABSTRACT - Inspite of the fact that India is a pioneer in the field of biogas technology, to date she has only 126,000 family-size plants. Some of the reasons for the programme being a non-starter are the high initial cost of the plant with a moveable gas holder, the high repair and maintenance costs, and the dependence upon imported skills and fabricated parts. A relatively low-cost technology, named as the Janata Plant, has been developed by the Gobar Gas Research Station, Ajitmal, U.P. AFPRO, a non-government technical service agency which is involved in the systematic transfer of this technology through its related grass-root voluntary organisations. Having identified the 'key-role' of village masons in the construction of the Janata Plant, AFPRO has been making concentrated efforts in their training. This paper discusses the systematic approach adopted by AFPRO in an exhaustive practical brick-by-brick training of village masons on the Janata Plant in a decentralised manner, as well as the impact created by this programme.

Indian villages offer a potential of 10 million family-size cattle dung plants and 500,000 community latrine-attached biogas digesters. This potential will be considerably increased if agricultural waste and wastes provided by other animals are also used. However, this potential has not been realized inspite of the fact that India is one of the pioneers in biogas technology. Some of the reasons for low adoption of biogas plants are the high initial cost of conventional plants with moveable steel gas holders, the high recurring cost of maintenance and repairs, and the total dependence upon an urban-based technology.

DEVELOPMENT OF LOW COST TECHNOLOGY

There has been continuous work at several research institutions to circumvent these bottlenecks. The Gobar Gas Research Station (GGRS), Ajitmal, evolved a low-cost, fixed-dome model to suit Indian conditions.

The performance of 14 pilot demonstration plants installed by progressive farmers was evaluated for a year. Finally, after being convinced of their performance, the Planning Research and Action Division of State Planning Institute, U.P., the parent body of the Gobar Gas Research Station, released the design and drawings for the transfer of this technology. The Ministry of Agriculture, Government of India, cleared the new design for adoption in 1978. It was called the "Janata" plant, i.e. the people's plant, to indicate that it was within the means of the common people. This new design was particularly attractive because of the following features :

- Low initial investment for construction
- Used locally available construction materials
- Could be constructed by upgraded local skills
- Since it had no moving parts of steel gas holder, the maintenance cost was negligible
- Saved space as it was built below the ground level
- Was based on the continuous digestions process, which was already accepted in principle by Indian people
- Could be charged with materials which could be made into a slurry, a practice already followed with the conventional plant
- Required no fabrication work, therefore no dependence on workshop, hence could be built in the remotest area.

INVOLVEMENT OF NGO'S/VOLAGENCIES

AFPRO came to know of the Janata Plant in early 1979 and evolved a strategy for the promotion and transfer of the technology through volagency efforts. As part of this effort, AFPRO organised a week-long practical training course for 24 supervisory staff of 20 related agencies in June '79. The participants had either an engineering background or practical experience in the construction of the floating dome biogas digester. During this course, participants were completely exposed to the construction techniques of the Janata plant and observed the working of several plants. They also had discussions with farmers who were using the Janata biogas digester. In October '79, AFPRO presented a paper on the biogas plant at a national workshop on "integrated approach to agricultural development," attended by 80 project directors from related NGO's/volagencies, government and universities. Two of the major recommendations of the participants of practical training course and the national workshop were :

- AFPRO promote and transfer the fixed-dome biogas technology by constructing demonstration plants in various regions of the country, to enable grass-root level volagencies and farmers to see the construction, performance and benefits of this technology.

- Organise and conduct practical training courses for rural masons on the construction techniques of the Janata Plant, so that the demand created for the plants may be met with locally available manpower and expertise.

PILOT DEMONSTRATION-CUM-TRAINING PROJECT

AFPRO launched a pilot project in January 1980, to implement the above the recommendations, with the following broad objectives :

- To construct demonstration Janata Plants in different regions of India;

- To train local village masons on the construction techniques of this technology, using locally available material;

- To observe the functioning of Janata digesters in varying soil conditions, and possible causes for break downs and failures etc.; and

- To work out the comparative costs of the Janata Plant for different areas.

A team of technicians consisting of a supervisor, master masons and masons was employed and was given thorough practical training for a month at headquarters before being assigned to the job of constructing "demonstration-cum-training Janata Plants" in different areas. This team travelled all over the country building digesters at sites selected by NGO's/volagencies. Later on, AFPRO increased the number of "mobile teams" of technicians for effective working and greater coverage in shorter periods. While AFPRO bore travel expenses of their technicians, the construction costs and hospitality were borne by the local volagencies, which also selected masons for training.

Four to ten local masons were trained on the Janata Plant at each location, depending upon the resources and motivations of the local agency.

EXHAUSTIVE TRAINING OF VILLAGE MASONS

The demonstration-cum-training project created widespread interest in the Janata biogas plant technology. It also brought home to AFPRO the following two important aspects of this technology :

- A well trained master mason was the "king pin" in the transfer or extension of Janata Plant technology, as plants constructed from drawing alone by untrained masons had a fairly high rate of failure due to gas leakage.

- Allowing local village masons to work along with AFPRO technicians on one "demonstration-cum-training plant", was not enough to develop sufficient confidence in them to construct independently the Janata Plant.

On the basis of the above observation and feed-back from the related volagencies, AFPRO modified its original approach with a view to provide more exhaustive brick-by-brick, practical training of village masons on Janata Plants. These trainings are conducted by AFPRO specialists, supervisors and master masons at selected places and are popularly known as "construction-cum-training workshop on Janata Plant". During the 21-day training, selected professional masons from the region construct 2-3 Janata Plants under the supervision of AFPRO training team. Experience of building different sized plants and interaction amongst masons from different areas have contributed towards making the rural masons a more confident body of people. In some situations where community latrines existed and nightsoil-based plants were built, the masons learnt of this technique as well. A sample training schedule of construction-cum-training workshop is given in Appendix A.

The AFPRO technicians classify the trainee masons into three categories, taking into account their earlier skills and those acquired during the construction training - namely, Master Masons (MM), Masons (M) and Assistant Mason (AM). A total of 594 masons in the three different categories (MM-114, M-267 and AM-213) were trained from Sept. 1980 to Nov. 30, 1982 (Appendix B). Out of these, only Master Masons are advised to construct Janata Plants independently, provided they are able to read and understand drawings. The Masons are advised to have more practice by working along with Master Masons for sometime to gain confidence and skill, whereas those rated as Assistant Masons by the trainers are advised only to work under the supervision of master Masons.

FEEDBACK OF THE MASON TRAINING PROGRAMME

For over 2 years, AFPRO has organised and conducted construction trainings in 21 States and Union Territories of India. Over 200 voluntary organisations, government, non-government, autonomous bodies, etc., have taken advantage of these courses (Appendix C). As per feedback received from the field, several of the masons trained have started constructing plants independently and are bringing about certain modifications to suit local conditions. The sponsoring NGO's volagencies provide the necessary coordination at the local level. It has been observed from the feedback that wherever the masons or their sponsoring agencies have strictly followed the advise given by the AFPRO trainers, based on categorization, the Janata Plants constructed by them have been successful. On the other hand, wherever the advise given was ignored, the Janata Plants constructed have failed due to gas leakage. There is a wide variation in the expertise and involvement of AFPRO related grass-root level agencies in the transfer of this technology, but on the whole the prospects look very encouraging. The discussions with trained masons from time to time give AFPRO a confidence that on their own they will bring about some innovations. Under such circumstances, the evolution of an even cheaper and better biogas digester is within the realm of possibility.

IMPACT OF TRAINING ON TRANSFER OF TECHNOLOGY

The Government of India has launched a national programme for installing 400,000 family size biogas plants in the Sixth Plan period. Rs. 50 crores (approx. US$ 55 million) have been earmarked for this purpose. The programme which started in 1981-1982, has adopted a multi-model and multi-agency approach. Based on AFPRO's past experience in training of rural masons, the project has laid great emphasis on the organisation of large numbers of training courses through competent agencies in rural areas. The Government of India has adopted the training model evolved and followed by AFPRO.

The Government of India, State governments and autonomous bodies have asked AFPRO to continue the work of dispersing the biogas technology. AFPRO has accepted this responsibility and involved several experienced grass-root level agencies, who conduct locally the "construction-cum-training courses on Janata Plants".

Before the involvement of AFPRO, particularly in organising training courses, the Janata Plant technology was restricted to one state only, i.e., Uttar Pradesh, where it was developed and adopted for promotion and transfer by the State Government. The creation of a large number of trained masons, through the effort of AFPRO and related NGO's/vol-agencies, has helped in the transfer of this technology to other states and far-flung areas, eg. North Eastern Region States, and island state territories like Andman and Nicobar, etc. So far 21 states/union Territories have been covered by the installation of 152 demonstration or training Janata Plants of different sizes since January 1980 (Appendix D). The summarized table of achievements of AFPRO in terms of number of Janata plants constructed, masons trained and sponsoring organisations with their statewise distribution is given in Appendix E. This small and systematic effort of AFPRO is enabling the States/Union Territories to initiate action for the large scale extension of this technology for the benefit of rural masses.

CONCLUSION

To say that there is a vast potential for biogas technology is meaningless unless targets set can be realized within a time limit. In AFPRO's opinion, such a target can be realized only through decentralisation of the implementation process. A cadre of trained masons must be available at the block and village levels. There are over 5000 blocks in India and it is estimated that each will require the services of two master masons, supported with 4-8 masons as well as assistant masons. Approximately 10-12 masons can be effectively trained at each construction training programme. Therefore, at least 4000 training programmes will be required before the cadre of masons is available. AFPRO has indicated a line of action which may offer solutions; and this is now being taken up by grass-root level voluntary organisations. Thus, AFPRO's vision of extending a low-cot biogas technology in a decentralized manner by involving village masons and structures at the grass-root level has begun to materialize.

Appendix A

SAMPLE TRAINING SCHEDULE
(21-Day Duration)

AFPRO-Sponsored and Conducted Regional Training Workshop for Rural Masons on the Construction of Janata Biogas Plants in the Different States of India.

	First Plant (4 or 6 m^3 size)	Second Plant (2 or 3 m^3 size)
First to fourth day	- Selection of site - Plant layout	- Selection of site - Plant layout
Fifth day	- Foundation of the plant	
Sixth to eight day	- Construction of digester including pressure area (gas storage portion of the digester, which is just above the arch of the inlet and outlet gates)	- Digging of plant pit
Ninth day	- Form work & shuttering	- Foundation of the plant
Tenth day	- Casting of Plant Dome	
Eleventh day to fifteenth	- Curing of Dome (5-day period) - Construction & plastering of inlet and outlet chamber and mixing tank	- Construction of digester including pressure area (gas storage portion of the digester) - Form work & shuttering - Casting of Plant Dome - Curing of Dome (5 days period)
Sixteenth day	- Open the dome (removing shuttering from work and mud mould etc. through outlet chamber)	- Construction of inlet and outlet chamber and mixing tank

Seventeenth day	- Groove cutting in the Dome ceiling - Cleaning/washing etc. of gas storage area	- Plastering of inlet outlet chamber and tank

Demonstration-cum-discussions session with local farmers, Extension Staff of that particular State-based volagencies and other local, Government agencies, to explain the constructional and operational aspect of Janata Plant, as well as clarify any doubts etc.

Eighteenth day	- Painting the grooves with pure cement slurry then pasting it with cement mortar and then two plastering (first rough plaster and second fine plaster) and finishing.	- Open the Dome (removing shuttering etc. - Groove cutting in the ceiling - Cleaning/washing etc. of gas storage area
Nineteenth day	- Digester plastering and and finishing - Floor plastering & finishing - Piling of mud on top of the plant	- Painting the grooves with pure cement slurry then pasting it with cement mortor and then two plastering (first rough plaster and second fine plaster) & finishing
Twentieth day	- Fitting of accessories and final checking etc.	- Digester plastering finishing
Twenty first day		- Floor plaster and finishing - Piling of mud on top of the plant - Fitting of accessories and final checking etc.

APPENDIX B

Statewise Distribution of Masons Trained Under the AFPRO Sponsored and Conducted Training Workshop on Janata Plant Construction (From September 1980 to November 1982)

Sl. No.	State of India	Different Categories of Masons Trained									
		Master Masons			Masons			Assistant Masons			Total Masons Trained
		Up to Dec '81	Jan '82 to Nov '82	Total	Up to Dec '81	Jan '82 to Nov '82	Total	Up to Dec '81	Jan '82 to Nov '82	Total	
1.	Andaman & Nicobar	–	–	–	–	2	2	–	2	2	4
2.	Assam	–	2	2	–	5	5	–	4	4	11
3.	Andhra Pradesh	3	–	3	9	6	15	–	67	67	85
4.	Bihar	2	4	6	10	17	27	1	4	5	38
5.	Delhi	2	–	2	1	–	1	3	–	3	6
6.	Gujarat	4	6	10	7	8	15	6	3	9	34
7.	Haryana	–	7	7	1	16	17	–	12	12	36
8.	Jammu & Kashmir	–	4	4	–	4	4	–	5	5	13
9.	Karnataka	–	–	–	6	8	14	–	7	7	21
10.	Kerala	1	2	3	9	19	28	4	7	11	42
11.	Madhya Pradesh	5	8	13	8	25	33	4	19	23	69
12.	Manipur	–	1	1	–	3	3	–	7	7	11
13.	Maharashtra	2	10	12	–	8	8	–	4	4	24
14.	Meghalaya	–	1	1	–	7	7	–	4	4	12
15.	Nagaland	–	1	1	–	3	3	–	2	2	6
16.	Orissa	–	–	–	7	12	19	5	4	9	28
17.	Punjab	1	2	3	–	5	5	–	3	3	11
18.	Rajasthan	2	8	10	9	8	17	4	4	8	35
19.	Tamilnadu	4	–	4	2	4	6	1	15	16	26
20.	Uttar Pradesh	2	13	15	6	28	34	3	4	7	56
21.	West Bengal	3	14	17	3	1	4	2	3	5	26
	Total	31	83	114	78	189	267	33	180	213	594

APPENDIX C

Statewise Distribution of Organisations (Voluntary, Non-Government and Government Agencies), Who Sponsored Masons for the AFPRO Conducted Construction Training Workshop on Janata Plants (From September 1980 to November 1982)

Sl. No.	State of India	Voluntary Organisations			University/Institute Polytechnic			Central & State Govt./ Military Ferm/ICAR Institutes			KVIC/Khadi Board/ Agro. Industries Corporations			Total Organisations
		Up to Dec '81	Jan '82 to	Total	Up to Dec '81	Jan '82 to	Total	Up to Dec '81	Jan '82 to	Total	Up to Dec '81	Jan '82 to	Total	
1.	Andaman & Nicobar	–	–	–	–	–	–	–	1	1	–	–	–	1
2.	Assam	–	6	6	–	–	–	–	–	–	–	1	1	7
3.	Andhra Pradesh	6	2	8	1	–	1	–	–	–	–	1	1	10
4.	Bihar	6	7	13	–	1	1	–	1	1	1	2	3	18
5.	Delhi	1	–	1	–	–	–	2	–	2	–	–	–	3
6.	Gujarat	11	5	16	–	–	–	–	3	3	1	5	6	25
7.	Haryana	1	2	3	–	–	–	–	5	5	–	1	1	9
8.	Jammu & Kashmir	–	–	–	–	–	–	–	1	1	–	–	–	1
9.	Karnataka	4	1	5	–	–	–	2	–	2	–	–	–	7
10.	Kerala	9	10	19	–	–	–	–	3	3	–	–	–	22
11.	Madhya Pradesh	6	5	11	1	1	2	1	–	1	–	–	–	14
12.	Manipur	–	7	7	–	–	–	–	–	–	–	4	4	11
13.	Maharashtra	2	2	4	–	–	–	–	–	–	–	2	2	6
14.	Meghalaya	–	5	5	–	–	–	–	1	1	–	–	–	6
15.	Nagaland	–	1	1	–	–	–	–	–	–	–	1	1	2
16.	Orissa	4	4	8	–	–	–	–	1	1	7	1	8	17
17.	Purjab	–	1	1	2	–	2	–	–	–	–	–	–	3
18.	Rajasthan	2	1	3	–	–	–	–	–	–	–	–	–	3
19.	Tamilnadu	5	11	16	–	–	–	–	–	–	–	1	1	17
20.	Uttar Pradesh	3	6	9	–	1	1	–	1	1	–	3	3	14
21.	West Bengal	6	4	10	–	–	–	–	14	14	–	1	1	25
	Total	66	80	146	4	3	7	5	31	36	9	23	32	221

Appendix D

Statewise Distribution of Demonstration Training Janata Biogas Plants Constructed by AFPRO

(From January 1980 to November 1982)

Sl. No.	State of India	JANATA PLANTS CONSTRUCTED								Total Plants
		2 m^3	3 m^3	4 m^3	6 m^3	8 m^3	10 m^3	15 m^3	20 m^3	
1.	Andaman & Nicobar	-	-	2	-	-	-	-	-	2
2.	Assam	-	1	-	-	1	-	-	-	2
3.	Andhra Pradesh	4	4	1	1	-	-	-	-	10
4.	Bihar	1	5	2	4	-	-	-	-	12
5.	Delhi	1	1	1	-	-	-	-	-	3
6.	Gujarat	1	9	12	-	-	-	-	-	22
7.	Haryana	2	2	-	2	-	-	-	-	6
8.	Jammu & Kashmir	1	-	-	-	-	-	-	-	1
9.	Karnataka	-	1	1	-	-	1	1	-	4
10.	Kerala	1	-	1	2	-	-	1	-	5
11.	Madhya Pradesh	1	-	4	-	-	1	1	-	11
12.	Manipur	-	-	1	1	-	-	-	-	2
13.	Maharashtra	-	3	1	-	-	1	-	-	5
14.	Meghalaya	1	-	-	-	-	1	-	-	2
15.	Nagaland	-	-	-	1	1	-	-	-	2
16.	Orissa	1	4	1	5	-	-	1	-	12
17.	Punjab	1	2	1	2	-	-	-	-	6
18.	Rajasthan	-	6	-	1	-	1	1	-	9
19.	Tamilnadu	1	3	-	1	1	-	-	-	6
20.	Uttar Pradesh	4	8	2	7	-	1	-	1	23
21.	West Bengal	-	3	-	3	-	-	1	-	7
	Total	20	56	30	30	3	6	6	1	152

Appendix E

Summarized Table of State-Wise Distribution of Organisations who Sponsored Trainee Masons, Number of Masons Trained, and Demonstration/Training Janata Plants Constructed by AFPRO

(From January 1980 to November 1982)

Sl. No.	States of India	Demonstration/ Training Janata	Masons Trained	Sponsoring Organisation for Mason Trainees
		Jan'80 to Nov'82	Sept'80 to Nov'82	Sept'80 to Nov'82
1.	Andaman & Nicobar	2	4	1
2.	Assam	2	11	7
3.	Andhra Pradesh	10	85	10
4.	Bihar	12	38	18
5.	Delhi	3	6	3
6.	Gujarat	22	34	25
7.	Haryana	6	36	9
8.	Jammu & Kashmir	1	13	1
9.	Karanataka	4	21	7
10.	Kerala	5	42	22
11.	Madhya Pradesh	11	69	14
12.	Manipur	2	11	11
13.	Maharashtra	5	24	6
14.	Meghalaya	2	12	6
15.	Nagaland	2	6	2
16.	Orissa	12	28	17
17.	Punjab	6	11	3
18.	Rajasthan	9	35	3
19.	Tamilnadu	6	26	17
20.	Uttar Pradesh	23	56	14
21.	West Bengal	7	26	25
	Total	152	594	221

VOLUNTARY AGENCIES AND BENEFICIERY INTEREST
IN HUMAN WASTE MANAGEMENT

G. Surya Rao

Consultant
Urban Community Development

1. INTRODUCTION

In India, till about the turn of this century, latrines were very scanty in urban areas and almost unheard of in rural surroundings. They were also strange to the traditions and customs of Indian home; and defaecation in the open fields was not only a common habit but also considered a matter of great convenience before the advent of civilization.

1.1 With the recent trends in urbanisation, human waste disposal has posed a great challenge to the Third World countries, where poverty, ignorance and customs play a contradictory role against new innovations. With the towns and cities getting more and more congested and increased in number, open space has disappeared in the surroundings of living zones; and lanes and by-lanes, which were hitherto unfrequented by man, have gained undue importance with busy traffic.

1.2 These changes posed an urgent need to have latrines within and nearby dwelling spaces according to one's own ingenuity and capacity. The need to have this facility at a lowest cost was obvious and it was indeed an evil genius, who devised the bucket type latrine, in which human beings make house-to-house collection of excreta and carry them to the roadside dumps, from where they are reloaded into trucks for transport to trenching pits.

1.3 Human excreta are a reservoir of causative agents for gastro-enteric diseases and parasitic infestations, transmissible through all possible media. With improper disposal, human waste can be a source of disease, a dangerous pollutant to the environment and a misfit as an efficient fertilizer.

1.4 The statistics regarding excreta disposal are very staggering in India, which is a very vast country spreading over 3.2 million square kilometers, each having on an average a density of 195 persons. According to the 1981 census, the country's population was around 684 million, with a per capita income equivalent to US$ 180. With minimised epidemics and better living conditions, the life expectancy has risen to 51 years, even though much of the marginal population is undernourished with children and women remaining as the worst sufferers (1).

1.5 Against this demographic picture, one third of the urban households (over 7 million) do not boast of a latrine; another one third are content with bucket-type service latrines; and amongst the remaining one third, 21 per cent share flush latrines, 7.2 per cent enjoy independent flush latrines and 5.2 per cent have septic tank latrines (2).

1.6 There is a terrific disparity in the existing levels of excreta disposal within the country and rural areas, which have about 80 per cent of the population, are conspicuously deprived of this facility. Again, in urban areas these facilities are very much in favour of high-income groups; that too without much of expense to them.

2. SEWERAGE

Conventional sewerage is no doubt ideal and is the best form of disposing of human waste. But looking at the enormous costs of construction and maintenance, it is really prohibitive and impossible for a poor and densely populated country like India. We have now just about 300 out of 3000 towns with a sewerage system and most of them are with partial coverage to as low as 10 per cent. Under-utilization of the installed capacity is another discouraging feature leading to a large wastage of investment, which is attributable to the negligence and indifference of administration on one side and poverty and the ignorance of the common man on the other. The conditions might be the same in other developing countries, where the gulf of parity between resources and requirements is ever widening.

2.1 The need for underground sewer cannot be ignored in the long run. Until it is necessary to devise and depend upon other simpler solutions for many more years for the simple reason, the core central city will always be crowded with narrow lanes, where sewerage lines cannot be laid with ease.

2.2 The delay in latrine conversion programmes all these years was because of the concept that the sewer system is indispensable for human waste disposal. Technology must adapt itself to local needs and conditions and must offer solutions at a minimum cost; yet providing a satisfactory answer to the total problem. But the engineering stand all these years was firm stating that no other method except sewerage is desirable to deal with human waste disposal. Our planning experience over the past three decades is indicative of the infeasibility of providing a sewerage system to all urban population within a foreseeable future. But the total sanitation programme has a rightful claim for priority attention in developmental plans because of its capability in improving personal hygiene, community health, social uplift and economic well-being.

2.3 For us, the problems are three-fold: (i) converting bucket latrines into low-cost water-seal latrines; (ii) providing new latrines in houses where there are none; and (iii) providing well maintained community latrines to meet the needs of pavement dwellers, floating population and those having no latrines.

3. INITIAL ATTEMPTS

Persons engaged in excreta collection and carriage are mostly Harijans (Bhangis) and this occupation has become a social stigma, which undermined their status and ultimately perpectuated into a hereditary form. For these very people, whom Mahatma Gandhi has loved so much and rehabilitated them to some other respectable occupation, several alternative systems to service latrines have been tried ever since 1930.

3.1 At the request of Gandhiji, one of his close associates, Dr. Cassell, devised a trench latrine, which was tried out in Wardha Sevagram. An improvement on this was the dug-well and bore-hole latrines; but none of these could escape criticisms on some ground or other.

4. NATIONAL PROGRAMMES

4.1 Rural Water Supply and Sanitation Programmes

Soon after independence in 1947, Government of India gave much thought to human waste disposal and this programme - covering few selected backward areas - was launched in 1954. Septic tank latrines and overhead tanks for water supply have been constructed on a war footing to achieve stipulated targets and spend earmarked budgets.

4.1.1 It was purely an engineering fete, not interferring with the backwardness, illiteracy and customs of the local population and as such for some time, these latrines have been left ornamental and later dirty eyesores, emitting filthy odour. People have outrightly opposed the idea of introducing the latrines inside dwelling premises, and so the construction was launched in clusters in the periphery of habitat zones. The motivation to erect privacy walls at their expense did not at all reach the beneficiaries, as the implementing department was not equipped with this type of task force.

4.1.2 Thus in course of time, these latrine seats were seen acting as small elevated platforms for fodder stack and dung cake heaps (fuel made of dung). Defaecation was common alround the seats but not upon, reflecting the poor utility of the total programme.

4.2 Community Development

To make up the community education gap and convert people as willing partners in the total development programme, National Extension Service and Community Development blocks have come up simultaneously at a large scale all over the country in the 1950's and these programmes did not keep the beneficiaries silent at the receiving end. Through Social Education Organisers and Village Level Workers, the element of education and motivation about the utility and usage of these toilets was introduced along with several other programmes. People, who have reached the stage of accepting and adapting the new method, were made to commit a portion of the cost as their share.

4.2.1 This approach gave a positive and right direction to the sanitation programme; but the intensity and success again depended much on the quality of the motivating force, which is an integral part of the bureaucracy. The changing policies - out of political and vested interests in the later years - had a bitter attack on the two crucial and vital elements, namely, self-help and people's participation, which were indeed part of our old culture and village life in the past.

4.3 Slum Improvement

Recognising the need to improve sanitary conditions in slums and backward localities in urban areas, Government initiated the environmental improvement programme in the sixties. An amount of Rs. 120.- was initially fixed as per capita expenditure on community latrines, baths, water supply street lights and approach roads. Implementing agencies were to ensure a balanced utilization of allocated funds to provide these basic needs with people's involvement and co-operation.

4.3.1 But in practice, this again has become another engineering exercise, where the bureaucracy felt shy and diffident to contact the communities and or at least invite their suggestions. The yardstick provided in the guidelines stipulated a latrine seat and a bath room for every 20 persons, and a water tap and a street light for every 200 population. In some slum areas, taking advantage of the available open space, construction work was completed for latrines and bath rooms. At this point, if the funds are exhausted, the programme was deemed to have been completed with needy structures; but not necessarily with water connection, which are essential for their utility.

4.3.2 There are instances where these funds were also utilized for laying sewer lines, which can be safely concealed from public view and criticism. This was again a unilateral decision and action without assessing the future utility and exact capacity of the residents to make best use of the community facility. It was executed through a contractor, who is an alien to the local community, and can be questioned only by the engineer. Even if there are few people, who are sufficiently motivated to ask for a sewer connection, the immediate answer would be: "Apply through a registered plumber, spend money and go through the usual procedures". All this ends up with much capacity and potential for the new sewer line; but the utility is decimal.

5. THE RESULT

What is the ultimate result?

- The target is achieved, provided the utility aspect is not questioned.
- The convenience and feelings of the people are simply ignored.
- This has created terrific apathy and aversion against the governmental agency implementing the programme.
- Taking advantage of the darkness all around, there are instances where these latrines and baths were utilized for unsocial and illicit activities, which again provoked unrest and nuisance in the neighbouring communities.

5.1 Who is the looser in all these situations-

- *Is it the engineer?*
- *Is it the contractor?*
- *Is it the beneficiary?*
- *Or is it the Nation as a whole?*

5.2 At whose fault is it happening?

- The policy maker?
- The bureaucracy and the local subordinates implementing the scheme?
- Or the people, who have no say against what is happening before their eyes?

5.3 The national plans and policies are laudable in any situation. But encouraging results are not generally evident as the emphasis is more on targets, monetary provisions and technological innovations, ignoring the human aspect, which is traditionally handicapped with its own ignorance, socio-economic conditions and its own perception about its felt-needs. All the attitudes of considering the local community as an inert object, and deciding plans and programmes even without uttering a work to them, are not a surprising fact in our administrative dealings even today. This makes the people and the bureaucracy assume opposite postures, ultimately affecting the utility of the total programme.

5.4 Money, if prudently used and efficiently managed, cannot be a real problem. It is ridiculous to count resources only in monetary terms that come out of governmental exchequers. There are vast resources in terms of men, materials and money, which have to be tapped and made best use of through proper techniques and approaches. But bureaucracies, in general, lay little emphasis or do not welcome them at all, as they may tend to upset the established practices and administrative procedures. For all problems, the solution is technology or money, which is unfortunate and distressing. It is high time to realise that human approach and people's involvement are the missing links in our developing nations, which perpetuate misery and instigate apathy and indifference amongst the masses.

6. GANDHI CENTENARY CELEBRATIONS

This was an instance, where Government and voluntary agencies, adapting Gandhian philosophy, have played very effectively a joint role; and these celebrations had a triggering effect on sanitation programmes all over India in 1969. Harijan colonies were specially chosen with a firm intention to provide all basic amenities and local competitions were also held to inculcate and promote sanitary and clean habits. To widely preach and practice some of the principal ideals of Gandhiji, the Gandhi Centenary Celebration Committee chalked out several programmes to fight against various social injustices done to harijans.

6.1 Governmental Effort

To popularise house connections to sewer and to promote dry latrine conversion programme, the Government of India offered 25 per cent subsidy and 75 per cent loan assistance. This matter received further emphasis in the Government of India letter dated 10th June, 1968 (Annexure-I) to promote a special campaign for the conversion of dry latrines into flush type ones. To achieve maximum success, it was suggested that :

- no new building be allowed without the provision of a flush-type latrine;
- compulsary connections be ensured in sewered areas; and
- a special drive be launched in unsewered areas to convert dry latrines into water-seal closets.

6.2 The above order also urged the municipalities to prepare schemes and submit them urgently for Governmental assistance. However, there has been no tangible progress all these years in most of the states, presumably because there is no suitable mechanism to provide the initiative, guidance and direction necessary to plan and implement programmes of this nature.

6.3 State Governments were equally determined to relieve the human beings (Bhangi Mukti) from the undignified job of carrying nightsoil as head load. An ordinance was promulgated in 1970 in Bihar and Orissa banning construction of new dry latrines and also indicating that continuation of dry latrines is a cognisible offense punishable with both fine and imprisonment, and this created a sense of urgency for the people to go in for latrine conversion.

6.4 Under the relevant provisions contained in the Gujarat Municipal Act, the State government issued certain Model By-laws for municipalities (Annexure-II) for conversion of bucket-type latrines into water-borne latrines in 1963; but this did not include any clause for the provision of a latrine as such in the houses.

6.5 The break-up of the estimated cost of a latrine conversion (in 1970's) and the ratio of sharing by the house-holder and the local body is given in Annexure-III, which indicates that the programme is viable and profitable to both parties (3).

7. VOLUNTARY AGENCIES

Safai Vidyalaya

It was established by Harijan Sevak Sangh in Gujarat and it did pioneering work to promote Bhangi Mukti and also played a catalytic role in the progressive conversion programme. An innovative step was taken by the Government in appointing the Principal of the Safai Vidyalaya as the Honourary Advisor to Government to ensure speedy implementation of latrine conversions. This close association and active involvement of a voluntary agency has given a special dimension to the total programme. With their joint effort, between 1964 and 1978, nearly 150,000 dry latrines were converted with nominal incentives to the beneficiaries.

7.1 Sulabh Shauchalaya Sansthan (SSS)

It is a product of the Gandhi Centenary Committee in Bihar during 1970, which first thought that the development of a design for the hand-flush latrine was an end in itself; but soon realised that it was just a means and the ultimate goal was to convert all dry latrines, at low cost, using their own technology and not to allow new service latrines to come up. The Government of Bihar realised the usefulness of this voluntary organisation and sought its assistance for its statewide conversion programme, offering suitable financial assistance to the beneficiaries in the form of loan and grant.

7.1.1 On behalf of municipalities, SSS is also maintaining several community latrines, baths and urinals charging a nominal sum of 10 pisa (one-tenth of rupee) from each user to meet operative expenses and staff salaries. A committee of eminent local citizens with social work aptitude looks after the maintenance of these public latrines and their accounts.

7.1.2 Regarding maintaining community latrines, the local bodies have failed miserably inspite of huge expenditure on round-the-clock duty arrangements, creating terrible eyesores and potential disease transmitting zones at vital and busy centres in urban areas. With the SSS coming into picture, these places have turned out to lovely centres with beautiful gardens and no flies.

7.1.3 The procedures devised for latrine conversion by SSS provided a great relief to households. The factors that promoted community enthusiasm and participation are (i) the character and functional role of the Sansthan workers; (ii) the urgent need for a practical and economic solution to get rid of dry latrines; and (iii) the financial and procedural aid extended to the house-holder, without himself being exposed to the cumbersome procedures of securing loan and doing the work on his own.

7.1.4 Without the active participation of a voluntary agency like SSS, the conversion programme would not have had such a pace with the prevailing slow-moving administrative machinery and soil-to-sky corruption. The voluntary agency - with a very friendly and informal approach - motivates and persuades people to adopt the conversion programme. If there are any hurdles or difficulties anticipated, it takes adequate precautions in advance and does not allow the household to feel his pinch. SSS is a self-supporting organisation which takes 10 per cent of the cost as a commission to meet the cost of staffing, research and development. It has about 50,000 latrines conversions to its credit, in addition to efficiently maintaining several community latrines all over the country.

7.1.5 With sample and streamlined procedures, the SSS takes the programme right from the initial propaganda stage to the end. This approach, with its laudable results, is taken note by other states, which also started similar programmes, seeking the help of this Sansthan. Having spread its approach and philosophy to Sri Lanka, SSS has acquired international status few years ago and is now familiarly called as the Sulabh International.

7.1.6 Just as any other organisation, this agency has passed initial stages of struggle for existence, getting recognition and finally gaining wide acceptability. Great applaud comes not only from different states in India, but also from international agencies abroad. Of late, the negative forces of jealousy and antagonism amongst few vested interests in the bureaucracy are striking roots with signs of waning official support. The usual red tapism and corrupt attitudes may not have much gain from their dealings with a voluntary agency like this, just as they enjoy from their other clients in routine administration and the country's overall development is of not much concern for them. Such hardships by the administration at lower and intermediary levels appear inevitable for any voluntary organisation even with a clean record of honest and sincere services.

8. OTHER STATES

Kerala : A scheme was launched at about the same time, when the State government has compelled the local bodies to get all bucket-type latrines converted and abandon the scavenger service by the close of the Gandhi Centenary Celebration year and the results were marvellous. It remains an on-going programme even today with local organisations and families getting supplies of closets and slabs as incentives from the Panchayat Samithis in rural areas. This practice is now introduced in few urban areas also through UNICEF-assisted programme of small and medium town development.

8.1 Tamilnadu

The Research cum action project was tackling the conversion programme in selected rural areas since 1974 with a government subsidy of Rs. 145.- for each unit. The Urban Community Development project in Madras has started extending this benefit to urban households in Madras Metropolitan area.

8.2 West Bengal

In 1974, the Calcutta Metropolitan Development Authority started a conversion programme in individual houses in addition to providing community latrines in slums. The beneficiary under the scheme bears 25 per cent of the total cost and the rest is offered as subsidy by the Authority.

8.3 Uttar Pradesh

The planning Research Action Institute, Lucknow, invented a new economical design called PRAI latrine with one pit, which in some respects was even better than the septic tank latrine. Some important modifications were made by SSS and the new type with tow pits is called the pit privy or water-seal latrine, or the Sulabh Shauchalaya in Bihar. There are even quite a few modified designs, depending upon the soil and water table conditions. The design of a commonly used one is given in Annexure-IV.

9. SOCIOLOGICAL CONSIDERATIONS

Many people believe that the main bottlenecks in effectively implementing sanitation programmes in low-income settlements are of economic and technical nature. So their outlook is more for low-cost methods with better engineering skill. But in this context, one should not forget (which is not often the case) several human factors, which influence changes in sanitation practices - either in initial provision or insubsequent care and maintenance.

9.1 A recent World Bank study states (4) :

> "It is easier to change technology than to change behaviour, and it is more difficult to determine cultural acceptability than technical feasibility".

9.2 The same study quotes Dr. David Bradley of the Ross Institute of Tropical Hygiene as follows :

> "No matter how much we have learned about the engineering details of alternative sanitation systems and the related health aspects, unless these findings can be translated to the target population in a way they can accept and understand, this is mostly an academic exercises".

9.3 In development there is no such thing as a purely economic or a purely technical problem; but ultimately they are all human problems.

10. Then what are the key social and psychological factors that have to be borne in mind, as we attempt a change in sanitation practices?

Dr. William J. Cousins (5) tried to summarize the main factors in the following formula :

$$M \times 4A + S = CP$$

M stands for motivation, the four A's are awareness, acceptability, availability and adaption, S means satisfaction, and CP is for changed practices. This formula implies that in order to effect change in present sanitation practices, people must be motivated and made aware of new practices, which should be easily acceptable and available so as to facilitate adaption. After adaption, the beneficiary must derive sufficient satisfaction so that he can continue adapting forever the changed practice.

10.1 Motivation is to bring about the desired change for accomplishing the felt-needs.

The question is then whose felt-needs?

- those of the engineer or health educator, who feel the need for people to use sanitary latrines?

- or those of the people themselves, who feel the need to use latrines?

If the answer is people, then which people?

- rural or urban?
- rich or poor?

- young or old?
- healthy or sick?

10.2 We often tend to treat people as an unidentified mass. When we talk of changes in human behaviour, we should remember that we are not attempting at changing masses; but we are attempting to get individuals, like us, change their habits which they have been following all along and which are backed by customs, traditions and values passed on from generation to generation.

10.3 Individuals are members of groups and man is a social animal governed by group norms to a great extent. Each of the members in the group and the group as a whole have different motivations and urges, some of which are favourable and some others antagonistic to our overall objectives.

10.4 Inspite of continued effort for the last three and a half decades, there is still no wide acceptance for the usage of sanitary latrines. This is due to a variety of reasons and beliefs other than economic and technical and they might be :

- it is cleaner to use fields
- the field gets manure directly deposited onto it
- there are too many technical difficulties
- it is a sin to use latrine
- and so on...

10.5 Motivating may also vary with age, sex and education. people adapt latrines for the sick, women and children. In some cases, women resist it because it deprives them of an opportunity to gossip with their friends.

10.6 Socio-economic status may also influence motivation, where convenience, cleanliness and prestige may be the positive factors. On the other hand, economic and technological problems and unending paper work in bureaucracy may act as dis-incentives.

10.7 So the problem is to analyse various types of people and different types of motivations and pair them together so as to facilitate acceptability and adaption. The other important aspect is to pick out relevant information and education material and push it into the minds of the clientele in a palliative way,- using appropriate methods and channels. Many people may be aware of a new practice, but not all of them will adapt. Thus awareness is important, but it alone is not enough.

11. ADAPTION AND FOLLOW-UP

Once the individual accepts an idea and the agency ensures its availability, the final step is how to make the individual adapt the new practice that the agency is struggling to introduce. Peer group pressure, local leader's influence or a community workers' advice may ultimately trigger action.

11.1 There is still much work to be done even after people adapt a new practice. In the case of low-cost latrines, to ensure user satisfaction, the promoting agency has to guarantee that the latrines are (i) technically sound, (ii) easy to maintain and keep clean, (iii) odour free and, (iv) quickly delivered and installed. In short, it is important to anticipate and avoid all possible negative side-effects, so as to encourage more people to accept the new ideas for translation to action stage.

11.2 These various agency efforts have no set chronological order. Where to start to convince people and where to end depend upon the situation. More stress may be warranted on certain steps and this again is not constant. To many, it is an herculean task; and this it is true especially when the idea is totally new to the community, and more so when it is introduced by a strange community worker.

12. WORK FORCE

As one can guess, the beginning is always difficult, laborious and time-consuming. Therefore, the motivators - whether from the bureaucracy or from a voluntary agency - should posses extra ordinary qualities of commitment, devotion and selflessness. Also, they must be closely identified with the community in which they are working. People must treat them as their true friends, philosophers and guides, who are part and parcel with them in all their joys and sorrows.

13. REPLICATION

This programme approach warrants for workers of superlative qualities and this may drive us to the conclusion that it is a slow process with no chances for replication. The habitat housing programme in Hyderabad, in which toilets for individual households is a part, is a concrete example to contradict this view. It was indeed a slow process in the initial period, when the Urban Community Development team had to put in a lot of effort to gain the acceptance of the weaker section communities and slowly change their attitudes to the desirable direction.

13.1 After implementing a programme to the stage of vivid perception, an opportunity was created for other communities to come and have a look at the evident progress in their neighbouring community after all the struggles. Free and frank discussion within the peer groups of the same social and economic footing facilitates easy communication process, minimises the agency work, and eliminates many of the initial steps of education and motivation. Enlightened persons from within the community have been enrolled as volunteers to act as effective links between the implementing agency and the prospective beneficiaries. These efforts have awakened the masses and made them ready to accept any developmental programme, including sanitation, without much reservation and resistance. It looks as though a stage is now reaching, when official agencies might be unable to cope up with their demands and thus the problem is becoming the other way round. This may be further aggravated if the bureaucracy does not simplify and straighten their procedures for speedy and effective programme implementation.

14. BUREAUCRACY

It does not mind much about its wasteful expenditures as long as it implements the total programme. But when a local community or a voluntary agency comes forward to undertake a task, any assistance that comes from the official end is very often with great reluctance and resistance. In the housing programme initiated by government for weaker sections, as high as Rs. 15,000.- were spent for each tenant with no foreseeable returns and at the same time buying a lot of criticism from the public. In the Habitat Housing initiated by the Urban Community Development, the entire construction has become the responsibility of the slum dwellers and when the Government was approached to sanction some incentive to these poor, some officials in key positions have remarked : "When we are constructing houses for them, we have to spend as much money as is needed; but now, when people are themselves constructing their own houses, why should the government give any incentive or subsidy."

14.1 This type of narrow thinking, wrong interpretation and jealousy against others - whether those voluntary agencies or individuals doing things for the overall betterment of the country - is not desirable. In the national interest, these volunteers deserve all encouragement and support, which the Governmental administration should ensure.

15. VOLUNTARY ORGANIZATIONS

They can produce speedy results at lesser costs. The governmental effort to reach the poor, in all its welfare activities, can become a reality only if the local voluntary organisations are given proper recognition and adequate support sought by them. A suitable mechanism is required at a state level to plan and guide the field level administrative units, and at the same time sponsor voluntary agencies to fulfill the overall objectives at optimum speed - without leaving matters to the vagaries, individual tastes and preferences of the local implementation machinery.

15.1 The sanitation programme has large dimensions and a mere expansion of the bureaucratic empire would not yield desirable results. Large numbers of voluntary organisations committed to the task have to be invited to assist the government and create a healthy and long-lasting link between them and the people. It is only then that we can expect speedy results at minimum costs, with the elements of goodwill and understanding prevailing even after programme implementation. The beneficiary should also be acknowledged as a crucial partner in the total process, whose acceptance is vital for the ultimate success of any sanitation programme.

15.2 It is important to have a technically sound low-cost latrine; but that is only a beginning of the total task of getting it widely accepted and used to the best advantage of the family and the country as a whole.

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THE WANGING'OMBE RURAL SANITATION PROJECT
NOTES FROM THE FIELD

Ivan A. Blakely
UNICEF Project Officer

As a sequel to the UNICEF-assisted Wanging'ombe Gravity Water Supply project serving fifty developing villages with a population totalling close on 80,000 inhabitants, the Wanging'ombe Rural Sanitation Project was conceived in 1980 in order to further up-lift the health standards of the people in the area.

In realizing the close link between a permanent supply of clean water and proper sanitation facilities in order to eradicate or at least minimize the incidence of water related diseases, many of which are of faecal origin, it was felt that the water supply would be more meaningful if it were accompanied by an environmental health education campaign and the introduction of better sanitation technology.

A cross-sectional survey of the area, in four villages by the Regional Medical Officer, together with a TAG mission and UNICEF in August 1980, and again in October 1980, confirmed the desirability for improved sanitation, and also that the villagers were prepared to take up a second challenge by participating in the same way as they had done in the water supply.

The sanitation project was therefore designed as a project of the people of the Wanging'ombe area, to be implemented on a self-help basis, with assistance from the Government and UNICEF, only in providing inputs which are not available at local level. The UNICEF input is mainly in the form of hardware, such as cement for the building of pit linings, and also reinforced concrete squatting slabs which are being cast at the UNICEF base camp in the centre of the project area. However, since the new technology was developed at the base camp, under guidance from Prof. A.M. Wright of the TAG group, UNICEF is also assisting in transferring the new technology into the villages, initially by way of seminars at the base camp for the four pilot villages, and later in the form of demonstration units in the same villages.

The project was planned for implementation in three phases, namely, the preparatory phase, the pilot programme phase and the main programme phase. Having recently entered into the main programme phase, the following resume of what actually happened, on site from the beginning up to the present date, could be helpful in trying to forecast what might be expected during the remainder of the most important programme phase.

THE PREPARATORY PHASE

This began with initial meeting in four villages in August 1980, to find out, firstly, if there was really a need for improved sanitation in the area or not, and secondly, if there was a need, what would the level of acceptance be in terms of self-help by the villagers. The affirmative response from village councils in both cases let to a further exchange of ideas on how best the problem could be tackled, what local resources in terms of building materials and skills were available, what items or components were lacking which prevented villagers from constructing longer lasting pit latrines which are structurally safe, instead of the existing unsound temporary types which had to be re-built frequently as storm water caused pit walls to collapse in the rainy season, and termites weakened the bush-pole platforms used for squatting on.

Traditionally, Wanging'ombe is a brick-making area, and the use of both sun-baked and kiln burnt bricks is common in almost all villages, especially in the construction of primary schools where burnt bricks are prevalent, however the jointing material used is mud in lieu of cement.

It was soon learnt that cement was one of the biggest constraints facing villagers, both in terms of availability and also affordability, and while sun-baked or burnt bricks could be used for structures above the ground, with only mud jointing, the same conditions would not apply below the surface, where ground water seepage would tend to disintegrate mud joints through permanent saturation. It was also learnt that insufficient appropriate technology, and insufficient environmental health education which could lead the villagers forward towards a better understanding of the importance of good personal hygiene, were two other major constraints.

On the basis of what was learnt during the meeting with village councils, both in August 1980 and again in October 1980, when the second TAG mission visited the project area, it was recognized that inputs, over and above local capacity would be required in the hardware, appropriate technology, and health education components.

Beginning with the hardware and appropriate technology components, since these two are closely linked, the first step in the design of the project was to develop a variety of suitable low-cost pit latrines by building as far as possible on the locally available resources and technology. This exercise was done at the UNICEF base camp in November 1980, by Prof. Wright and the UNICEF Engineer, during many hours of discussion and exchange of ideas. The objective was to create a selection of options, each of which would be an improvement on the existing technology, and would also be readily affordable by the villagers, and from which they could choose in accordance with their needs and preference.

Basically two types of ventilated improved pit latrines were considered, and there were (a) permanent type; and (b) semi-permanent type.

Two versions of the permanent type were among the options, one was the "off-set" alternating type, and the other was the "direct" double vault compost latrine called the Tanzanian UTAFITI type. Both of the permanent types would require emptying each vault in turn after a period of approximately 6 years.

Five versions of the semi-permanent type were also included, and out of these, three were "off-set", and two were "direct" type. The semi-permanent types would not require emptying, but would have to be abandoned on filling up after approximately 12 years.

Before the second TAG mission left the project area in November 1980, designs were on paper for six of the proposed options, and the design for the seventh option, namely the UTAFITI type was available from the Ministry of Health.

The next stage in the design of the project was to construct the proposed options at the UNICEF base camp, firstly to test their feasibility, secondly to monitor any difficulties encountered, and thirdly to monitor the materials input.

Burnt bricks were of course, the main component, with the use of cement mortar for jointing. Reinforced concrete slabs of various sizes were used for covering the pits and also as squatting plates. The privy rooms or superstructures were built also with burnt bricks, with modesty walls taking the place of doors, except in the case of the UTAFITI type in which a wooden sheeted door was used. Some of the ventilation chimneys were initially constructed using PVC pipes, however these were later changed to burnt bricks throughout, and included a nylon fly-screen at the top. Roofing materials included the use of C.I. sheets, however again as a further option, some of the units were changed to a thatched roof in order to reduce costs and in turn render them more affordable.

In considering the superstructures, the TAG mission recognized that the most important part of the improved type latrines was that below and including the squatting slabs, hence it was not considered necessary for external inputs to include the construction of privy rooms, except the ventilation chimney.

The average number of burnt bricks used in the demonstration models was 1390, for the complete structure including the privy room. The average number of bricks used below slab level was 760, and the average number of bricks used above slab level for privy shelters was 630.

The amount of cement used below slab level was more than two bags initially, however it was found that by reducing the traditionally thick joints $1\frac{1}{2}$" and sometimes 2" down to $\frac{1}{2}$", two bags of cement were more than sufficient to construct the pit lining and the vent stack. The superstructures at the base camp were all built with burnt bricks using cement mortar, and for this an additional two bags were required, on average.

Only a minimal supervision was offered to the team which constructed the demonstration models, this was for the specific purpose of seeing a more realistic result, and in turn getting some idea of how easy, or difficult it might be to pass on the technology into the villages. The results were encouraging.

The construction of the seven selected options at the base camp took place between mid-November 1980 and mid-February 1981, and their completion was geared to coincide with the final stages of the preparatory phase, namely a Seminar for all key personnel involved in the project at all levels.

The two-day Seminar, which was organized by UNICEF, was held on February 24th and 25th 1981. at Soliwayo village which is situated in the centre of the project area. Its main purpose was to bring together all the participants in order to meet each other, some for the first time, and also to share with their colleagues details of the specific role which each individual would play, as a contribution to the Wanging'ombe Sanitation Project, to make it a success.

The third TAG mission was also arranged to coincide with the Seminar, during which time the demonstration models at the base camp were inspected and discussed by the participants. Later, four "candidate" systems were selected for promotion in the four pilot villages. These were the two permanent types, and two out of the five semi-permanent types. Two main committees were formed also during the Seminar. First was the Steering Committee, headed by the Area Commissioner, and comprising of former members of the water project committee, including Regional and District Medical Officers and Regional, District, Divisional and Resident Health Officers. The second committee, headed by the Regional Medical Officer, was the technical team comprising of all personnel involved in the actual implementation of the project.

A field trip was made on 25th, February to each of the four pilot villages, after which the Seminar was closed by the Ag. UNICEF Representative, Mr. L.G. Wadstein.

THE PILOT PROGRAMME PHASE

Prior to moving into the four pilot villages, a series of one-day seminars were held at the base camp in order to introduce the project to local artisans, to test their reactions and capability in following the new but simple technology, and thereafter work began in earnest in each of the villages almost simultaneously. The construction of the "candidate" system was entirely a UNICEF-supported exercise with the use of local masons. The reason for this was to speed up the operation in order to get construction of household latrines underway as early as possible after villagers had the chance to observe the options and decide on which one was most suitable for them. A request for the construction of all seven options by each village council was met, however even with this additional work, the demonstration models were mostly completed by mid-June, when the Resident Health Officer eventually arrived in the area to take up duty.

At this stage it was not quite clear how far villagers would be left to make their own individual choice from the options, however it was hoped that a standard model would be chosen for each whole village, thus facilitating the casting of concrete slabs at the base camp. It became apparent towards the end of July that the general choice in all four villages was the semi-permanent direct pit latrine, which so closely resembled the traditional design. The selection was made largely on the basis of the very simple technology involved, and also probably because of the limited health education which had been possible up to that point.

The huge task of brick-making began in the pilot area as early as July, and continued throughout the remainder of the dry season up to mid-November 1981. Reports of the first completed improved pit latrines began to come in as early as September, and this in turn led to the first Technical Committee meeting which was held at Njombe on 21-9-81. Monthly meetings were held thereafter, however in addition to this, a fourth scheduled TAG mission visited the project in early November, and it was during this visit that some curiosity arose regarding the initial choice of technology. Participants at the Seminar held in February had recognized the desirability to promote the use of permanent type latrines as far as possible within the limits of acceptance, and the TAG mission was anxious to learn about the basis on which the villagers in the pilot area had decided to adopt collectively one of the semi-permanent options. After brief meetings at Regional, District and village levels, it was clear that insufficient explanation on the merits of each technical option had been extended to the villagers. Demonstration models had been built, but there had not been a formal meeting with village councils to provide guidance during the selection process, and without this guidance, the model chosen was that most resembling the traditional type.

However, even at this stage, it was not too late to review the situation as only about 44 of the semi-permanent units had actually been constructed in the pilot area, with pit excavation on-going in a total of approximately 100 households.

A new exercise was conducted in each of the pilot villages which included a full briefing on the merits and expected useful life of all seven options. The exercise also served as an initial introduction to the village councils on the topic of decomposed excreta removal from alternating pits, and its use as a fertilizer for garden crops.

The results of the new exercise were indeed surprising. With sufficient guidance, and more awareness, in the logics of future cost implications, future space problems within the villages, the harmless nature of decomposed excreta, and the benefits which can be derived from its use as a fertilizer, albeit the latter with some reservations, the four village councils confirmed the acceptability of a permanent alternating type latrine.

Concrete slab making at the base camp halted temporarily, and a closer look was taken at the design of the alternating pit latrine which had now been chosen by the pilot villages, in order to try to further reduce its cost. From the beginning, it had been noted that the off-set alternating model involved the biggest external input of all the options, due to the fact that eight concrete slabs were required to cover the double vaults, and a further two were required inside the privy room, one as a squatting slab and one as a plain sealing slab.

A study of the traditional brick kilns in the area revealed that the simple technology, used in forming the arch over the openings left for the insertion of firewood, could also be used (with slight modificatio), in covering the vaults of the double pit latrine by means of a dome, thus eliminating the need for the eight concrete slabs. In this, an alternate means of emptying the pits had to be found, as the top of the pits would be permanently sealed, and it was decided that the easiest way to facilitate this was to leave an opening of 2 ft by 2 ft at the bottom of each pit. This would mean that when a pit would require to be emptied, a shallow excavation would be made at the rear of the pit to locate the opening, through which the decomposed excreta could be removed by simply raking it out. After emptying, as also during initial construction, the opening would be blocked by the use of bamboo canes to prevent backfilled soil from entering the pit.

With the knowledge that there would not be any more bricks required in the new design than the original design, and also with the confidence that the simple technology could be passed on to the local artisans, it was decided first to build a demonstration model at the base camp, and thereafter in each of the pilot villages. However, the construction went only up to slab level, with one vault left open, and one completely sealed by the dome, so that villagers could see clearly the details of how it was built. This work has already been completed, and it is expected that household construction of the new alternating option will begin shortly after the rainy season, in April. The pilot programme will therefore overlap into the main programme phase.

THE MAIN PROGRAMME PHASE

Having entered into this phase in January, which is scheduled to last for three years, and consists of 15 villages each year, the first 15 villages were selected in December, and a more consolidated strategy has been possible, from experience gained in the pilot phase.

Introductory meeting in each village took place between 20th January and 11th February 1982, and the unanimous acceptance of the new dome pit latrine in all villages to date brings growing hopes that the Wanging'ombe Sanitation Project might be as successful as the water project.

THE PROBLEMS OF HUMAN WASTES DISPOSAL IN A MALAYSIAN NEW VILLAGE

W.C. Lam

Associate Professor
School of Biological Sciences
Universiti Sains Malaysia
Penang, Malaysia

Assistant Secretary
School of Biological Sciences
Sahabat Alam Malaysia
Penang, Malaysia

S.H. Poh

Final Year Student
School of Biological Sciences
Universiti Sains Malaysia
Penang, Malaysia

ABSTRACT - Permatang Tinggi, a new village of about 2,000 people in northern Peninsular Malaysia, was chosen for the study. The richer villagers use the pour-flush toilet system connected to septic tanks. However, a significant proportion of the villagers uses the bucket system. The problems of human waste disposal arose mainly with the latter system. The buckets were manually collected from each house once or twice every week due mainly to shortage of labour. The wastes were stored at the roadsides on the outskirts of the village to await transportation by lorries for final disposal. The defects of the bucket system are many and they include offensive smells, flies, health hazards and general unpleasantness. It is suggested that underground community biogas digesters be built for primary treatment of the wastes and the sludge be further treated by stabilisation ponding. The advantages of the proposed system are discussed.

INTRODUCTION

The disposal of human wastes in Malaysia is highly unsatisfactory. In 1974 it was estimated that about 5% of the population, mainly in urban centres (2), had direct access to community sewerage systems and that a large proportion of the population had no facilities for human wastes disposal (Table 1). The situation has not changed very much since then (1,5).

Table 1. Percentage of Population in Malaysia Using Various Types of Human Waste Disposal System in 1974.

Sanitary Facility	% of Population
Sewerage system	5.0
Septic tank	14.4
Bucket system	17.4
Pit latrines	30.4
No facilities	32.8

In rural areas, the problems of human wastes are critical due to its low priority given by the government as compared with other infrastructural facilities such as roads, schools, electricity and water supplies. An inefficient human waste disposal system will expose the community to infections by pathogenic organisms and provide conditions conducive for the breeding of disease vectors such as flies.

The probability of risk of occurrence of disease epidemics - such as cholera and other human waste-related diseases which affect a great number of people within a short period of time - increases from a sparsely populated rural setting to a more densely populated new village set-up. An efficient human waste disposal system, therefore, cannot be overemphasized, especially when there is a drive for increased low-cost housing in a national attempt to satisfy the pressing housing demands from the lower economically and nutritionally disadvantaged sector of the population which are, therefore, least resistant to health hazards.

THE NEW VILLAGE - PERMATANG TINGGI

Permatang Tinggi (Fig. 1) in northern Peninsular Malaysia is a typical new village in Malaysia. It is the biggest village in the cluster of five villages in the area and is the best developed in terms of infrastructures. The total population of the area is about 3,000 with Permatang Tinggi Baru having about 2,000 (Table 2). The village has 324 houses with 382 families, each having on the average 4 to 6 people. The land use around the village is mainly agricultural (Table 3) and the main crops are coconut and rubber (Table 4).

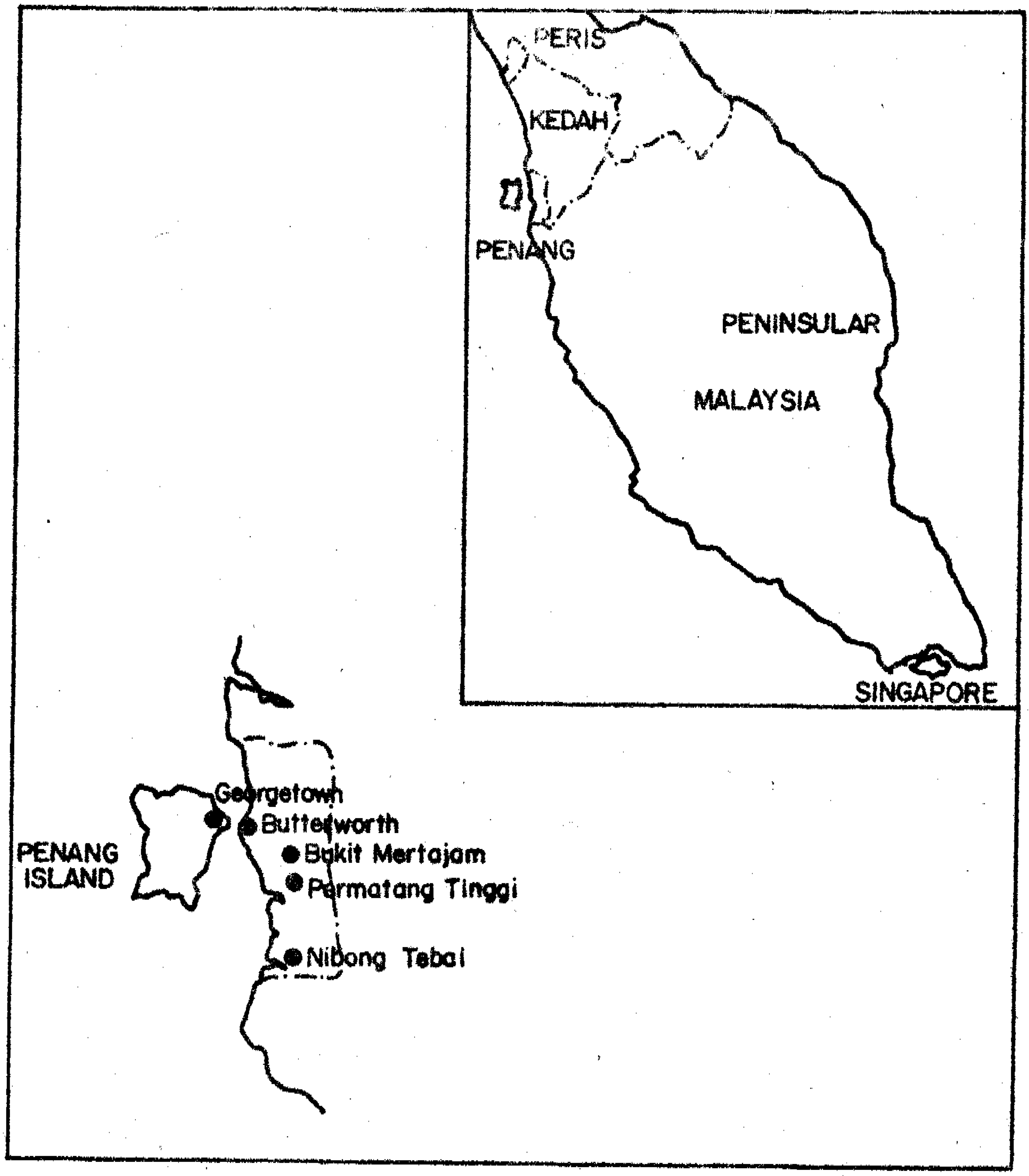

Figure 1 Site of Permatang Tinggi in Northern Peninsular Malaysia

Table 2. The distribution of Population in the Permatang Tinggi Area.

	Population
Permatang Tinggi Baru	2146
Tonkang	518
Permatang Sena	155
Estat Weng Lee	120
Estat Nenas	114
Total	3023

Table 3. Land Use in the Permatang Tinggi Area.

Land Use	Acreage (ha.)
Agricultural	49
Non-Agricultural	6
Governmental use	3
Housing	12
Total	70

However, only about 30% of the population are involved in agricultural activities and the rest are mainly factory workers, government employees, etc. and others. It is interesting to note that a large proportion of the population goes out of the village to work. A recent survey of the income distribution of the villagers (Table 5) showed that about 90% earned M$ 400.00 or less per month (US$ 1 = M$ 2.3).

HUMAN WASTE DISPOSAL SYSTEM AT PERMATANG TINGGI

Various types of sanitary facilities are presently being used in the village of Permatang Tinggi. These consisted of the bucket, pour-flush, pull-flush and pit latrines.

Table 4. Distribution of Agricultural Crops in Permatang Tinggi.

Agricultural Crop	Acreage (ha.)
Coconut	24
Rubber	16
Oil Palm	8
Others	1
Total	49

Table 5. Income Distribution of the Villagers of Permatang Tinggi.

Income per Month	% of Population
Less than M$ 250.00	41
M$ 250 - M$ 400	48
More than M$ 400	11

The majority of the villagers use the bucket system (Table 6). The bucket system and the pit latrines are most unsatisfactory while the flush systems discharging into individual septic tanks are more adequate but are not functioning satisfactorily, due to poor maintenance.

Since the majority of the villagers use the bucket system, the problems associated with the system are of utmost concern. Management of human waste disposal in Permatang Tinggi is under the Municipal Council of Seberang Prai. Under the system, a team of conservancy workers are employed to empty the buckets each morning. The wastes are then sent to conservancy trucks to be transported for trenching.

The bucket system is very unsatisfactory in Permatang Tinggi since it is labour-intensive; the working conditions are bad and the workers are exposed to health hazards. As such, labour to operate the system is increasingly difficult to get, with the result that the already unsatisfactory nature of the system becomes worse. Although collection includes the washing out of the remaining wastes from the buckets, very often the washings are conveniently disposed off in the nearest drains and surrounding areas. This results in the contamination of surface- and groundwater sources, besides it attracts flies. This practice of disposal of the washings of the remain of human wastes also poses a health hazard to children playing around the houses.

Table 6. Sanitary Systems in Use in the Village of Permatang Tinggi

Sanitary System	No. of Houses
Bucket	214
Pour-Flush	54
Pull-Flush	18
Pit	18
Total	304

The shortage of labour for the conservancy service has become critical in the Permatang Tinggi new village, so much so that the collection of human wastes from the bucket is presently being done once or twice a week. Although the service normally begins very early in the morning, due to severe shortage of labour it occupies the whole morning and sometimes extends to the afternoon. Thus this subjects the villagers to the unpleasantness of the system for a prolonged period. If there is a breakdown of the service due to one reason or another, there is a real possibility of overflow of the buckets with subsequent health risks to the villagers. Also, prolonged non-removal of human wastes results in the breeding of disease vectors such as flies, cockroaches and rodents. The breakdown of conservancy service has happened in Permatang Tinggi.

The conservancy services in Permatang Tinggi also face the shortage of conservancy trucks for the transportation of the wastes for final disposal. The wastes after collection were temporarily stored at a few sites by the roadsides at the outskirts of the village. This poses a number of problems to nearby residents. The most immediate complaint was the unpleasant smells carried by even a slight breeze. Besides being unsightly, the temporary storage of each batch of wastes became a continuous affair of storing batch after batch, and so the areas are foci of health risks due to spillage and carelessness. The sites also attract animals and flies which increase further the health risks.

SUGGESTIONS FOR HUMAN WASTES TREATMENT FOR A NEW VILLAGE

It is suggested that pour-flush water-seal latrine be installed for discharging into underground community digesters at least for primary treatment of human wastes. The construction of such a system is shown in Figure 2. The main digester is made from three pieces of readily available concrete drains (175 cm Ø and 150 cm long) and the effluent compartment is made from a piece of small concrete drain (60 cm Ø and 90 cm long). The cost of constructing the digester is about M$ 1,800 (Table 7) and the cost of converting a bucket toilet to a pour-flush toilet is M$ 100.

The operative volume of the digester is about 6.5 m^3. Assuming the volume of excreta per person per day is about 4×10^{-4} m^3, the amount of waste from a household of six persons would be 2.4×10^{-3} m^3. If the dilution rate is ten times, the volume of wastes per household is 2.4×10^{-2} m^3 per day. If a retention time of 30 days is required, the digester would be able to serve nine households. The cost of conversion of the bucket type latrine to the pour-flush water sealed latrine connected to underground digesters is estimated at M$ 300 per household.

Table 7. Estimated Cost of Biogas Digester for Human Waste Treatment as Shown in Figure 2

Items	M$
Large concrete drains (3 pieces)	900.00
Small concrete drain	50.00
Cement	150.00
Sand	50.00
Manhole cover	50.00
Piping of various sizes	100.00
Cost of digging	100.00
Labour	250.00
Miscellaneous	150.00
Total	1,800.00

The digesters could be desludged once a year by sewage tankers. The effluent can be retained in three ponds about 120 cm to 150 cm deep for a further period of 7 to 10 days (5), during which organic and bacteriological content of the waste water is reduced by about 90%. Land required under Malaysian conditions has been estimated to be about one hectare for 5,000 people (5). Operation and maintenance of these stabilisation ponds require very little skill.

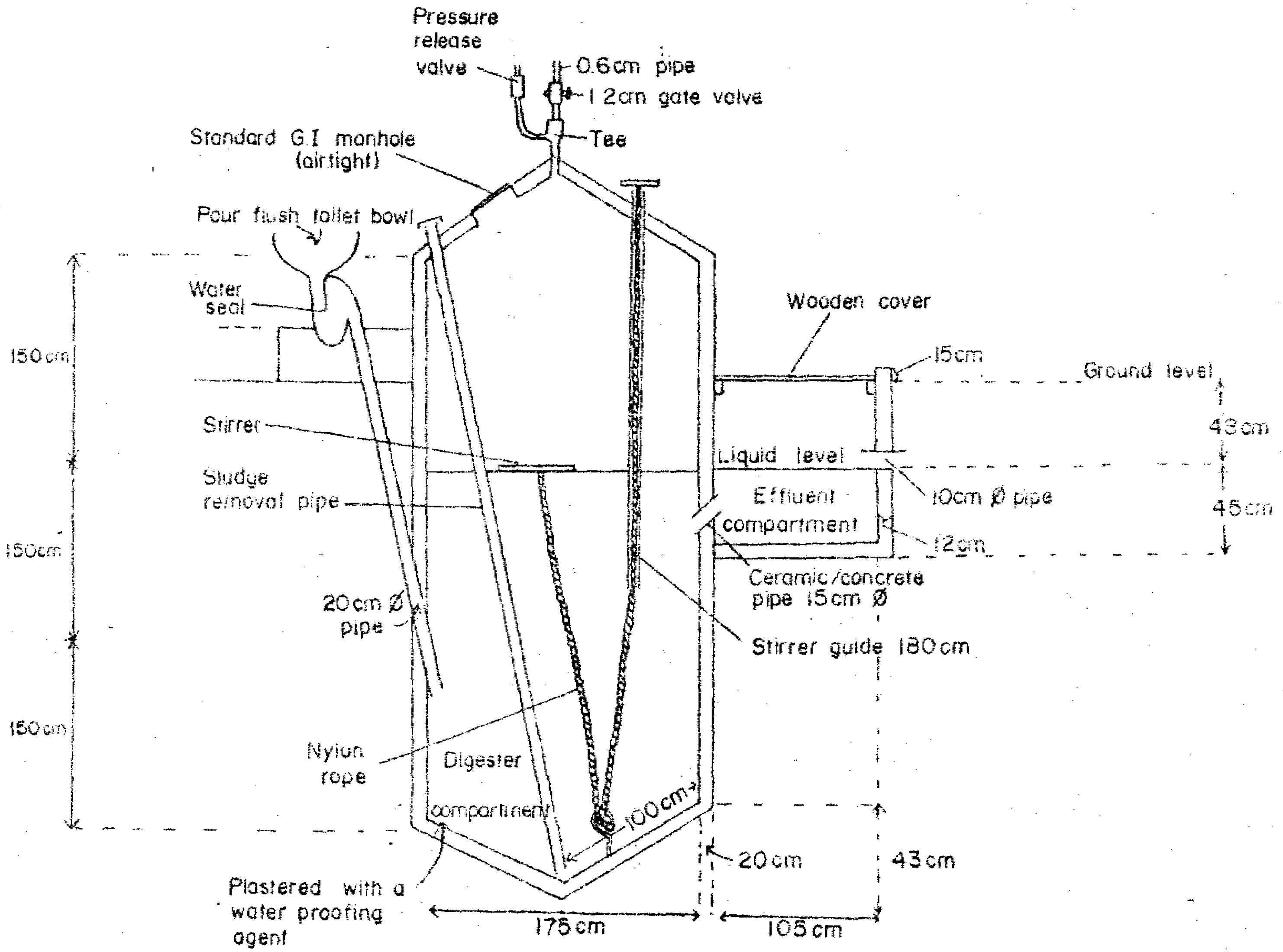

FIG. 2: DIGESTOR FOR TREATMENT OF HUMAN WASTES

DISCUSSIONS

Despite its importance, health care received only one percent of the Malaysian federal government development budget in 1982. In the Fourth Malaysia Plan, only M$ 120 million or one quarter of the total amount allocated for health care is for rural health services. Medical services are given top priority while in rural areas sanitation is of low priority. For good public health in the rural areas as well as for the protection of the nation's water resources, effective systems for treatment of human wastes should be installed.

The inhabitants of Permatang Tinggi belong to the lower-income group of people in Malaysia. Although the bucket system of human waste disposal is one of the cheapest in terms of capital investment, it is unreliable and highly dependent on the availability of labour. With increasing standards of living of the general population and higher expectations of job satisfaction, staffing is a big problem in the conservancy system. The bucket system at present in Permatang Tinggi is highly unsatisfactory. Similar situations appear to exist in other new villages. To maintain a clean and healthy environment, there seems to be very little choice for new villages like Permatang Tinggi in the near future but to opt to a waste disposal system that requires as little as possible human labour to operate, is as simple as possible to maintain, and is reliable.

Although the pour-flush water-seal latrine discharging into underground digesters is too expensive for the inhabitants in the new villages to implement, the system is low cost in comparison to more conventional reliable waste treatment methods. In considering the improvement of sanitation situations in rural areas, the Ministry of Health should take upon itself the concept that underground digesters for the treatment of human wastes in new villages as basic infrastructural facilities are comparable to the central sewerage systems in urban areas. All the materials for construction of the pour-flush water-seal latrines connected to underground digesters are available locally. To establish these facilities, materials could be provided by the Ministry and the community encouraged through self help by subsidies, demonstration and training in groups in the construction, use and maintenance of these facilities, as well as technical supervision in the actual construction process.

It is suggested that pour-flush water-seal toilets connected to underground digesters be implemented as a pilot project in rural areas in Malaysia for the treatment of human wastes. The pilot project should assess the feasibility, appropriateness, and general acceptance of the system from the villagers.

The concept of anaerobic treatment of human wastes followed by stabilisation ponding has many advantages. Besides its effective removal of smells and reduction of harmful organisms, its biogas could be used as a fuel for community purposes such as lighting of streets and of sports facilities. The sludge after further treatment is an excellent organic fertiliser. The effluent in the stabilisation ponds is excellent for culturing algae which could be harvested as animal and animal feeds.

The use of biogas system in the rural areas in Malaysia has been suggested (3,4), and their advantages highlighted. Biogas digesters using a combination of various human, animal and agricultural wastes has been successfully used in China and India (6).

ACKNOWLEDGEMENT

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AQUA PRIVIES AS APPLIED TO THE REFUGEE HOLDING CENTERS IN SOUTH-EAST THAILAND

Ksemsan Suwarnarat

Consultant
Water Technology and Laboratory
Bangkok, Thailand

Chainimit Nawarat

Architect and Planner
Premier Product
Bangkok, Thailand

GENERAL ASPECTS OF THE AQU-PRIVY (AP)

The aqua-privy is a modified septic tank and was first built by Grifi and Williams in Darjeeling in 1917, an adaptation of the American cylindri septic tank (Williams, 1924). A vertical drop pipe extends from the toil bowl or squatting hole to just below the water surface within the tan The tank is charged with water at the outlet, and then water is added sufficient quantities to maintain this water seal. Household wastewat (greywater) can also be disposed of in the aqua-privy. The solids sink the bottom, and the effluent is carried to a leaching field or soakaway f infiltration into the soil. The tank must be desludged periodically. If t tank leaks, the water seal ceases to function and the AP will become a si ple pit privy. Due to this aspect, success with the aqua-privy has be varied. There are positive reports from Nigeria (Oluwande, 1976) and t British West Indies (Sebastian, and Buchanan 1965), but on the other ha Botswana (Daily News, 1975) once issued a ban on aqua-privies because the odour problem. Aqua-privies in Botswana were usually built on-si with manual techniques. Therefore, the water seal could not be ensured.

The unique feature of an aqua-privy is the vertical submerged pi which is used as a drop-shute for the faecal matter. (Wagner & Lanoi 1958). The shute has a water seal which is brought about by the liqu within the receiving tank. This shute offers an unobstructed passage f any materials which are disposed of into the AP. The submergence of t shute provides a water seal which prevents odourous gases of the purifyi sludge from entering the environment of the user. Comparing the AP sy tem with the well known water-seal latrines such as the pour-flush latri or the water-seal squatting plate (Wagner & Lanoix, 1958), the content the AP is inferior in terms of odour prevention; i.e. the odour occurs w: in the tank will be able to leak into the user's environment at a propor of (area of chute opening : area of the horizontal cross-section) - this p portion will generally be around 5:1000. The aqua-privy is, however, perior in two aspects, namely :

1. The drop chute will not be obstructed by anything smaller than passage; i.e. 8 to 15 cm in diameter according to the design. T means that rags, rope, shoes, twigs, leaves etc. cannot abuse AP but the labyrinth water seal of a pour-flush latrine will be cl ged by these materials.

2. The drop chute does not require water for flushing. Faecal mat dropped into the chute may float and linger for a while but disperse and sink to the bottom of the tank. Faecal matter o normal diet composition usually sinks immediately, leaving the s face of the water seal free.

APPLICATION OF THE AP AT REFUGEE HOLDING CENTERS

Refugee holding centers have been established since the influx of refugees into the Thai territory. These holding centers have been finan by many international and Thai agencies. Major contributors to the hold center management and control are The Thai Supreme Command who contr the policy, and the UNHCR who coordinates the supply of resources.

The holding centers have been organised to actually hold the refug at a definite locations where appropriate treatment may be rendered. T refugees are meant to be staying at the centers temporarily awaiting furtl transfer to their motherland or otherwise to a third country.

Due to the above-mentioned situation, the holding centers are not lowed to developed into a permanent community inspite of their populat size and density. The nature of buildings, infrastructures and activit have also been kept within the scope of a camp. With regard to the fae waste disposal, many methods have been applied.

Major applications are :

1. Open trench privy
2. Pit privy
3. Pour-flush pit privy
4. Aqua-privy

These methods are being used simultaneously at various proportio The AP, being the new-comer, has been introduced by the UNHCR probal due the accumulated experience on the other preceding methods. For ir tance, the open trench and the pit privy are difficult to maintain clea and the pour-flush privy requires flush water which is either not available or not used regularly. The AP is obviously a compromise between the two other types. It does have a water seal and does not requires flush water in order to function.

A number of AP have been designed and manufactured by Premier Products Co., Ltd., Bangkok, Thailand, according to the purchase order of the UNHCR. These AP are made of fibre glass reinforced plastic which may ensure a number of particular aspects :

1. The water seal is maintained by an absolutely water-light structure;

2. Due to a definite and self-supporting structure, the tank can be moved to, and reused in, another place.

3. The unit can be manufactured, stocked, distributed and installed within a short time. Production and stock can be adjusted to cope with the unpredictable demand from time to time during crisis situations.

4. Prefabrication technique allows a rigid quality control.

5. The light weight material is easy to handle during transportation and installation, especially by mutual help among unskilled refugees.

The AP system must be looked upon as a waste disposal system which comprises of three important parts :

a) The toilet or the receptacle, where defecation takes place.

b) The digestion tank, where treatment of the faecal matter tanks place.

c) The final disposal of the treated effluent to recycle the treated wastes into the natural environment.

According to the manufacturer, they have been held responsible for the first two parts. The manufacturer, however, offers also consultancy upon the construction of part c) in the form of instructional booklets and occasional visits to discuss application problems with the sanitarians at the camps. Part c) of the AP system is apparent under the management of camp sanitarians.

TOILET FUNCTION OF THE AP

Personnels have been sent to five holding centers to inspect more than half of all the toilets installed. The total number of APs visited was 1,424 seats. This large number of sample ensures a good coverage of the situation.

The following aspects are checked.

1. General condition : "Usable" means that the person feels that he has no reluctance to defecate at the toilet, and "not usable" means vice versa.

2. Fly nuisance : if there were less than 5 flies crawling on the seat or in the toilet room at the instance the door is opened, flies will be registered as "found". If the inspector sees that the number of flies are more than five , he will register the result as "excessive". If no fly is found he will register "nil".

3. Discharge failure : means that the effluent has been blocked and that the liquid level in the drop chute is found higher than normal.

4. Smell will be noted as failure when the inspector is disturbed by the smell so badly that he does not want to defecate there.

5. Comfort will be noted as failure when the temperature and the internal environment such as floor, roof, etc. are so bad that the toilet cannot serve the purpose.

6. Privacy is a failure if the inspector feels that he can be seen from outside through holes, cracks or inadequate visual protection.

The results of the survey in Table 1 show that the APs are generally in good conditions as toilet units. Problems on flies and smell are negligible. The leakage of the AP tanks was not found. The main problem is only at the final discharge which cannot be improved at the toilet or the digestion tank but at the final disposal provisions.

Table 1. **Performance of Aqua–Privies on Personal Hygiene**

Site	% Inspected	No. of seats inspected	Condition		% usable	% flies found	Reasons of failure % total			
			Not usable	usable			discharge	smell	comfort	privacy
1. Panat	63	200	4	196	98	1.5	4	–	–	–
2. Sra Keow II	60	632	24	608	96	14	24	–	–	–
3. Kamput	47	336	6	330	98	15	4	–	2	–
4. Mairut	80	168	–	168	100	37	–	–	–	–
5. Karb cheng	61	88	–	88	100	–	–	–	–	–
Total	62.2	1,424	34	1,390	98.4	13.5	32	–	2	–

Flies found on the seat are never more than five per seat

TREATMENT FUNCTION OF THE AP

The AP units are expected to work as septic tanks in two functions, namely settling and digestion. The treatment functions are indicated by a number of analyses as follows :

COD (Dichromate chemical oxygen demand) : When organic faecal matters are digested and escape from the digester as methane, COD will be reduced. Also when organic solids settle and accumulate in the lower part of the tank, COD in the effluent will be less than in the influent.

NH_3-N (Ammoniacal nitrogen) : When the organic protein becomes hydrolysed by digesting bacteria, NH_3-N will be released. Solids will be reduced and methane fermentation will likely to occur.

Grease (Hexane-extracted solids) : Grease is the main constituent of the faecal solids. Digestion process may produce grease in the form of scum which can also further disintegrate as the reaction proceeds.

Vdatile acids (Acetic and other organic acids) : Volatile acids are the intermediate substances in the anaerobic conversion of faecal matter to methane.

pH (Hydrogen ion potential) : pH outside the range 6 to 8 will not encourage the methane fermentation. Low pH (i.e. below 7) also induces the release of odourous gases from the digesting liquor at a roughly proportional degree.

The result of analyses on samples of influent and effluent of the APs in Table 2 show that the APs are operating well as digesters.

Table 2. Performance of the Aqua-Privies on Treatment

Analyses		Influent		Effluent	
		Range	Mean	Range	Mean
pH				6.76 to 7.51	
COD	(g/l)	80 - 320	237.0	3.6 to 18.8	12.4
NH_3-N	(g/l)	1.0 - 3.3	2.8	862 - 2421	1457
Grease	(g/l)	0.47	36.4	38 - 414	105
Volatile acid	(g/l)	0.3 - 1.2	0.65	4.1 - 44.3	22.7

A reduction of COD from 237 g/l to 12.4 g/l shows that the solids are settled and accumulated within the tank. Only 5% of the COD is allowed to pass into the effluent. Solids digestion also takes place because NH_3-N increases to a very high level. An increase of grease from 36.4 to 105 mg/l indicates that the digestion is still incomplete. An increase of volatile acids from 0.65 to 22.7 also points out the state of digestion.

The analyses results in Table 3 indicate active digestion and sedimentation, but methane fermentation cannot be expected. Methane fermentation and also the general condition may be expected if the number of users is reduced to below 20 persons per seat.

EPIDEMIOLOGICAL ASPECTS

This aspect concerns with the prevention of health hazards associated with faecal contamination. The following tests for parasites in the influent and effluent have been made (Department of Medical Science, 1980).

1. Al (Ascaris lumbricoides)
2. Hw (Hook worm)
3. Hm (Hymenolepis nana)

The results in Table 4 show that there is practically a complete removal of these parasites.

Table 3. Various Aspects of Treatment in the AP

Number of Sample	Station	pH		COD		NH_3-N		Grease		Volatile acids	
		in	ef	in g/kg	ef mg/l	in mg/g	ef mg/l	in mg/g	ef mg/l	in mg/g	ef mg/l
WT–24/25	S_1, in ef		7.48	290	9.825	3.3	1218	40	101	0.9	12.8
WT–26/27	S_2 in, ef		7.21	120	16.963	1.5	1936	62	145	0.3	36.5
WT–28/29	S_3 in, ef		6.79	270	19.450	3.1	2027	45	199	0.9	15.5
WT–30/31	S_4 in, ef		6.95	210	9.763	1.0	1172	47	113	0.4	21.5
WT–32/33	S_5 in, ef		7.51	270	10.938	2.2	1842	nil	142	0.6	18.8
WT–34/35	S_6 in, ef		6.76	240	12.338	1.2	1078	28	59	0.5	23.3
WT–37/38	P_1 in, ef		7.54	300	18.750	1.0	2363	21	406	0.5	43.2
WT–36/39	P_2 in, ef		7.28	320	18.338	1.4	2421	21	414	1.2	44.3
WT–40/41	K_1 in, ef		7.00	270	3.600	1.9	635	16	39	0.6	4.1
WT–42/43	K_2 in, ef		7.22	80	4.126	1.3	862	9	38	0.4	6.8

in = influent
ef = effluent

S = Srakeow
P = Panatnikom
K = Kamput

Table 4. Removal of Ascaris, Hook Worm and Hymenolepis nana from the Faecal Effluent Which Passes Through the AP

Location	Number of Parasites per Gram Sample					
	Accaris		Hook worm		Hymenolepis	
	in	out	in	out	in	out
Srakeow	1	0	53	9	-	-
	177	0	707	0	-	-
	0	1	88	0	18	0
	18	0	247	1	18	0
	88	3	265	4	-	-
	-	-	283	0	1	0
Panat	1	0	283	1	1	0
	18	0	141	2	-	-
Kamput	1890	1	3392	4	53	0
	1	0	8	0	-	-
Total	2194	4	5467	21	91	0
% Removal		100		100		100

It is worth nothing that the final disposal of the AP effluent has been done by discharging it into seepage pits. Many of the seepage pits are close to water supply sources. This situation is very dangerous to the environmental health conditions.

Analyses for total bacterial count and also E. coli MPN in Table 5 show that dug-wells (dug by hand or manual tools, usually not deeper than 10 m) are badly contaminated by the effluents of the seepage pits of aqua-privies. One of the dug-well which is not yet contaminated (see no. 10 in Table 5) is quite clean, while the other wells which may be as far as 45 metres from a seepage pit are badly contaminated.

The effluent of the AP's should be piped or drained in a covered trough and be disposed of in an oxidation pond rather than in any of the soil treatment process because the area of the holding centers are too limited to prevent contamination to wells. Otherwise, piped water supply from an external sources should be used.

Table 5. Incidents of Dug Well Contamination by Seepage Pits

No	Location	Distance to Seepage pit (m)	Bacteriological analyses	
			Total colony (-/1)	*E. coli* (MPN/100 ml)
1	Karb Cherng	20	7,800	240
2	"	7	31,000	> 240
3	Srakeow	26	8,500	> 240
4	"	10	180,000	> 240
5	Mairood	45	180,000	> 240
6	"	40	300,000	> 240
7	"	35	300,000	> 240
8	"	15	300,000	> 240
9	"	35	120,000	> 240
*10	"	15	7,000	< 2.2

* This installation is not yet in use, hence does not show a contamination of an uncontaminated.

ALTERNATIVE METHOD OF FINAL TREATMENT

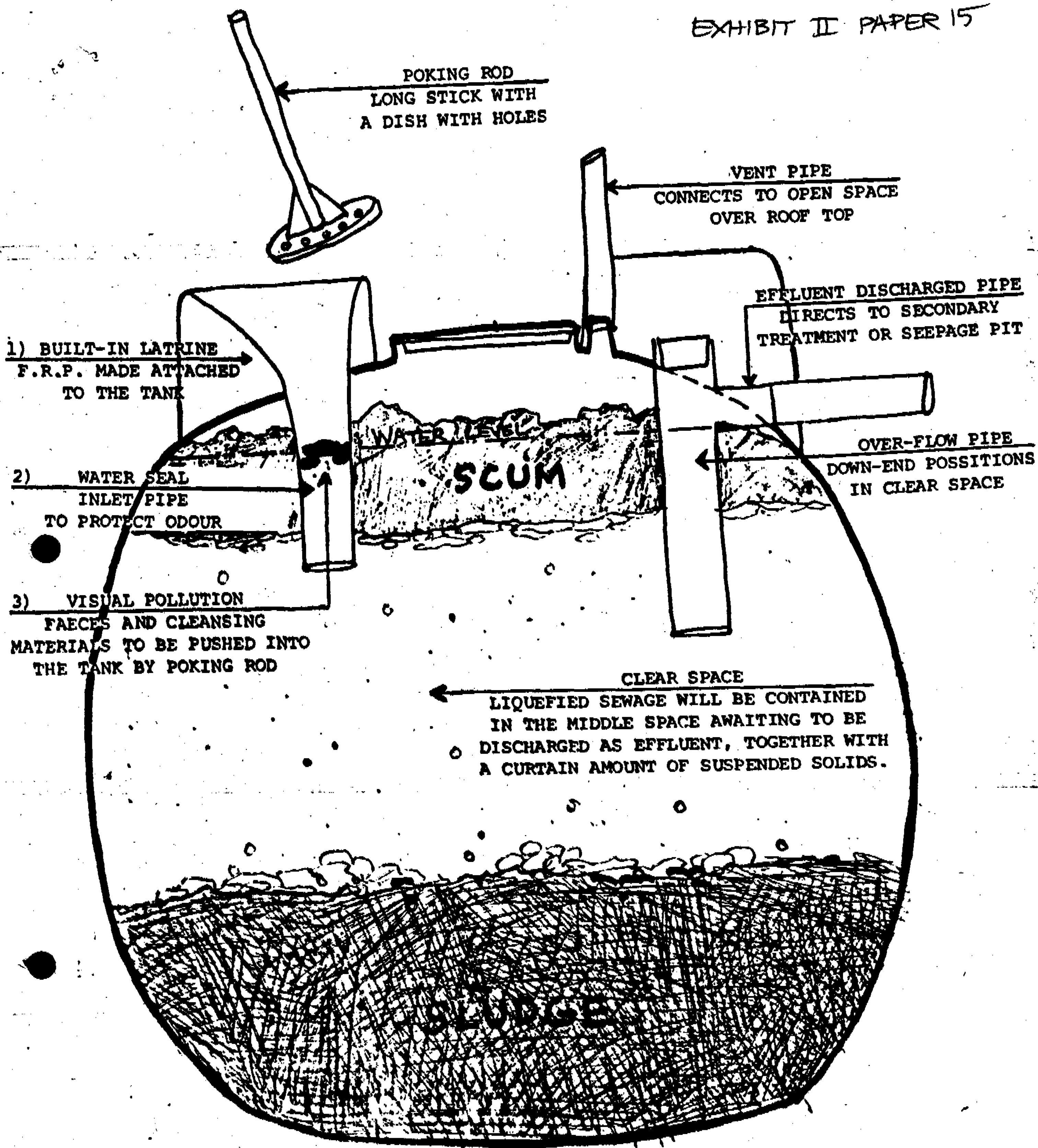
The results of this study show that the seepage method is not suitable for the holding camps which use dug-wells as sources of water supply, due to the heavy contamination of these wells. It is, therefore, more appropriate to isolate the AP effluent from soil water for treatment by stabilisation ponds.

These ponds should be designed based on the number of users. A safe estimate of 40 grams BOD per capita per day is applicable.

The primary pond receiving effluent from the AP should be sealed with water-tight materials such as clay, asphalt or cement grouting. The exposed water surface should not be smaller than 2 m^2 per person. The pond should be 1 m deep. In order to make sure that the effluent will be safe for villagers downstream from the stabilisation pond, polishing ponds are recommendable.

These subsequent ponds should be designed upon the decay rate of bacteria. The principles can be found in many technical papers. A design diagram is also available (Suwarnarat, 1980). With this principle, the effluent of the AP can be purified and become totally safe.

EXHIBIT II PAPER 15



BIO-CHEMICAL PROCESS

FAECES WILL BECOME LIQUID SOLUTION AND LATELY DIGESTED INTO 3 FORMS :

- SCUM, OR FATTY PARTICLES FLOATING ON THE WATER SURFACE
- SLUDGE, OR SLURRY OF SETTLED PARTICLES
- GAS

"ZEPTIK" IS MODIFIED AQUA PRIVY MADE OF F.R.P. TO ASSURE WATER PROVING QUALITY TO THE TANK

EXHIBIT I PAPER 15

12.4 AQUA-PRIVIES

Aqua-privies are essentially septic tanks which are situated immediately below the lavatory pan or squatting plate (Figure 12·4). The liquid level in the tank

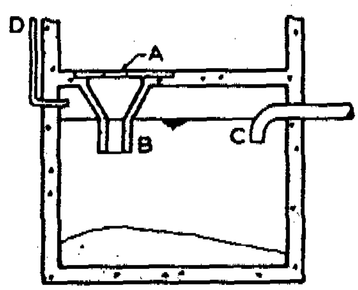


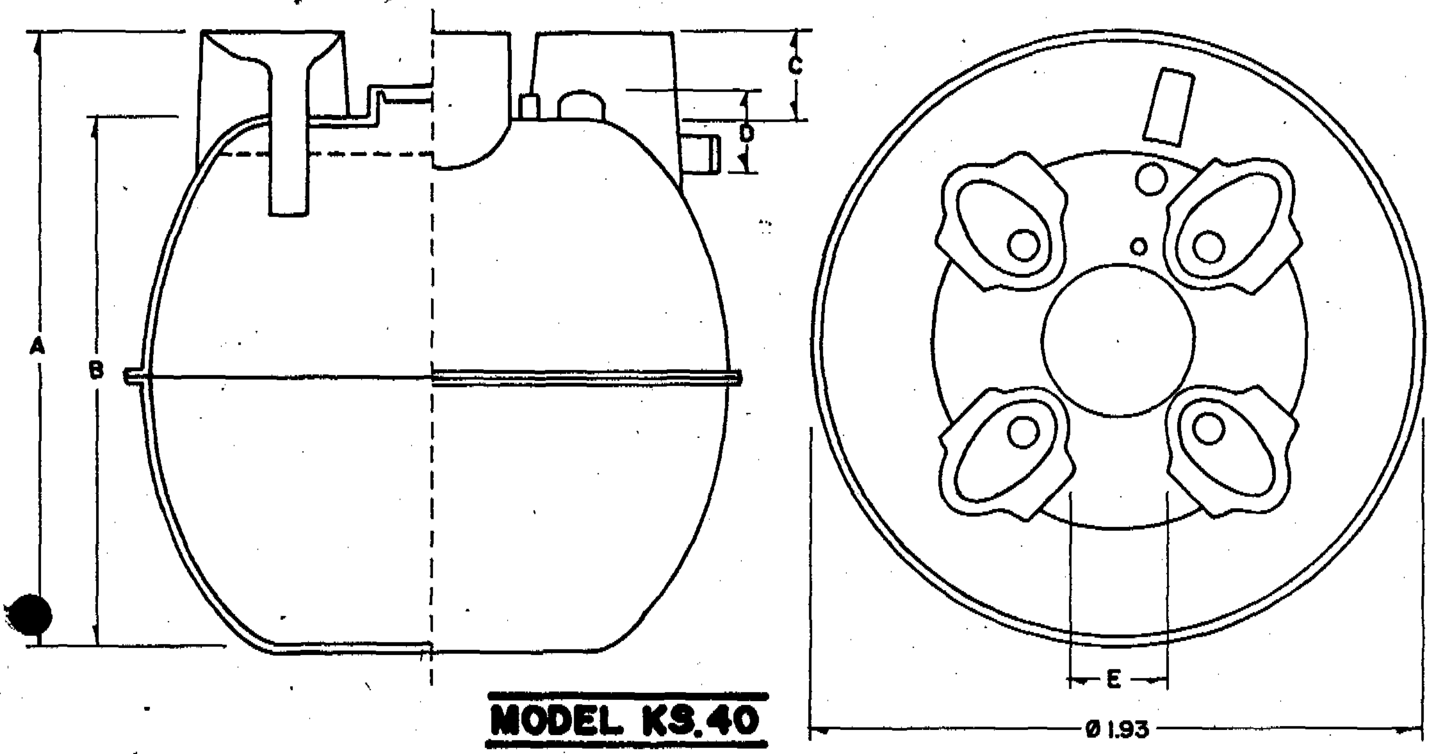
Figure 12.4 Simple aqua-privy. A, squatting plate; B, drop pipe; C, effluent pipe; D, vent pipe

must be maintained so that a water seal is formed at the vertical drop hole. Since sullage is not usually added to the tank, the water level is in practice often too low to make the desired water seal and there are the consequent problems of odour release and of fly and mosquito breeding. A solution is to divert sullage into the tank; even then additional water may be required. As a result these units are not very popular as permanent installations on individual plots. They are useful however as temporary communal facilities in military and refugee camps where there would be direct control over the maintenance of the water seal.

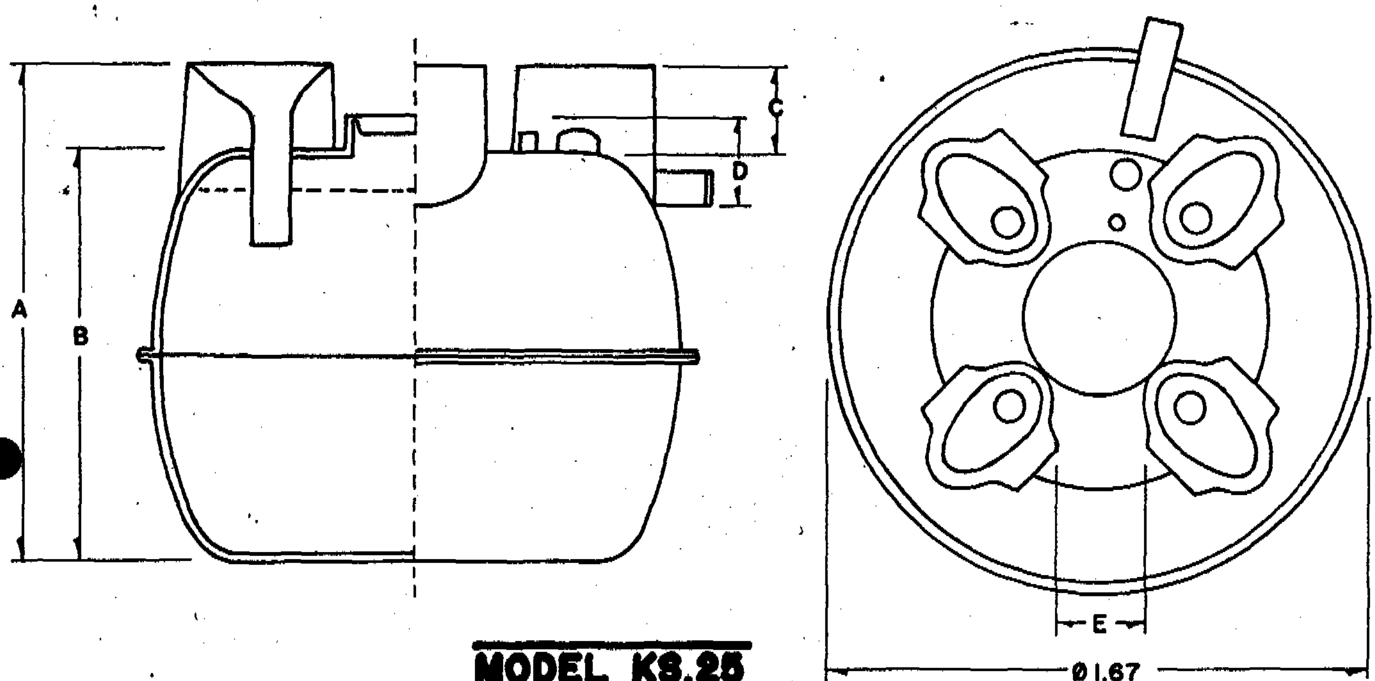
EXHIBIT III PAPER 15

FIBREGLASS AQUA PRIVY

MANUFACTURED BY PREMIER PRODUCTS, THAILAND.

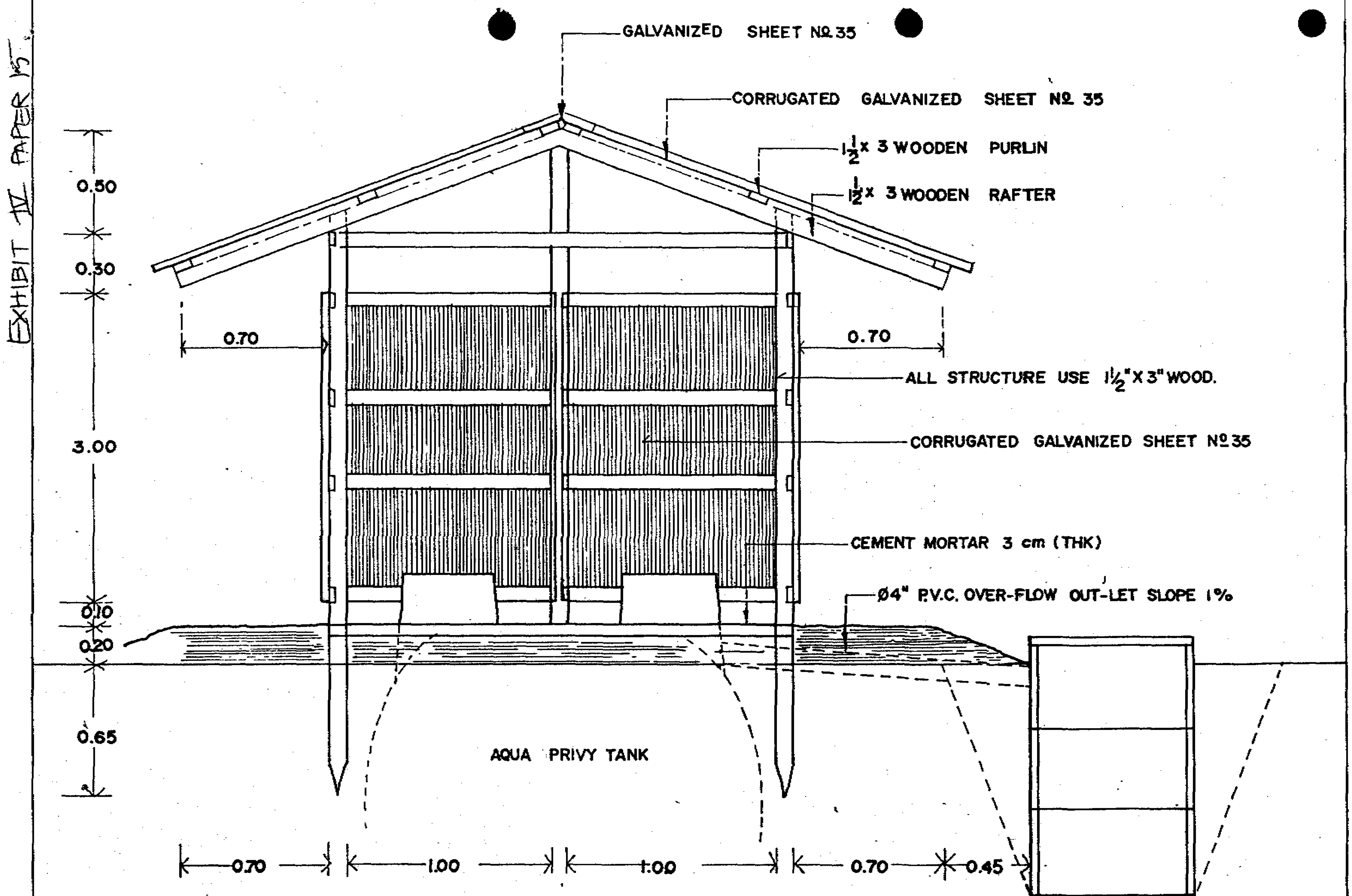


MODEL. KS.40

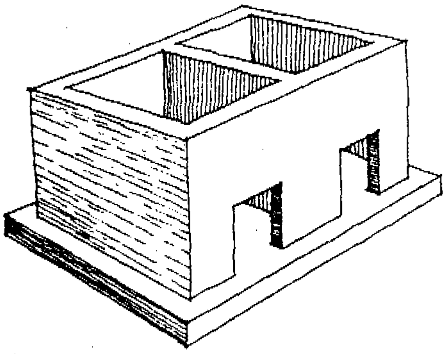


MODEL. KS.25

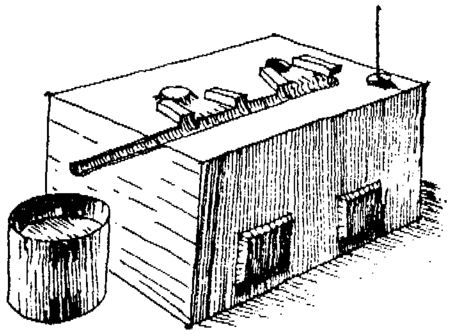
	KS 40	KS 25
A - BOTTOM TO TOILET TOP (m)	1.925	1.590
B - BOTTOM TO TANK TOP (m)	1.665	1.345
C - TANK TOP TO TOILET TOP (m)	0.255	0.255
D - OUT-LET PIPE TO MANHOLE (m)	0,260	0.260
E - TOILET TO TOILET (m)	0.315	0.315
TOTAL WEIGHT (Kg)	120	100
GROSS WEIGHT (Kg) PLUS WATER	2,800	4,200



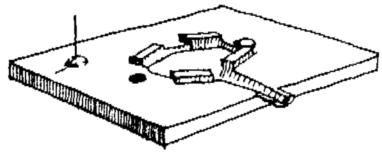
SECTION A-A | SCALE 1:25



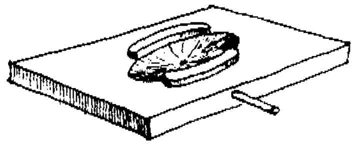
TWO VAULTS ARE ALTERNATINGLY USED



SQUATTING PLATE URINE DRAIN AND FOOT SUPPORTS ONE DROPHOLE IS CLOSED WITH A LIT , THE OTHER HAS BEEN SEALED AND DATED . THE DRAIN LEADS THE URINE TO A SEPARATE TANK OUTSIDE THE BUILDING .



SQUATTING PLATE WITH CENTRAL DRAINING AREA



OUR PROPOSAL FOR A SQUATTING PLATE ,WHERE THE REMOVABLE URINE DRAIN CLOSES ONE VAULT AND LEAVES A DROPHOLE FOR THE OTHER VAULT. NOW THE URINE TANK CAN BE PLACED INSIDE THE TOILET BASE .

CONCLUSIONS

The AP used at the holding centers are good and reliable as hygienic and trouble-free toilets. The existing effluent disposal system (soil seepage) is inadequate. Stabilisation ponds should be built instead.

The prevailing conditions call for an immediate closure of all dug wells at Karb Cherng, Srakeow and Mairood, while new effluent system should be constructed.

The camp management must decide between the construction of either an effluent drainage and disposal (oxidation pond) system or a remote water supply system.

If the general environmental health aspect is considered important, the effluent drainage and oxidation pond is unevitable.

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PILOT DEMONSTRATION PROJECT ON LOW COST NIGHTSOIL BIOGAS PLANTS FOR COMMUNITY AND FAMILY USE

Raymond Myles

Senior Specialist-Cum-Head
Appropriate Technology
Action for Food Production - AFPRO
C-17, Community Centre
Safdarjang Development Area
New Delhi 110016, India

ABSTRACT - This paper presents a case study of the working of three human waste fed biogas digesters built, one in a semi-urban area and two in a rural environment. The transfer of a technically perfect system was beset with problems because it introduced into a cultural ways of life that contravened age-old social habits, mores and customs. It underlines the need for considerable educational work amongst beneficiary groups that must precede the introduction of any alien technology.

This paper presents a case study of three biogas digesters built by AFPRO, a non-government technical service agency, in a municipal and rural area of India. AFPRO was asked to undertake this task by the municipality of Midnapur, a town in West Bengal; and by a voluntary agency working in the areas around Varanasi, U.P., India.

The problem of human excreta disposal is an age-old one but has assumed vast proportions because of the rapid growth of towns; and because of the inability to serve the 500,000 scattered villages by a safe, efficient, cheap and socially acceptable means of waste disposal. It is this situation which forces one to look at the low-cost sanitation options available even though it is agreed that conventional water-borne sewage disposal systems **are possibly the best.**

AFPRO was asked to provide assistance because the organisation had gained considerable expertise in the construction of biogas plants throughout the country in varying soil and climatic conditions, and had disseminated this technology by training rural masons to construct such plants. AFPRO undertook this task in order to ascertain whether (i) it was possible in India to use biogas digesters as a safe means of human waste disposal, (ii) the system could be replicated at a large scale, (iii) the end-products of the digestion process would be used for fuel, lighting and manure; and

(iv) these plants, individual or community based, were economically viable entities.

COMMUNITY UNIT IN A RESETTLEMENT COLONY

The first nightsoil fed plant was built in the municipality of Midnapur. It was a resettlement colony built for scavengers employed by the Municipality. These people serviced the dry latrines in the town and removed the waste matter in cart loads. The colony consisted of rows of houses, built back to front, with an open space between the rows. The district officials were very enthusiastic about the project, whereas potential beneficiaries were full of doubts about the prospect of receiving free fuel for cooking and lighting. They expressed hesitation in using the methane for cooking, but were extremely excited about arrangements for lighting and were not averse to dumping nightsoil (previously dumped elsewhere) into the biogas plant. The State authorities expressed their willingness to bear all the costs of the project, if AFPRO could bear the expenses of the first experimental plant. AFPRO was assured by the local authorities that once the plant was commissioned and functional, the beneficiaries and local authorities would look to the maintenance of the plant, and would construct more plants if they found the first one successful.

The effective volume of the digester was 37.5 m^3 with a capacity of 37,500 litre (1:1) of cattle dung slurry, which would produce 15 m^3 of gas daily at a 50-day retention period. This output was considered adequate for cooking and lighting at a rate of 2 m^3 per family. Since this was an experiment, it was decided to serve the needs of 7 families. For this purpose, a 15-m^3 biogas plant was planned, construction began on January 16, 1982, and the plant was completed on 3rd March, 1981. However, for keeping in view the public health aspects, it was decided to feed only 300 litres of slurry to get a retention period of more than 120 days. As the nightsoil from dry latrines was in a thick slurry form, it only needed dilution. Therefore, the daily feeding rate was maintained at 250 litres of nightsoil to 50 litre of water. Both inlet and outlet chambers were sealed with rubber to prevent foul odours from escaping. A long channel led from the outlet chamber to composting pits.

Feeding, which was done in batches, began on April 9th and was completed on April 25. Gas was first used on May 11, 1981, for lighting and thereafter all the families started using gas for cooking because connections were already given and stoves fixed.

The gas was more than adequate and a further 8 families were provided connections. The inhabitants of the colony were so impressed that they petitioned AFPRO through the local authority for a similar facility in June 1981. Unfortunately, AFPRO could not accede to this request immediately. Several months had elapsed when they finally went to complete the project. The local elections led to a change of the Chairman and the

Administrator was also transferred. There was a shift in priorities and the feeding of the plant was discontinued.

AFPRO analysed the reasons for the failure of the first phase of the project as follows :

1. The project was undertaken by AFPRO at the request of the administrator of the area who was able to convince the elected body of the benefits of the scheme. The newly-elected Chairman was unenthusiastic for undisclosed reasons and the new Administrator was not familiar with the benefits endowed on the community by this technology.

2. There was no water supply in the colony and the beneficiaries had to obtain the 50 litres of water from a distance. The local authority had promised piped water but did not carry out this promise.

3. The non-beneficiaries objected to the smells which arose from the inlet at each loading time. AFPRO had assumed that persons used to carrying cart loads would not object to slight odours for approximately 15 minutes a day. Perhaps the inlet should have been sited some distance away.

In order to revitalise the project, it has been suggested that :

1. A meeting of the Area Administrator, the Chairman of the Municipal Cooperation and beneficiaries be called to discuss the problems. An association or registered society of beneficiaries be formed to ensure the smooth running of the digesters.

2. Piped water be made available to the locality.

3. The plants to be built in the second phase be sited some distance from the homes.

4. The gas be charged for and the proceeds go towards the maintenance and repair costs.

5. The local authority should ensure that a continuous supply of raw material is available for the continuous smooth functioning of the plant.

COMMUNITY LATRINES ATTACHED UNIT IN A VILLAGE

The next two plants were built in two village around Varanasi, U.P. at the request of the Lal Bahadur Shastri National Memorial Trust. The first plant was built at Beriban, in a Harijan colony after consultation between the volagency, AFPRO and the beneficiaries who were poor farmers. It was agreed that four lavatories would be built, two each for men and women, and that these would be connected to a digester. The plant would provide a safe means of waste disposal, fuel for lighting, and slurry for a fish tank. This particular village, Beriban, was chosen because it already had a community tube-well which had been functioning for two years.

The latrine consisted of locally made china clay pans in a hand flushing system with a water seal. It was recommended that 1 litre of water be used after each visit to the lavatory. In order to prevent too much water flowing into the digester, a U-trap with grill was provided at the junction of the channel from the latrine and the inlet pipe into the digester; and an inch high obstruction was provided on the bottom of the channel at its end, in order to reduce the velocity of water flowing in the channel. A soak pit was provided for extra water to flow into it through the U-trap, allowing only the human excreta with adequate water to enter the biogas plant through the inlet pipe. The channel and man-hole housing the U-trap had removable covers to facilitate inspection and cleaning.

It was assumed that the latrines would gain popularity very slowly. In order that there may be enough material for the digesters in the early stages, a slurry mixing tank was provided through which cattle dung could be fed.

In order that water may be conveniently available, a 1000-litre tank was built 5 metres away from the lavatories. The beneficiaries agreed to construct a channel from the community tube-well to the tank for the conveyance of water.

It was assumed that the lavatory would be used by approximately 70 persons per day. A digester of 2 m^3 (70 cft) capacity was built. A pre-oxidation tank for pre-drying of digested slurry was also provided.

The commissioning of the latrines and plant was delayed by about 3 to 6 months. This was because the initial feeding was to be done with cattle dung contributed by the potential beneficiaries. These people were unable to make this contribution as they had very few animals (cattle), and were using the dung as fuel and compost, and selling cow pats for a small remuneration. Ultimately the volagency had to buy the 2500 kg of dung required.

The plant was commissioned in August 1982 and has been working since but not to its capacity. The reason is that the channel from the community tube-well to the water storage tank has not been built by the villagers. Therefore they do not carry the 1-2 litres of water necessary for flushing the matter out of the pans, rendering the lavatories insanitary. About 20-30 persons are using the lavatories daily.

Since the potential and actual beneficiaries are very poor, AFPRO has suggested that the volagency take on the responsibility of constructing the channel. Until such time as the channel is ready, the volagency should consider employing a person who will keep the storage tank full and keep the lavatories clean. The volagency may also provide large tins of water to be used by the lavatory users. This is necessary if this project is to succeed as a demonstration project and more people are convinced of the need to have safe disposal systems for human waste.

FAMILY UNIT

The third plant was built on the campus of the Lal Bahadur Shastri National Memorial Trust at Village Murdaha. The Trust had originally planned a septic tank-cum-soak pit for new lavatories and the Trust wished to demonstrate to the population around how human waste could be hygienically disposed of. Since the Trust did not have adequate technical guidance, AFPRO completed the job by converting the soak pit into a biogas digester of 2-m^3 capacity. The entire project was completed as part of a masons training programme.

The feeding of the plant began in February and gas was available in March 1982. The plant provides gas for two 100-candle power lamps. One burns 4 hours and the other for the whole night. Both are at present working well. There were, however, some problems later noted. Too much water was being flushed into the latrine and this happened rather frequently. This resulted in too much water in the digester and reduced the slurry concentration. AFPRO technicians looked into the working of the plant and as a remedial measure, a second manhole with a by-pass to a second soak pit was constructed. The plant has been functioning well since then.

CONCLUSION

There are many low-cost design options available for the safe disposal of human waste. However, a large-scale transfer of these systems is hampered by the lack of political will, financial constraints, and social inhibitions. AFPRO's experience has brought home the lessons that a technically perfect system would still require an enlightened and committed group of people to make it acceptable to the general population. Also, social habits and usage of the system will necessitate local modifications. For a sustained use and further improvements in technologies introduced, locally available and well trained technicians are needed in large numbers. The training and upgrading of their skills should be considered a continuous support and not only one-time effort to promote a technology.

RESEARCH CUM ACTION PROJECT - LOW COST TECHNOLOGY FOR HUMAN WASTE DISPOSAL

K.N. Vijayanthi

Community Officer
Community Development Wing
Tamilnadu Slum Clearance Board
Madras, India

INTRODUCTION

With the increasing health consciousness and need for better sanitation, human waste management has assumed special importance. In India, this has greater social significance where certain castes are engaged in collection of human waste which places them the lowest in the social ladder.

In many rural and urban areas, open-air defecation is still in practice, and the areas are exposed to transmission of diseases through inanimate objects like water, soil and animate objects like flies and other transmitting agents.

In small towns, dry latrines are prevalent. The human excreta are collected by scavengers and disposed of.

In a paper read at a National Seminar on the conversion of bucket privies into sanitary water seal latrines, convened by the Government of India in collaboration with the World Health Organization and the United Nations Children's Fund (UNICEF) in the year 1978, it was rightly observed that the conversion of service latrines into another system was highly desirable on social, economic and health grounds. An extract from the report reads as follows:

> "The operation of a conservancy system is vulnerable. Its total weakness lies in the employment of human beings in such degrading work to which its very beneficiaries attach a social stigma. The stigma perpectuates a hereditary service by poor, sullen and unwilling labour. Increasing wages, decreasing efficiency and mounting tensions constantly plague the service. Nevertheless, the abolition of dry latrines may result in a economic disadvantage to the scavenger, arising out of a fear of loss of hereditary means of livelihood on an assured and permanent basis".

The Seminar felt that a boldier and forward-looking policy was needed on the parts of State Governments and local bodies to include mass education, preferential appointments and promotions as appropriate and vocational training for other skills (1).

Government and various service organizations in India have been engaged in constant research to stop the service latrine system, to eradicate social injustice, and also to try to find an alternative to the primitive latrine system. This would effectively curb the transmission of epidemics and other diseases.

EXISTING PATTERN OF HUMAN WASTE DISPOSAL

The metropolitan cities do have ground sewer systems. Considering the prohibitive costs of construction, maintenance and problems of management, it is difficult to extend the systems to all the areas. In the absence of sewer systems, the alternative which is sought after is the septic tank. It is safe and good from the point of health and sanitation. But it is still out of reach of the vast number of people due to its high construction cost. For a country like India, it is equally important to seek alternatives for management of human wastes which are cheap, have less complicated technology, are easy to maintain, and widely accepted by laymen.

With further experimentation on low-cost sanitation, methods like Khurpi, trench, dug well, bore-hole latrine, overhung latrine or drop privy and aqua-privy latrines were tried and they are described below.

1. Khurpi Method

In this method, the person going to the fields for defecation would take along a Khurpi, dig a hole in the ground, defecate into it and cover the excrement with dirt. This method of excreta disposal cannot be considered as an approved method but rather as a tentative or emergency method.

2. Trench Latrine

Instead of a single, shallow hole, trenches are dug beforehand. After defecation, the users would cover the excrement with some dirt. It could not become popular because it did not prevent bad smells.

3. Dug Well Latrine

Under this system, human waste goes much deeper than in the trench latrine. But this system was found to be more injurious for the entire population. Hence this system cannot get mass acceptance.

4. Bore Hold Latrine

A hole 7.5-9 metre deep with a 23-30 centimetre in diameter is dug. On the surface, a cement plate is fixed as a foot step. But the main defect in this method was atmospheric pollution due to the formation of gas and bacterial growth.

5. Overhung Latrine or Drop Privy

This method is adopted by people living close to canals, rivers or the sea where the total excreta would drop into the water and be carried away. But this again pollutes the surface water.

6. Aqua-privy

It is a modified form of the septic tank. The pan of the aqua-privy latrine is provided in the first chamber itself and it requires less space and water. The aqua-privy has two chambers, one is a digestion chamber, the other is called an aerobic chamber. The chambers should be cleaned once every five years.

But experts have criticised the functioning of these latrines as there is no provision to prevent atmospheric pollution due to formation of gas, and to prevent bacterial growth and foul smells.

RESEARCH CUM ACTION PROJECT LATRINE

To invent a system devoid of these problems, the Institute of Public Health, Poonamallee, Madras, has been conducting extensive research since 1956. As a result of this research, a model which is technically sound, easy to maintain and socially acceptable was invented in 1961. The model was named "Research Cum Action Project" (RCAP) latrine.

Salient Features of Research Cum Action Project Closet

1. It is clean, hygienic and durable.

2. It is convenient for use both by children and adults.

3. Faecal matters glide easily into the trap and leach pit without sticking to the pan.

4. Water requires for flushing is minimum.

5. Faecal matters will not be visible due to the water seal.

6. The 'Y' pipe introduced in the design permits a continuous use of latrine to alternate between 2 pits without any disruption.

7. Casting of the materials is simplified to minimize expenses.

8. Various faecal-borne diseases and intestinal infestations are avoided.

9. It is low-cost and is within the reach of common people.

10. Maintenance is individualised and requires no system and hence management is simplified.

This low-cost water-seal Research Cum Action Latrine, with a simple but effective pit, can be constructed in sandy, loamy clayey or gravelly soil conditions.

The essential parts of the Research Cum Action Project Latrine are (1) Pan and trap, (2) 'Y' pipe and lead of pipe, (3) Squat plate, (4) Pit cover slabs, and (5) Pit.

1. Pan and Trap : - The Research Action Project latrine is designed with smooth cement, red oxide cement or porcelain pans to suit affordability of the rural and urban poor families. The field tested cement pan is found to be superior to the salt dozen earthware porcelain pan from the functional point of view. The pan is designed at a 45° angle which facilitates fast flow of water, thereby less consumption of water. The water seal facility prevents foul smell and entry of flies into the pit.

2. Pipe Connections : - The 'Y' pipe and lead-off pipes are the two important and necessary pipes. The 'Y' pipe facilitates easy switch over to the alternative leach pit when the first pit is filled to capacity.

3. The Squat and Cover Slab : - The squat plate is standardized to facilitate easy construction and correct positioning of footrests. In exceptional cases where transportation charges are heavy, the squatting plate can be cast at the site itself, besides covering a slab for leach pit. But care should be taken to see that the footrests besides the pan are done to the proper shape and size as per the type design.

4. Pit: - Pit measures .63 x .63 x 1.8 metres and is lined with bricks. Nightsoil is collected in the pit.

Site for Latrine

The latrine should be located at a minimum distance of 3 metres from drinking wells in the same compound or in the adjoining compound.

How to Construct the Latrine

Step 1 : - Clean and level the site chosen for the latrine. Now build four brick pillars each 23 cm x 23 cm to a height of 30 cm above the ground level, and spaces 65 cms edge to edge are built. The pillars should be carried to a depth of at least 7.5 cms below the ground level. If the soil is other than sandy, the pillars should be taken down to the original ground. The top of all four pillars should be in a level. This should be checked by the spirit level.

Step 2 : - Mount the squat plate over the pillars and insert the pan through the opening in it. The squat plate is made such that the pan will be suspended from it and can be seated well in it.

Step 3 : - Fit the socket of the trap correctly to the pan. The trap should be supported on two full bricks placed under it. Now pour water into the trap and check if the water seal is maintained correctly. The joint between the trap and pan can be packed with clay or cement mortar with 1:2 ratio.

Step 4 : - The 'Y' pipe is to be joined to the outlet leg (Spigot) of the trap which should be properly centered on the 'Y' pipe socket. All joints should be made water-tight with clay or preferably with cement mortar. One branch of the 'Y' pipe opens into the pit through lead off pipe. Unconnected branch should be plugged with clay inside to prevent leakage of nightsoil.

Step 5 : - The space below the squat plate can be packed with clay around the pan and trap. The joint between the squat plate and pan may then be sealed with cement mortar.

Step 6 : Construction of Leach Pit : - The leach pit should be .63 square or round at the top and should be taken to a depth of 1.8 metres below ground level. While digging the pit, the tendency to make it wider at the top for excavation should be avoided. The sides should be vertical. The pit can be made deeper if a larger storage space is required. If the length and breadth of the pit are increased, the reinforcement of cover slabs is required and hence costlier.

The cheapest material that can be used for lining the pit is burnt earthen rings. These rings are placed one over another from the bottom. The joints should be kept loose. The pit could also be lined with bricks. Under-burnt bricks also would serve the purpose. The pit can be square or circular when bricks are used. The horizontal joints are bounded with mud mortar and the vertical joints are left open. The brick lining of the pit below the pipe level should not be plastered.

The open jointed brick work should be stopped 15 cm below the ground level. The remaining portion at the top should be built in mortar. The concrete slab should be placed on the top covering the pit. To prevent water seeping into the pit, the joint could be mud-packed.

If the beneficiary can afford it, a second pit may be prepared into which the other branch of 'Y' pipe is led. But this pit would not be used by plugging the branch of the 'Y' pipe with mud. When one pit is filled up, the second pit can be used without waiting for cleaning the first pit.

How to Clean

After each use, water should be forcefully poured into the pan for flushing the excreta. It is designed in such a way that a small quantity of water is required for flushing. Commercial pans and traps require much more water for the purpose. Disinfectants should not be used for flushing as they do not serve any useful purpose.

The pit measuring .63 x .63 x 1.8 metres would serve a family of 5 for a period of 5-7 years, depending on the nature of the soil. The night-soil falling into the pit becomes dry by the leaching action of earth. This can be removed by the beneficiary himself or with the help of a scavenger and the pit can be reused as usual. If there are two pits, the branch of the 'Y' pipe leading into the filled-up pit should be plugged with mud and the other branch leading to the empty pit should be cleared of the plugging. The latrine is ready for use without any loss of time. The filled-up pit can be cleaned when this is convenient. As the pit can be reused, the Research Cum Action Project latrine becomes a life-long proposition.

Rate of Pollution of Trend

The travel of bacteria will depend upon the type of soil. If the soil is compact and clayey, bacteria will travel upto 3 metres. In loose and gravelly soil, they travel more and hence the construction of the Research Cum Action Project should be 4.5 metres away from water sources. In such soil conditions, a 'Sand Cushion' for leach pits should be given to prevent bacterial spread.

COST OF RESEARCH CUM ACTION PROJECT LATRINE

Different costs of the Research Cum Action Project Latrine are presented in Table 1.

Cost Effectiveness and Affordability

The cost of the Research Cum Action Project latrine is about US$ 50, while that of a septic tank is about US$ 350. A sewer system would cost US$ 500 to US$ 700 per individual connection. The slum population of Madras city is poor and 70% of the households are earning less than US$ 35 per month. The earnings in rural areas average much less. In such a situation, the Research Cum Action Project latrine emerges as the best alternate sanitation unit and is within the reach of the common man.

Table 1 : Cost Items of Research Cum Action Project Latrine

S. No.	Item	Cement	Fibre glass	Porcelain
1.	Pan and trap and components.	78.00	100.00	120.00
2.	One bag of cement	63.20	55.00	55.00
3.	375 No. of bricks	132.00	132.00	132.00
4.	One cart load sand	15.00	15.00	15.00
5.	Mason charges	30.00	30.00	30.00
6.	Mazdoor charges	15.00	25.00	25.00
7.	Pit digging charges	25.00	25.00	25.00
8.	Sundries fluctuation of market rate.	30.00	30.00	30.00
	Total	388.20	465.20	485.20

Our experience has shown that it is difficult for the user to pay US$ 50 for the installation of a Research Cum Action Project unit at a time. Financial assistance is arranged through nationalised banks under their innovative banking schemes at a low rate of interest (about 4% per annum) repayable on easy instalments (about US$ 2 per month for 25 months). Besides, in the improved slums of Madras, financial assistance is extended to slum dwellers (households) by the Tamilnadu Slum Clearance Board for improving their houses and installation of Research Cum Action Project latrines.

In rural Tamilnadu and small towns, the local bodies provide material subsidy which would form about 50% of the cost of a Research Cum Action Project latrine. In the city of Madras, it is proposed to provide 50% subsidy to encourage wider installation of Research Cum Action Project units in slums with the UNICEF (United Nations Children's Fund) assistance as a measure to promote low cost sanitation.

PUBLIC OPINION AND PARTICIPATION OF THE PROJECT

A study on the awareness, utility, long-term performance and acceptance of Research Cum Action Project toilets by households of rural Tamilnadu was conducted at Kizhicheri village (Chenglepet district). It was revealed that 80% of the Research Cum Action Project toilets constructed by the Institute of Public Health are being used. Only 20% have gone obsolete. The utility and maintenance of the latrines are directly related to the education and income levels of the households. Of the 80% who are using the toilet, 30% are using it for more than 20 years by changing to alternate pits.

Many people who have installed the toilets do not seem to have the idea as to how the toilets function, despite the fact that they are properly informed about the functions of the Research Cum Action Project unit. However this has not affected the willingness to continue using the toilet as its functioning is satisfactory.

The degree of willingness to construct the Research Cum Action Project latrines increases directly in proportion to their awareness. In a few slums in Madras where a survey was conducted, it was revealed that the majority of those who have been informed about the Research Cum Action Project latrine expressed the opinion that this was a low-cost solution for good sanitary conditions.

When the respondents were asked whether they would like to install a toilet if they have space, 60% of the households expressed their willingness to construct a Research Cum Action Project latrine.

In slums where the message of the Research Cum Action Project latrine has not clearly reached, the people were skeptical about its functioning. For proper public participation, marketing the concept is found to be important.

The degree of interest shown in installing Research Cum Action Project latrines is more among those who have better education and economic conditions. This is mainly because the need for privacy increases with education and better economic conditions.

MASS EDUCATION CAMPAIGNS

It is clear that public participation could be ensured if the people are made aware of a given programme. The objectives of mass education in promoting Research Cum Action Project latrines are (1) to create an awareness among the people on THE dignity of having a private latrine, (2) to point out the importance of having a toilet from health and sanitation points of view, and (3) to education people on the availability of a low-cost latrine which is well within their reach.

The above objectives are aimed to creating a 'felt need' for a latrine among the people. Mass education is carried through film shows, individual and group contacts, printed materials, audio-visual aids, exhibitions, etc.

The Government mass media, namely radio and television, are also being utilised for this purpose. Voluntary organizations propagate these latrines as a part of their programmes.

According to a report published on the occasion of the 10th anniversary of the World Health Organization (1958), "Rural sanitation requires the provision of facilities and the willing participation of the families. As education or persuasion creates new wants, dissatisfaction with the existing conditions often arises and provides a drive towards betterment" (2).

However, mass education is only a means to create awareness and it is important to follow it by action programme. This should include generating necessary resources for the beneficiary and to arrange to install the sanitary unit, before the enthusiasm of the target group wanes. Campaigns combining mass education and action programme would be effective for implementation of the programme successfully.

The author hopes that this information on alternative methods of human waste disposal management will prove to be a guideline for future programmes in improving sanitary practices for developing countries.

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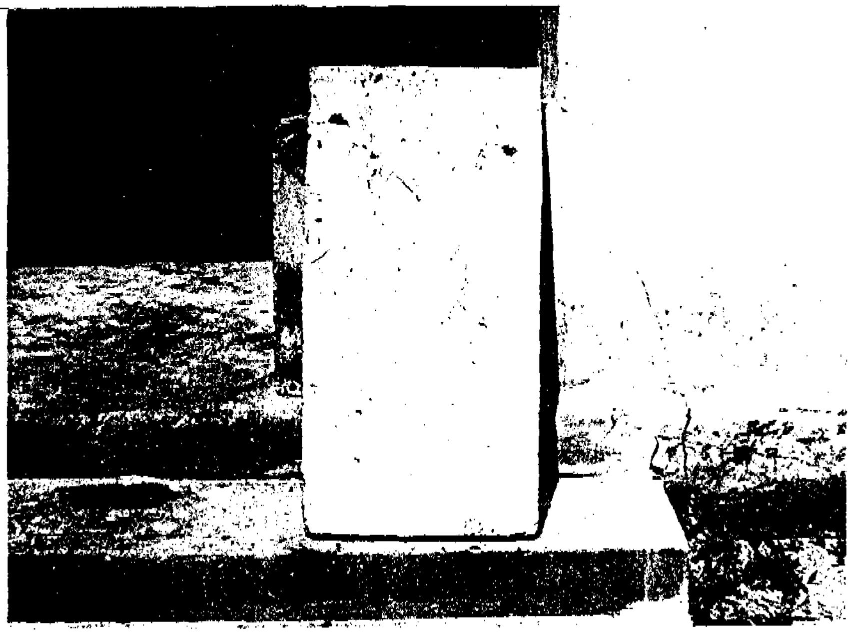
Appendix A

PARTS OF RESEARCH CUM ACTION PROJECT LATRINE

4. LEAD OFF PIPE



5. SLAB

6. TOTAL PARTS
OF RCAP LATRINE

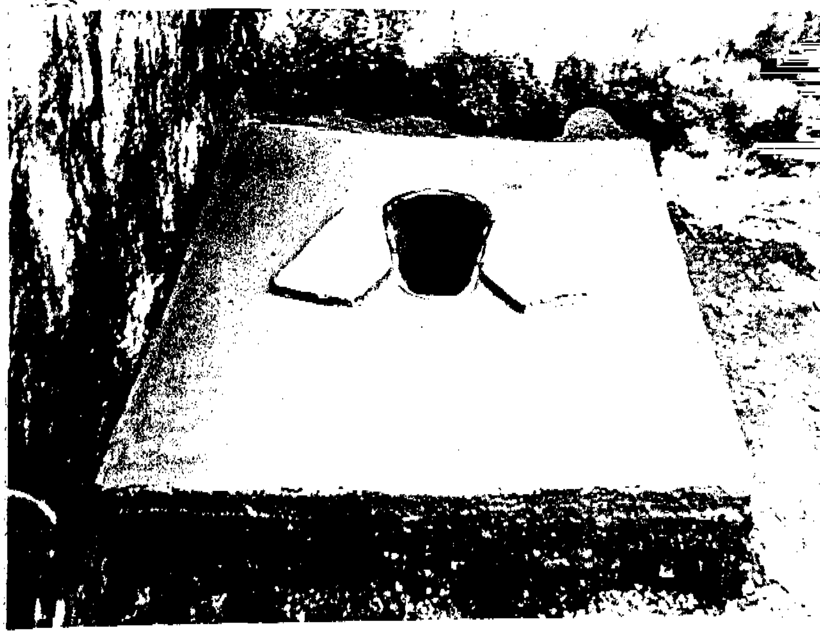
CONSTRUCTION OF RESEARCH CUM ACTION PROJECT

STAGE 1

STAGE 2

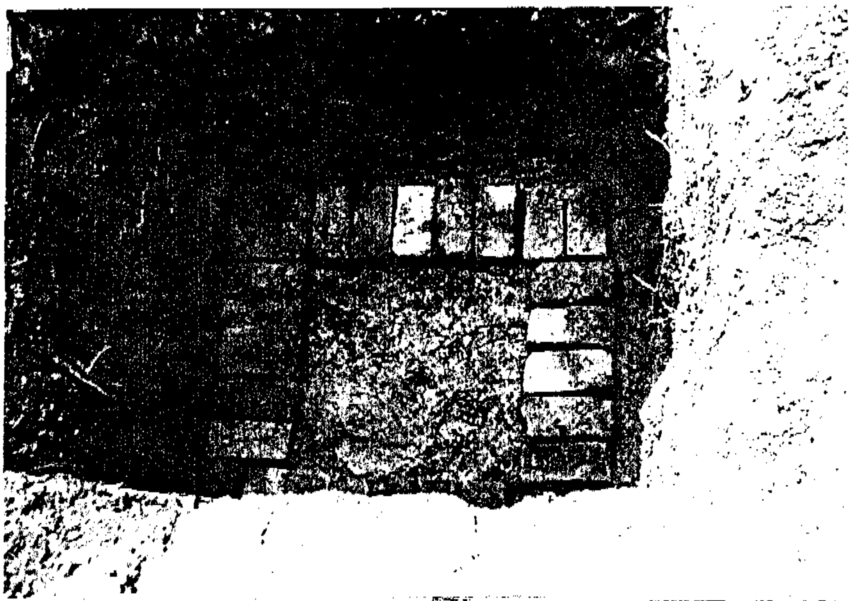
STAGE 3

STAGE 4



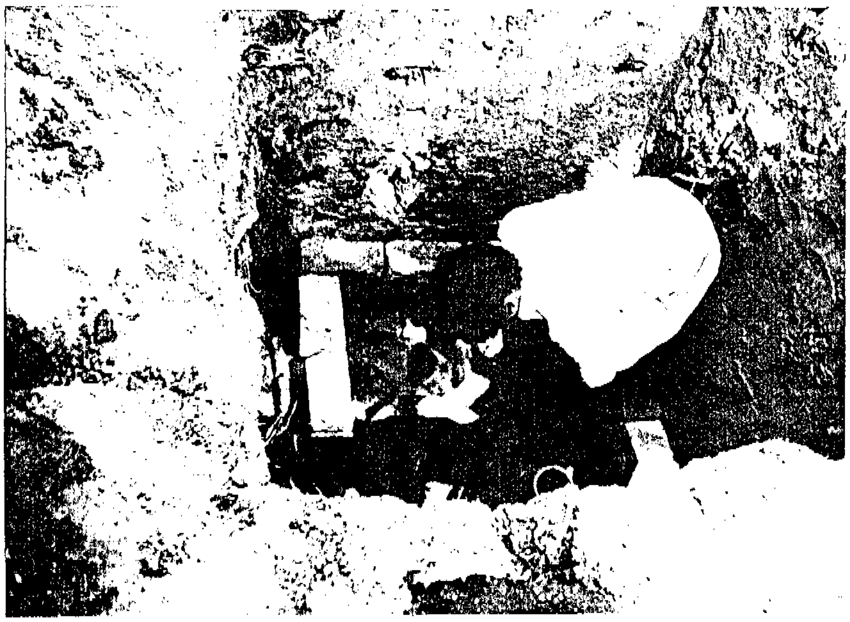
STAGE 5

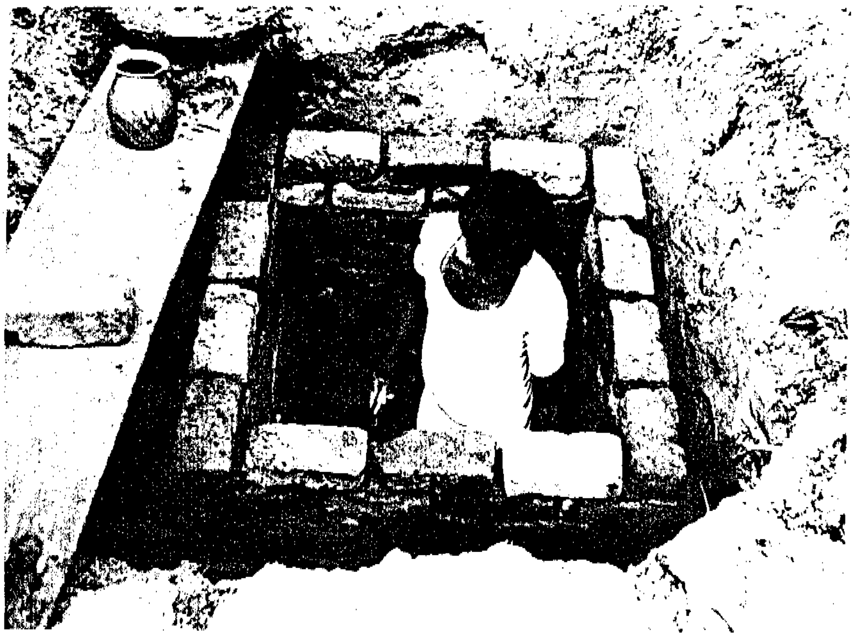
STAGE 6



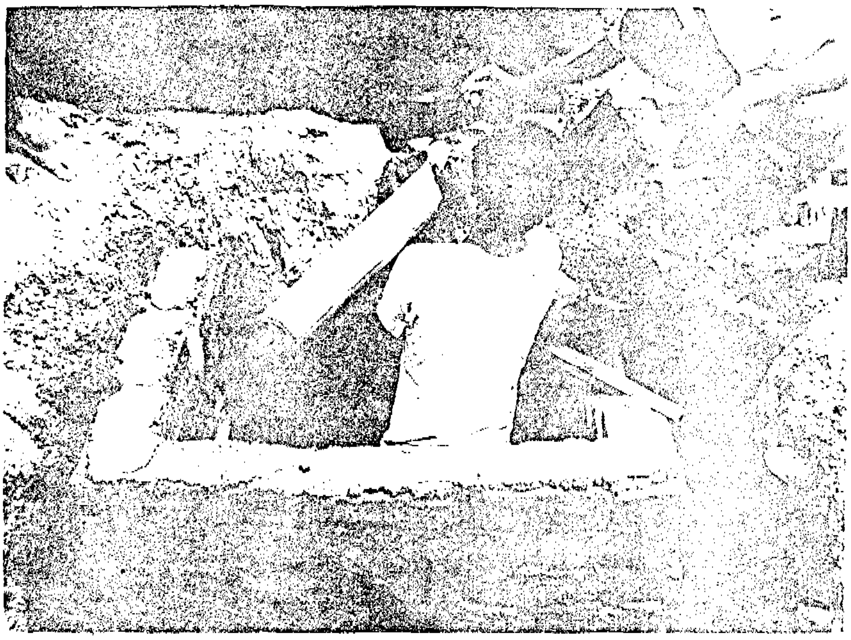
STAGE 7

STAGE 8

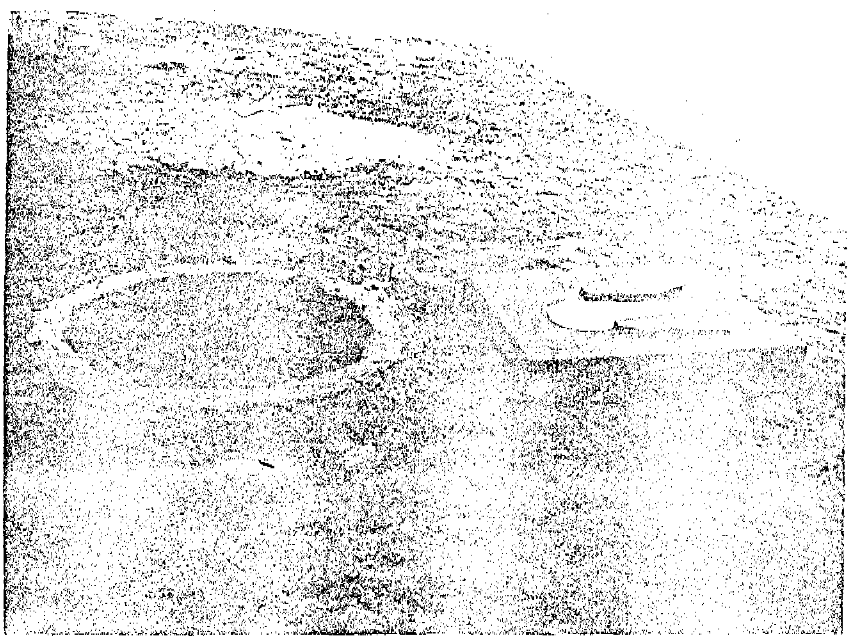




STAGE 9



STAGE 10



STAGE 11

LOW-COST SANITATION TECHNOLOGY AND IMPLEMENTATION STRATEGY IN TANZANIA

R.A. Boydell

Resident Adviser Low-Cost Sanitation
Ardhi (Ministry of Lands Housing & Urban Development)
United Republic of Tanzania

Part A
LOW COST SANITATION TECHNOLOGY IN TANZANIA

INTRODUCTION

Tanzania is a tropical country in East Africa located immediately south of the Equator. It has a population of approximately 17 million people, of which 15 million are rural dwellers and the remaining 2 million or so live in urban centres.

The present national centre is Dar es Salaam, a major sea port of the Indian Ocean which contains 1 million - or a half of the national urban population, of these 80% or more are living in squatter, low- or medium-cost housing in the urban fringe. A new capital city, 'Dodoma', is presently being developed at the geographic centre of the country.

Urban migration has been a problem over a number of years which the government tried to solve in the early 70's by the restriction on urban squatter areas and the creation of Ujamaa Villages, and more recently, by accelerated regional development programmes. However, the squatter areas continue to grow and the policy is changing from squatter removal to squatter upgrading.

Tanzania, which has been defined as one of the least developed countries in the world, is presently besieged by an economic crisis caused by the global recession, internal problems of drought, the war with Uganda, and other factors.

The main strategy for economic recovery is the Structural Adjustment Programme which lists priority sectors requiring strengthening and support. The provision of sanitation is not a part of this programme and also sanitation is low on the funding priority list of social programmes.

Tanzania has a socialist philosophy, the main theme of which is development through self-reliance and self-help. On-going sanitation programmes have to depend heavily on this philosophy.

TRADITIONAL SANITATION IN TANZANIA

Almost without exception, the tradition method of excreta disposal is the pit latrine, which is commonly seen both in urban and rural areas. It has been estimated that up to 60% of rural and 90% of urban dwellers have access to a pit latrine of some form.

The latrine is commonly constructed by excavating a pit one metre or so in diameter, about three metres deep, which is then cover by a platform of poles through which a drop hole is provided. The platform is often surfaced with compacted earth, and a superstructure is placed over the pit for privacy and shelter. In urban areas, there is a trend to build a more permanent unit by lining the pit with old oil drums, tyres or any convenient material.

The disadvantages of the traditional pit is that it often acts as a focal point of disease transmission rather than isolates excreta from the environment. Transmission vectors are created by fly and mosquito breeding and direct contact with excreta. Also, the pits often collapse after only a few months of use, or the wooden poles are eaten by termites and the platform collapses into the pit. All of these naturally lead to indiscriminate defaecation which further reinforces disease transmission routes. Although in rural areas a new latrine can be constructed, there is often a long delay before this is done. In urban areas, there is often not enough space to excavate a new pit, and the old pit when full has to be emptied which may also take a long time during which a new latrine is not available. The emptying process itself is difficult and although some towns in Tanzania have vacuum tanker service, there are few vehicles and the service is expensive. Also, the vacuum tankers collapse as many pits as they empty.

A new local industry has emerged in peri-urban Dar es Salaam - the hand emptying of pit latrines. A number of self-employed workers known as 'frogmen' offer their services of entering full pits latrines and emptying them with spades and buckets, or alternatively, in very wet pits they excavate a second adjacent pit (if space permits), then breach the wall between, this provides two half-full pits. However, all these methods require to be paid for and a recent survey in Dar es Salaam indicated that although 90% of peri-urban dwellers had a latrine, the majority were either completely full or had collapsed.

TRADITIONAL CUSTOMS RELATED TO SANITATION

Tradition customs are changing and diluting, especially in urban area. Although in rural areas it is customary for the elders never to be seen to use a latrine, or for different sexes and in-laws to use the same latrine or for children to use a latrine at all, in urban areas these become less important. If four or five unrelated families share a rented home with one latrine in a densely populated squatter area, the traditional privacy customs have little chance of survival.

RECENT RESEARCH AND DEVELOPMENT IN THE SANITATION SECTOR

In the mid 70's, the Canadian International Development Research Centre (IDRC) funded a Tanzanian research programme in which a number of excreta disposal technologies were constructed and tested in both rural and urban areas. The project concentrated on demonstrating the effectiveness of composting techniques using multrums and double-vault latrines alongside ROEC's and other units.

The most successful aspect of the programme was that it did demonstrate that permanent latrines could be constructed very cheaply using local artisans. However, the concept of composting human excreta was not readily accepted by the users. There was a repugnance against handling excreta and the users were not prepared to make the necessary efforts required to operate a sensitive composter, i.e., the addition of carbonaceous materials to balance the carbon/nitrogen ratio and the exclusion of liquids to maintain a low moisture content.

Two lessons may be learned from this research.

(a) The acceptance of an innovative technology and a behavioural change cannot be achieved simply without a long-term educational process, even if the technology is appropriate. However the efforts to try and introduce composting latrines into urban Tanzania where the end-product could not be used and the materials required to operate the system are not available were doomed to failure. Even the fact that large volumes of water are commonly discharged into a latrine from body washing and anal cleansing resulting in a moisture content far too high for composting was ignored in a blind effort to prove someone's pet technology.

(b) The project did however demonstrate that a minor innovation in building materials to reduce construction costs was acceptable to the local artisans. The units which were constructed from very thin (50 mm) concrete blocks and thin (20 mm) ferrocement slabs combined with traditional superstructure materials of makuti and/or thatch for just a few dollars are still structurally intact if not operational.

THE VENTILATED IMPROVED PIT LATRINE

At about the same period the composting research was being undertakes in Tanzania, research was also taking place in Zimbabwe (then Rhodesia) and Botswana which resulted in the development of the Ventilated Improved Pit Latrine (VIP), which is described in detail in an annex of this paper.

The advantages of the VIP are:

(a) It is hygienic and permanent, the pit being lined and structurally stable.

(b) It is provided with a screened ventilation pipe which controls the inter-linked problems of foul odours and fly breeding.

(c) Being an improvement yet still maintaining the format of a traditional pit latrine, it is readily acceptable to the user.

(d) It is a robust technology that is not sensitive to changes in usage or inputs.

In 1980 a Low-Cost Sanitation Unit was formed in Ardhi (Ministry of Lands, Housing and Urban Development). The Units' first programme was the design and construction of demonstration VIPs in Dar es Salaam. The projects success is demonstrated by the spontaneous replication of the units in Dar es Salaam. However, the construction cost of the unit design was substantially high (5,000 Tanzanian shilling or US$ 500), which was prohibitive to the low-income group for which it was intended.

FURTHER VIP IMPROVEMENTS

Because of the imminent Buguruni Squatter Area Upgrading Programme in Dar es Salaam, an economically better unit design had to be developed. The development was undertaken by Ardhi, The Building Research Unit and a consultant funded by the West German Aid Agency, KFW.

The new design incorporates building materials first used in the compost project, thin blocks and slabs together with waste sisal/cement roof sheets, the ventilation pipe being replaced by a chimmey also constructed from blocks. The new design reduced the cost by three fifths.

One notable problem faced by latrine builders in Dar es Salaam is the high level of the ground water which in some areas is less than half a metre below ground during the rainy season. The problem was overcome by designing a 'Mound Latrine'. These are standard VIP, but constructed with the floor slab approximately half a metre above ground. The pit itself is constructed during the dry season when the water table is at its lowest and the pit is taken as deep as physically possible; the portion of the pit above ground level is *cement-rendered to reduce porosity* and a small flight of steps are provided.

Presently the VIP is the favoured appropriate excreta disposal technology in Tanzania.

FUTURE RESEARCH

It is considered that the pour-flush latrine has a great deal to offer as an appropriate low-cost excreta disposal system and that it should be acceptable in Tanzania where the majority of the population use water for anal cleansing. However, the introduction of the pour-flush would be an innovation which must be thoroughly tested in small pilot programmes when research funds become available.

Part B
SANITATION PROJECT IMPLEMENTATION STRATEGY IN TANZANIA

INSTITUTIONAL ROLES AND RESPONSIBILITIES

In Tanzania a number of Ministries and bodies are responsible for planning and implementing sanitation programmes. They are:

(a) The Prime Ministers Office (PMO), which has executive powers, especially for Town Councils and Regional Development Authorities;

(b) Afya - The Ministry of Health;

(c) Maji - The Ministry of Water Energy and Minerals; and

(d) Ardhi - The Ministry of Lands, Housing and Urban Development.

The inter-linkages between these bodies and the overlapping responsibilities is noteworthy.

The Prime Ministers Office controls the function and policy of Town Councils and Regional Development Authorities. It also has a Community Development Division which coordinates community development programmes in all there aspects.

It is interesting to note that squatter areas and pit latrines are illegal in urban areas.

Afya, the Health Ministry, has overall national responsibility for environmental health/sanitation through its Department of

Environmental Health, who plays an active role in promoting rural sanitation. However, Afya has little influence in urban areas. Afya also contributes to the sector by seconding health officers that it trains to Town Councils and other Ministries such as Ardhi.

Maji, the Water Ministry, has national responsibility for domestic water supplies and is presently preparing a regional water master plan for the whole country with support from various bilateral donors. A number of the regional plans include sanitation programmes in one form or another. These programmes should be complementary to the Afya programme but tend to be designed in isolation.

Ardhi, the Urban Development Ministry, has responsibilities for urban sanitation and sewerage as an agent for PMO/Town Councils and Afya. Ardhi also trains surveyors, town planners public health engineers, etc. who are then seconded to Town Councils and Regional Authorities.

Generally, Ardhi is responsible for capital works (new construction), and the Town Councils assume the responsibility for operating and maintaining projects.

DONOR AID IN THE WATER SECTOR

Maji, the Water Ministry, which is one of the strongest institutions in Tanzania with specific responsibility, attracts the vast majority of bilateral donor aid for the rural clean water sector whereas little aid is channelled into sanitation, especially urban programmes. It is likely that the division in responsibility for sanitation has to some extent caused the skewness in the aid profile.

THE WATER AND SANITATION DECADE NATIONAL ACTION COMMITTEE

Similarly, the strength of Maji has diluted the effectiveness of the Decade National Action Committee who should be providing support to sanitation planning. Maji were fulfilling the clean water aims of the Decade before the Decade was created. Consequently, Maji has little need to support the Decade or sees little need to support the National Action Group.

GENERAL POLICY IN SANITATION

Although sanitation responsibilities are diluted through a number of institutions and the skewness in aid away from sanitation may seem gloomy, there is a very real awareness in Tanzania that excreta disposal programmes have an important place in the development process. However, because of the financial constraints faced by the Government, it has become apparent that subsidies for these programme cannot be made available and that the only way forward is by self-help. Furthermore, having realised that the only viable option is self-help, it also has become apparent that the promotional and education components of sanitation programmes become just as important as - or even more than - the technical/engineering components.

It has also been recognised internationally that the provision of latrines alone in a community will not improve the overall health of that community. The improvement of health is a long-term goal that will be achieved as much by education and thence behavioural change as by latrine building.

Therefore, in Tanzania the essential components of a sanitation programme are considered to be:

(a) The promotion of latrine building by self-help through community of individual efforts. The latrine type being acceptable from both hygienic and socio-economic criteria.

(b) An educational process in two areas:

- Technical education and support
- Health/Hygiene education

The practical interpretation of these components is different for rural and urban areas.

URBAN AND RURAL PROGRAMMES

It is difficult to weigh the priority of urban against rural sanitation programmes. The rural population is by far numerically greater and development in the rural sector may help to restrain the urban migration urge. However, because of over-crowding and close proximity, the health dangers faced by the urban population is far greater as demonstrated by numerous cholera outbreaks in the urban centres over the past few years, and the urban squatter areas are a major problem that will not disappear.

Another factor has to be considered also, that is, urban self-help programmes are more difficult to implement but are more cost-effective than programmes in scattered rural communities.

The key to success in self-help programmes is active participation from the community and individuals in all aspects of the project from planning to implementation. In rural areas, the communities are cohesive and more responsive to motivation from village leaders and are more able to find time from their work programmes. But in urban areas, the communities are less cohesive and less responsive to community leader motivation. Furthermore, the urbanite is less likely to have title to his dwelling and therefore less incentive to improve facilities. He is more likely to be committed to formal wage earning activities that cannot be disrupted. The urban dweller has higher expectations and more cash to fulfill them, therefore he may not easily be persuaded that a VIP is more realistic than a white porcelain flush toilet that is available to others in the town.

The different approaches to the rural and urban situations can be exemplified by comparing the projects in each sector.

(a) The Dar es Salaam Urban Sanitation Project has the following components:

* Promotion aimed at individuals using 10-cell leaders (community leaders).

* Provision of long-term soft loans for latrine construction.

* Latrine construction by contractor on a batch basis to gain economy of numbers.

* Programme reinforcement through a health/hygiene education campaign. The latrine type, being a single-vault VIP, is designed for mechanical emptying.

(b) The Wanging'ombe Rural Sanitation Project (which is the subject of a separate paper in this seminar) has its components as:

* Promotion aimed at village leaders who organise community participation in brick burning and latrine construction.

* Central fabrication (organised by the donor) of special latrine components such as reinforced concrete slabs which are provided together with cement as a subsidy to the communities.

The latrine type is a double-vault VIP, designed for hand emptying.

SPECIFIC SANITATION PROJECTS IN TANZANIA

A number of sanitation projects are presently being implemented or have been designed and are awaiting funding. These projects are administered by various responsible institutions and it is interesting to compare the various approaches.

(a) Afya is responsible for three project.

* The UNICEF-funded Wanging'ombe Project, as previously discussed.

* The USAID-funded Schools Health Programme, which is an integrated programme based in primary schools of two regions in Tanzania.

  The programme consists of health education, nutrition, immunisation, and provision of water supplies and sanitation.

  The sanitation component is organised on a subsidised self-help basis, in which the donor provides materials and the community provides labour.

* The Regional Environmental Sanitation Programme, which is organised internally by two departments of Afya, the Environmental *Health Division and the Health Education Unit.*

  The basis of the project is a series of regional seminars in which health and development workers from each region are brought together for workshops and practical demonstration of latrine building. These workers then return to their duties as sanitation promoters and extension workers.

  The programme has created a deep national awareness and reinforced the basic training of the health workers. Implementation funds as such are not available.

(b) Ardhi, the Urban Development Ministry

Through its Sewerage and Drainage Division, Ardhi has designed integrated sewerage/sanitation proposals for the main urban centres of Dar es Salaam, Arusha, Moshi, Mwanza and Morogoro and has also collaborated with Maji in an integrated water supply/sewerage/sanitation proposal for Iringa.

All the designs have their concept similar to towns central areas which are being served with water-borne sewerage or septic tanks as capital costs can be recovered through charges. The remaining 80% or so of the population are being served by low-cost sanitation. The low-cost programmes are being based on self-help and incorporate promotion, demonstration, technical education and assistance, and health education.

Also, the Urban Planning Division of Ardhi has recently designed a squatter upgrading project, 'Buguruni Area - Dar es Salaam'. It is unique in Tanzania in two aspects:

(i) a squatter area has been officially recognised by Government and efforts are being made to improve it, and

(ii) the projects components, which are:

- removal of a few houses and resettlement for them nearby to provide space for access roads and storm water drainage;
- survey of plots and provision of tiles;
- provision of water by stand pipes;and
- a low-cost sanitation programme. This programme will consist of the establishment of a sanitation centre from which latrine components will be sold to residents.

(c) Maji, the Water Ministry, as discussed previously, is preparing regional water master plans for the whole country supported by bilateral donors.

The original terms of reference for these plans did not require to consider sanitation, however, because of the various influences from the donors both internally and externally, many have changed their approach to integrated water/sanitation planning; and without exception the sanitation proposals are based on self-help reinforced by health education.

(d) CDA - The Capital Development Authority, finally I should mention the CDA a parastatal body responsible for building the new capital in Dodoma.

The original planning for Dodoma included water-borne sanitation for all. However, economic constraints have dictated that this policy could not be implemented and the majority of the population who will live in sites and service areas would have to be served by an alternative sanitary facility. Future sites and service programmes will include low-cost sanitation components.

As works commenced to build the new capital, a new focal point for urban migration was created and predictably a new squatter area 'Chang'-ombe' blossomed on the city boundary overnight and is still growing at the rate of two houses per day. Also, Old Dodoma township still exists and provides a stark contrast to the new capital.

Plans for a squatter area upgrading programme and an urban renewal programme are being prepared and will include low-cost sanitation components of self-help by promotion, technical assistance and health education.

CONCLUSION

(a) In Tanzania, there is a strong awareness that sanitation programmes are an integral part of the development process and that alternative cheaper technologies to water-borne sewerage are essential.

(b) The VIP latrine is considered to be the most appropriate technology presently available because of its acceptability and robustness.

(c) The strategy for project implementation is self-help programmes that rely heavily on promotion and education rather than technical innovation.

AUTHOR'S NOTE

The views expressed in this paper are those of the author and not necessarily those of the Tanzania Government, tHE UNDP or the World Bank.

Annex I
THE VENTILATED IMPROVED PIT LATRINE (VIP)

The major problems usually associated with a traditionally constructed pit latrine are:

1) The pits have a short life span due to the pit collapsing and/or the pit becoming full.

2) They are malodorous.

3) They are a focus of insect breeding, especially flies which are a major vector of faeco-oral disease transmission links; and also in some instances are a focus of mosquito breeding.

4) The squatting plate is often fouled with feces and is difficult to clean, and thus can be a reservoir of hookworm larva.

Over the past few years, research projects in Botswana and Zimbabwe have developed an improved pit latrine in order to overcome these problems. The main features of the improved pit latrine are that it is relatively permanent, easier to clean, and foul odours and fly breeding are controlled. Permanence is ensured by providing a structural lining of the pit either for the full depth or partially, and sufficient volume is provided to give a useful life of 10 years or more.

The most important modification is the addition of a ventilation pipe or chimmey, screened at the top with a mosquito gauze. This has the effect of controlling both odour and fly breeding which are inter-linked.

The odour/fly control mechanism in ventilated pit latrines is well researched and established.

Wind shear across the top of the chimney or vent pipe creates a strong updraft which vents out the foul odours. Gravid or egg laying flies which are attracted to their egg laying site by foul odour, follow the smell to the top of the vent pipe but cannot enter into the pit because of the gauze. Furthermore, the few flies that do emerge from larva in the pit are strongly phototropic and fly toward light, the most intense source of light into the pit is via the vent pipe. Therefore the young emergent flies travel up the vent, but are prevented from leaving by the gauze. The flies remain trapped until they dehydrate, die and fall back into the pit. This mechanism is reinforced by adopting a superstructure design that provides a low light intensity in the interior of the superstructure.

The VIP may be in a double- or single-pit format; the twin pit being suitable for hand emptying in a alternating maturation cycle.

APPROPRIATE HUMAN WASTE DISPOSAL TECHNOLOGY FOR DEVELOPING COUNTRIES

B.Z. Diamant, FICE, FIPHE, FRSH

Professor of Environmental Health Engineering
Department of Water Resources & Environmental Engineering
Ahmadu Bello University
Zaria, Nigeria

INTRODUCTION

The disposal of waste, in particular human waste, is considered to be one of the major factors dominating the integrity of the human environment. The proper disposal of human waste has always been regarded as a primary social and personal duty. Even in the old Biblical times, people were advised to carry a paddle in order to dig and "turn back and cover that which cometh from thee" (Deuteron 23:13). Nevertheless, this basic environmental duty is still not being properly observed in many parts of the world, mainly in developing countries, although this negligence poses very dangerous health hazards and sanitary nuisances. The threat is mainly caused by human waste originating from people infected with intestinal diseases, such as cholera and typhoid fever. This waste contains harmful germs that transmit these diseases, and when they are surfacely exposed, rain floods will flush and carry them by gravity to the lowest elevation of the area, which is normally the site and course for natural bodies of water, such as rivers and lakes. The waste is diluted in the water in small quantities that cannot be observed by human senses, thus turning the innocent-looking water into an obscur dangerous health hazard.

The sad fact in this hazardous process is that almost all people living without fit waste disposal facilities also do not have access to safe drinking water, so that the viceous circle is complete. This environmental situation is, unfortunately, typical for most rural areas in developing countries.

WATER AND WASTE IN DEVELOPING COUNTRIES

As far as safe drinking water and proper waste disposal are concerned, there is a distinct difference between developed and developing countries. Unlike the latter, most people living in the developed countries have today access to safe drinking water and sanitation facilities. Only a small fraction of the population in these countries live in rural areas. In West Germany, for example, only 3.7% of the population of 61.4 million lived in 1978 in communities smaller than 1,000 people (West German Statistics, 1979). In developing countries, the population distribution is entirely different, with an overwhelming rural population amounting to the proportion of 72% (WHO, 1973). In some developing zones, like the African Continent, this proportion is far higher and reaches 83% of the Continent's population (WHO, 1976).

As a rule, the urban sector is much better off than the rural sector in almost all aspects of life, including the basic environmental necessities of safe water supply and adequate sanitation. Therefore, this major problem in the developing world with its large rural population, lies, and has to be tackled, mainly in the rural areas.

The World Health Organisation has carried out during the previous decade (1970-80) a Global Survey on water supply and wastewater disposal in developing countries (WHO, 1976). An interim report on the Survey, released in 1976, revealed alarming facts. Only one out of 8 rural people living in developing countries in 1975 had access to proper waste disposal facilities, and only one out of 5, to safe drinking water. Based on these findings, the Survey made predictions for 1980, according to which "only" 3 out of 4 rural people would not have access to waste disposal facilities, and 2 out of 3, to safe drinking water by 1980. However, even these humble wishes did not come true: according to recent information, the actual improvement in the field of waste disposal has been unfortunately negative, and the rate has dropped from 14% in 1975 to 14% in 1980. In the water supply field, an increase from 22 to 29% has been recorded (instead of the predicted 36%) (ANON., 1981). Table 1 indicates the water supply and waste disposal situation in developing countries as a whole and in the African Continent, in particular according to the WHO Global Survey.

The poor environmental conditions in developing countries have had detrimental effects on the health of the population. For example, out of the 13.6 million children that died in the world in 1979, 13.1 million lived in developing countries. Most of these deaths were caused by water-borne diseases transmitted by contaminated drinking water. These deaths could have been potentially prevented (WHO, 1980).

The findings of the WHO Survey have highlighted the gloomy environmental health conditions in the developing world and have consequently urged the United Nations Water Conference, held in 1977 in Mar del Plata, to recommend to the U.N. to declare the coming decade 1981-1990 as The International Drinking Water Supply and Sanitation Decade (IDWSSD). On 10 November 1980, the U.N. General Assembly inaugurated the IDWSSD and its goal: "Clean water and adequate sanitation for all by the year 1990".

Table 1: Water Supply and Waste Disposal in the Developing Countries (According to the 1970–80 WHO Global Survey)

Zone / Year	Per cent population served with					
	Safe drinking water			Waste disposal means		
	Urban	Rural	Mean *	Urban	Rural	Mean *
Dev. Count.						
1975	77	22	37.4	72	12	28.8
1980	91	36	51.4	94	24	43.6
Africa						
1975	65	21	28.5	80	21	31.3
1980	80	35	42.7	95	25	36.9

* Means were based on 28/72 and 17/83 rural/urban population ratioes in the developing countries and in Africa respectively.

HUMAN WASTE DISPOSAL

Nigeria, being a developing country in the African Continent, has accordingly an overwhelming rural population that urgently needs improved water supply, and in particular, sanitation facilities. The rural people in developing countries form the backbone of the nation and the major feeders of its population. These vital duties are hampered by the lack of basic environmental facilities such as water supply and sanitation. The present IDWSSD will, no doubt, encourage and buster the search for satisfactory solutions for these two major environmental issues.

Water supply and waste disposal are two mutually related environmental issues that complement each other and have to be, therefore, simultaneously designed, constructed and operated. Certain authors believe that, in a way the development of a proper waste disposal system should precede the water supply, in order to provide an already existing protection for the latter (Feachem, 1978). Nevertheless, there has always been a tendency to prefer the water supply aspect to the waste disposal one. As a result, numerous water supplies have been constructed without the necessary protection of proper waste disposal system. It is expected, therefore, that with the start of the IDWSSD activities, this practice will be altered.

An appropriate technology for human waste disposal in rural areas of developing countries must be considered together with a number of basic factors that are involved in - and affect - the adequate solution. Since a very large number of people are involved in the issue, the recommended solution must be adjusted to mass production in simple, fast and economical processes. The economic aspect is particularly important, since rural areas in developing countries are characterized by extreme poverty. The people should be encourage, as far as possible, to participate in the construction of the proposed solution. Its design has to be, therefore, very simple and consist of the use of easily available local materials. The appropriate technology in this respect must consider, in addition to the directly involved technology, socio-economic and psychological factors, in order to reach a satisfactory result.

WASTE DISPOSAL DEVICES

There are various human waste disposal devices, each designed according to specific needs and circumstances. The most common of these include the flush toilet, the chemical toilet, the aqua-privy and the pit latrine.

The Flush Toilet

This is the most efficient and satisfactory human waste disposal method. The device incorporates a water flushing system, maintained by a piped water supply connected to the house as well as a piping network which carries the flushed waste to a central sewerage system, or to a local individual system. The latter is usually composed of a septic tank and a percolation pit. This excellent device cannot be, however, considered as an appropriate solution for rural areas, not only because it is to costly, but also due to the need for a piped water supply to operate the device. Rural areas in developing countries simply cannot afford piped water supplies connections in the houses.

The Chemical Toilet

This is a sophisticated device where waste is passing a fast aerobic decomposition by means of adequate chemicals added to the device. In most cases, it is a costly portable unit, used mainly for camping and public transportation (aeroplanes, buses, etc.). The device is very efficient, but it cannot definitely be considered as an appropriate solution, because of its high cost and the dependence on a regular supply of chemicals.

The Aqua-Privy

The aqua-privy is composed of a large brick- or concrete-built tank filled with water, where human waste is collected and stored for anaerobic decomposition. The waste reaches the tank through a drop pipe hanging from the floor of the superstructure erected above the tank. The lower part of the pipe is submerged in the water, so as to provide a seal preventing obnoxious anaerobic gases from entering the superstructure. The device requires also a ventilation pipe reaching above the superstructure, as well as a disposal system for the water displaced by the entering waste, usually composed of a small sub-surface draining system.

Although this device is intended mainly for locations having poor water supplies, it is too costly and too sophisticated for rural areas in developing countries. It requires a relatively large quantity of water (1 - 2 m^3) that has to be provided manually. The construction cannot be performed by the future user, and requires the costly services of competent artisans. The walls, whether made of bricks or concrete, are likely to develop thermal cracks, through which water might escape to a level below the drop-pipe, hence breaking the seal and causing a severe sanitary nuisance. The method, however, fits the needs of institutions or wealthy individuals who can afford to build and maintain it, but not regular houses in rural areas in developing countries. The most suitable human waste disposal method for these areas is, however, a device incorporating the same principles as the aqua-privy, i.e. storage under anaerobic decomposition conditions, but in dry, rather than in wet surroundings. If this device - known as the pit latrine - is adequately designed and constructed, it can serve as an ideal solution for the human waste disposal problem in rural areas in developing countries.

THE PIT LATRINE

The pit latrine is a pit dug in the ground, where human waste is deposited and stored, so that rain floods cannot carry it to the nearby water course. The ordinary pit latrine has the dimensions of 1 x 1 x 4 m depth (4 m^3). Through the process of the anaerobic decomposition of the human waste that takes place in the pit, most of the waste turns into gases and water, so that this storage volume can be sufficient for a family of 5 people for a period of 3-4 years, provided only human waste reaches the pit (Diamant, 1979). The structure of the pit latrine is simple, made mostly of locally available materials. It is very economical with a very simple design, so that the future user can construct it by himself, under a brief guidance of a health inspector. These qualities enable mass production of the device, as required according to the local conditions in the rural areas of Nigeria and similar developing countries.

The pit latrine is composed of 3 main sections: the dug pit, the superstructure and the rigid slab in between them, which is usually made of concrete, though wood has also been practiced for this purpose.

The Dug Pit

The pit is normally dug by the future user himself to a depth of 3-4 m. Deeper pits are not recommended due to the possibility that anybody may fall in and be injured. In non-rigid soils, the upper one metre should be retained by raw wood sections. An empty drum with the removed top and bottom can serve as a satisfactory retainer for the upper section of the pit. The main problem involved in the digging of the pit is its siting. The proper siting is meant to prevent any near-by water source from being contaminated by the content of the pit. A considerable amount of research has been carried out on the migration of the bacteriological contamination and the chemical pollution through the particles of the soil. Observations have shown that the direction of migration was identified with the natural slope of the ground and the ground water table. It has been further established that chemical pollution, such as nitrates, was able to migrate much further than bacterial contamination. The migration itself depends on the porosity of the soil and its slope. Under average soil conditions, chemical migration can reach a distance of 100 metres horizontally, whereas bacterial migration was found to penetrate 3 metres vertically and 11 metres horizontally in the direction of the soil slope (Wagner, 1958).

Pit latrines should be located, therefore, downhill of any water source, such as a well, at a distance of at least 30 metres.

The Slab

The slab is the most important component of the pit latrine. It is usually made of concrete, but it can also be constructed of any other rigid material, such as wood or metal. The only costly parts in the concrete slab are cement and the reinforcement iron bars, which have to be provided in cash rather than in kind. If the bars cannot be obtained locally, they can be replaced with bamboo canes. The quality and perfection of the slab will depend largely on the casting mould. The mould can be made of wood, but for mass production purposes, metal should be preferred. The metal mould, if adequately constructed, can give excellent results. The mould is normally provided by an organising body of the campaign, usually the local health office. The same casting materials (cement, etc.) which are provided by the future user, are required for producing a good slab or a bad one, according to the quality of the casting mould. A good concrete slab must have the following qualities incorporated to its design (Diamant, 1978):

- Strength. The slab must be strong and durable using proper quantities of cement and reinforcement, so that it can easily be removed from one pit to another, when the former is filled up.

- Easy Cleaning. The upper surface should be smooth and have a slope towards the centre hole, so as to enable quick rinsing with a small quantity of water.

- Comfortable Use. The slab should have elevated foot rests, so that the user will automatically stand in the correct position, minimizing the contamination of the slab. For the same reason, the hole opening into the pit should have the shape of a key hole, preventing excreta and urine from reaching the slab.

- Fly Control. Flies tend to breed in human waste, but they prefer to do so with the presence of light. The hole in the slab should be provided, therefore, with a wooden cover, which must be placed over it after use. In order to ensure the cover's presence, it should be chained, with the end of the chain connected to a hook anchored in the concrete slab.

- Easy Handling. A concrete slab is quite heavy and might be cracked when moved to be placed on a new pit, after the previous one has been filled. The slab should be cast, therefore, in two halves, connected by means of tongue and groove (see Figure 1).

- Superstructure Support. In order to prevent the lightly built superstructure from being carried away with the wind during storms, the 4 corners of the slab should be provided with iron holders anchored in the concrete. The 4 poles of the superstructure can be fixed to the holders, hence turning the concrete slab into a foundation for the superstructure.

- Smell Control. The slab should have at its far corner a small depression for holding a can containing lime. By spraying daily a handful of lime in the pit, an alkaline environment is performed there, hence suppressing the development of the anaerobic production of hydrogen sulfide, which is basically acid. The high pH conditions in the pit will lead to the formation of methane instead of hydrogen sulfide, the former is far less obnoxious than the latter. Any alkaline material can be used for this purpose, but lime is the cheapest and the most available material of its kind in the rural areas, where it is mainly used for white washing walls.

The metal mould should be prepared in a well-equipped workshop in town that is capable to produce accurate and good finishing work. The slab is cast in the mould upside down and is kept there for at least 4 days. It is recommended to equip the mould with folding walls, so as to prevent damaging the corners of the slab upon removal from the mould. Hence the mould will rotate from site to site and it might be suitable to have some 10 moulds for each 1,000 people living in the campaign area. A waiting list for the use of the moulds has to be established, with those already completing digging their pits being first in the list.

It is important that the future users should be involved as far as possible in the simple construction of the pit latrine. They should provide materials, including reinforcement bars and cement (a half bag, or 25 kg). This involvement will develop the feeling of partnership and ensure a better use and maintenance of the device.

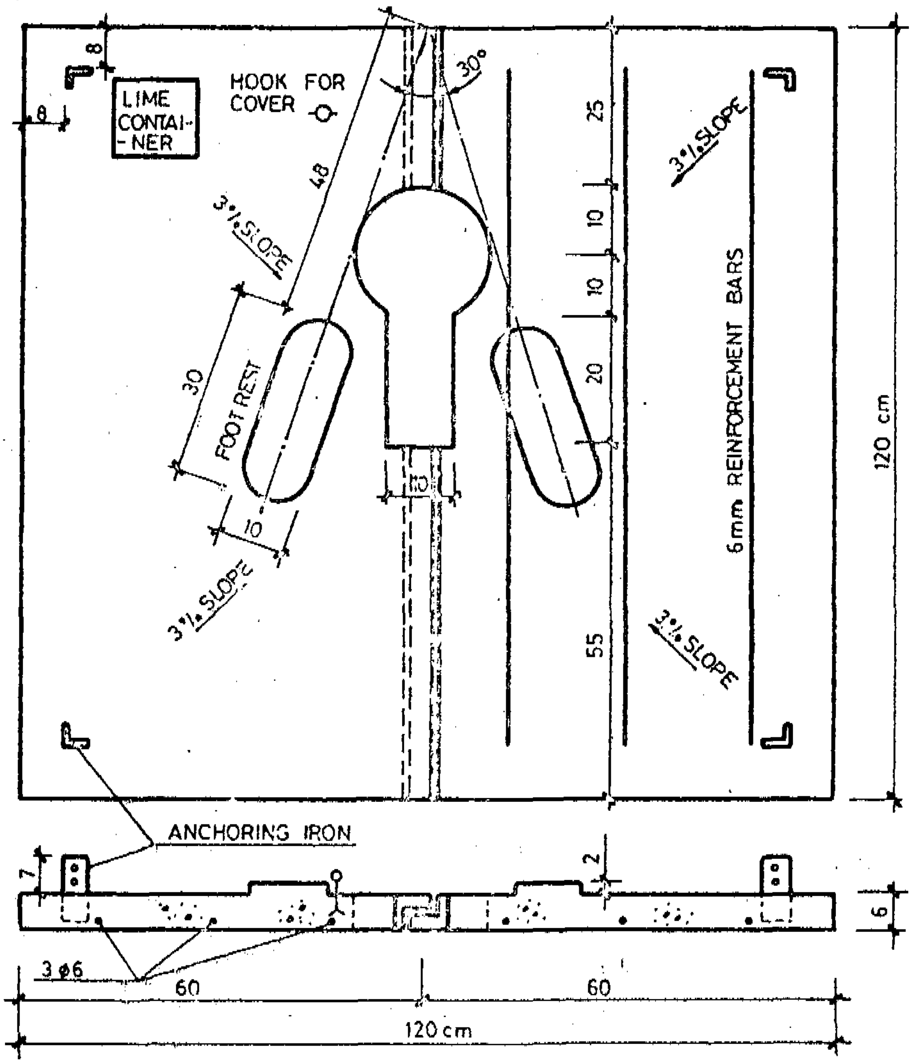


FIGURE 1: PLAN OF A PIT LATRINE CONCRETE SLAB

The Superstructure

Due to the mild climates in most developing countries, the superstructure over the pit latrine is meant mainly for providing the privacy of the user. It can be, therefore, built of light materials composed of raw wooden poles surrounded with home-woven mats. These are cheap and locally available materials, all provided in kind, and therefore less demanding in the prevailing poverty conditions.

In searching for a solution to the human waste disposal problem in rural areas in developing countries, the guiding considerations should mainly be mass production, economy and, of course, efficiency. Certain improvements have been suggested for the pit latrine, such as a concrete syphon attached to the central hole, ventilation pipes, etc. These improvements require the purchase in cash of materials and sections that cannot be built by the user. Furthermore, the syphon will require rinsing with water which is anyhow scarce and has to be carried from far sources. Simplicity has to be the guiding line in the present circumstances. The pit latrine, with its above-mentioned design features, can be considered as the most appropriate human waste disposal technology in the present circumstances.

URBAN WASTE DISPOSAL

Though the main human waste disposal problem in developing countries lies in rural areas, the urban wastewater disposal aspect has also a strong impact on rural areas.

Due to the increasing urbanization trend in recent years in many developing countries, numerous expanding large cities have started to design and construct central sewerage systems. Due to lack of local engineering manpower, most of these designs have been and are being carried out by international engineering consultants, mainly from developed countries. The most common wastewater disposal method in these countries is by means of dilution in a large body of natural water. This method can be tolerated there, because almost all people, including those living in rural areas in developed countries, have access to safe drinking water. Foreign consultants tend, therefore, to apply this disposal method in developing countries, where environmental conditions are entirely different, and where most people drink raw water from natural sources. It should be emphasized that even fully treated wastewater diluted under excellent dilution rates still pose a very dangerous health hazard for people drinking the water of the diluting river or lake (Diamant, 1978a)

Wastewater disposal by means of dilution must be completely abolished in developing countries and this has to be effected by adequate legislation. An appropriate replacement for the dilution disposal method is agricultural irrigation. Instead of being wasted in natural bodies of water where it causes severe contamination, treated wastewater can be used to irrigate crops and its organic content used as fertilizer.

However, irrigation with wastewater requires certain precautions and necessitates some limitations. The irrigated area has to be designated as a sewage farm and as such, should be fenced to prevent passers-by, in particular children, from entering the area. Raised crops should be restricted to kinds that require cooking prior to consumption, such as potatoes, yam or cassava, but not tomatoes or lettuce. Non-edible industrial crops should be always preferred to edible ones, since the former do not require any supervision and sorting. The method can be further developed by raising fish in ponds containing diluted wastewater. The fish are fed on the organic matter contained in the wastewater and the latter can be later diverted to irrigation as mentioned above. One important principle must be always kept in mind when practicing irrigation with wastewater - the primary purpose of the operation has to be wastewater disposal and not crop raising, so that in rainy days, for example, the wastewater has to be accepted and sprayed as in dry days, though the crop might be affected by excessive watering. This is the reason why the running of the sewage farm should not be entrusted with private farming enterprises that are normally not alert to this principle, but should be carried out by the local authority.

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A COMPUTER PACKAGE FOR THE ANALYSIS OF ANAEROBIC, FACULTATIVE AND MATURATION WASTE STABILIZATION POND DATA

Malwila G. Dissanayake

Visiting Professor
Experimental Station for the
Biological Treatment of Sanitary Wastes - EXTRABES
Federal University of Paraiba
Caixa Postal 306
58.100 Campina Grande
Paraiba, Brazil

ABSTRACT: Waste stabilization pond (WSP) design methods are largely based on first-order empirical and semi-empirical formulae. However, WSP is a complex ecosystem, where the kinetics are governed by several inter-dependent parameters. WSP data are seldom being analysed due to lack of analytical techniques. Due to this shortcoming, there are conflicting claims as to the efficiency of WSP in reducing organic and bacterial pollution. In this paper, a computer package is presented to analyse raw data of independent primary facultative ponds, anaerobic ponds and ponds in series. The package is capable of generating percentage reductions, surface and volume loadings - with and without evaporation and rainfall - of five-day biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), fecal coliforms (FC) and fecal streptococci (FS). The program can also generate completely-mixed, plug-flow and dispersed-flow kinetic constants, based on the models of Marais (1) and Thirumurthi (2) of BOD, COD, FC and FS. The results obtained from WSP in EXTRABES, Campina Grande, Brazil, were used to demonstrate the specimen calculations. The results were found to be more informative than raw data. The results generated can be used to formulate a comprehensive model, encompassing major parameters.

INTRODUCTION

Waste stabilization pond treatment is becoming popular in developing countries of Asia, Latin America and Africa due to low costs involved and abundance of sunlight in these regions. Pond treatment is specially attractive when land is available in abundant quantities. In this paper, a computer package is presented to analyse any kind of WSP data. In present day practice, anaerobic, facultative and maturation ponds - single or in series - are being used to treat domestic sewage. Due to lack of analytical techniques, however, data observed from many WSPs have not been analysed. Although some experimental pond data have been studied by researchers, data from full-scale ponds, which are in operation for municipal waste treatment, are seldom being given much importance. Due to this shortcoming, especially regarding full-scale ponds, there is a lack of understanding of the kinetics involved in WSP. Consequently, WSP design methods vary widely or are still based on empirical methods (3-5). To overcome the deficiencies of analytical techniques, a computer package is presented in this paper for WSP data analysis.

EXPERIMENTAL INVESTIGATION

Eleven waste stabilization ponds treating domestic sewage as shown in Figure 1 were investigated for a two-year period in tropical North-East Brazil. Four ponds (F2, F3, F4 and F5) were loaded independently (200 - 400 kg BOD_5/ha-day) so that they achieved facultative conditions. Two smaller ponds (A2 and A4) were heavily loaded with 6,695 and 2,810 kg BOD_5/ha-day, so that they achieved anaerobic conditions. In a five-pond series, the organic loading was adjusted to 544 kg BOD_5/ha-day so that the first pond (A1) was anaerobic, the second (Fi) was facultative and the subsequent three ponds (M1, M2 and M3) functioned as maturation ponds. Influent and effluent BOD_5, COD, SS, FC and FS were monitored weekly as major pollution parameters.

Chemical and bacteriological analyses were carried out according to standard methods (6). The experiments reported in this paper were carried out during March 1977 - May 1979. The pond layout is given in Figure 1.

The city of Campina Grande, Brazil is located at 7° 13' 11" South, 35° 53' longitude West and 547.7 meters above MSL.

During the experimental period, detailed tracer studies were carried out in some of the ponds. Dispersion number (DN) of ponds were calculated according to Levenspiel (7) and Thirumurthi (2). These results were included in the program to calculate dispersed-flow kinetic constants.

DEVELOPMENT OF THE PACKAGE PROGRAM

In this paper, a computer package was developed to analyse facultative, anaerobic and maturation WSP data. Experimental results obtained from pilot-scale pons in EXTRABES, Campina Grande were used to demonstrate the specimen calculations of the package. The computer package is capable of analysing data of upto three independent anaerobic ponds, four independent primary facultative ponds, and five ponds in series which should comprise an anaerobic pond followed by a secondary pond and three subsequent ponds. However, the package can be used to analyse data in any number of ponds, provided that the number is less than the maximum stipulated above for each category of ponds.

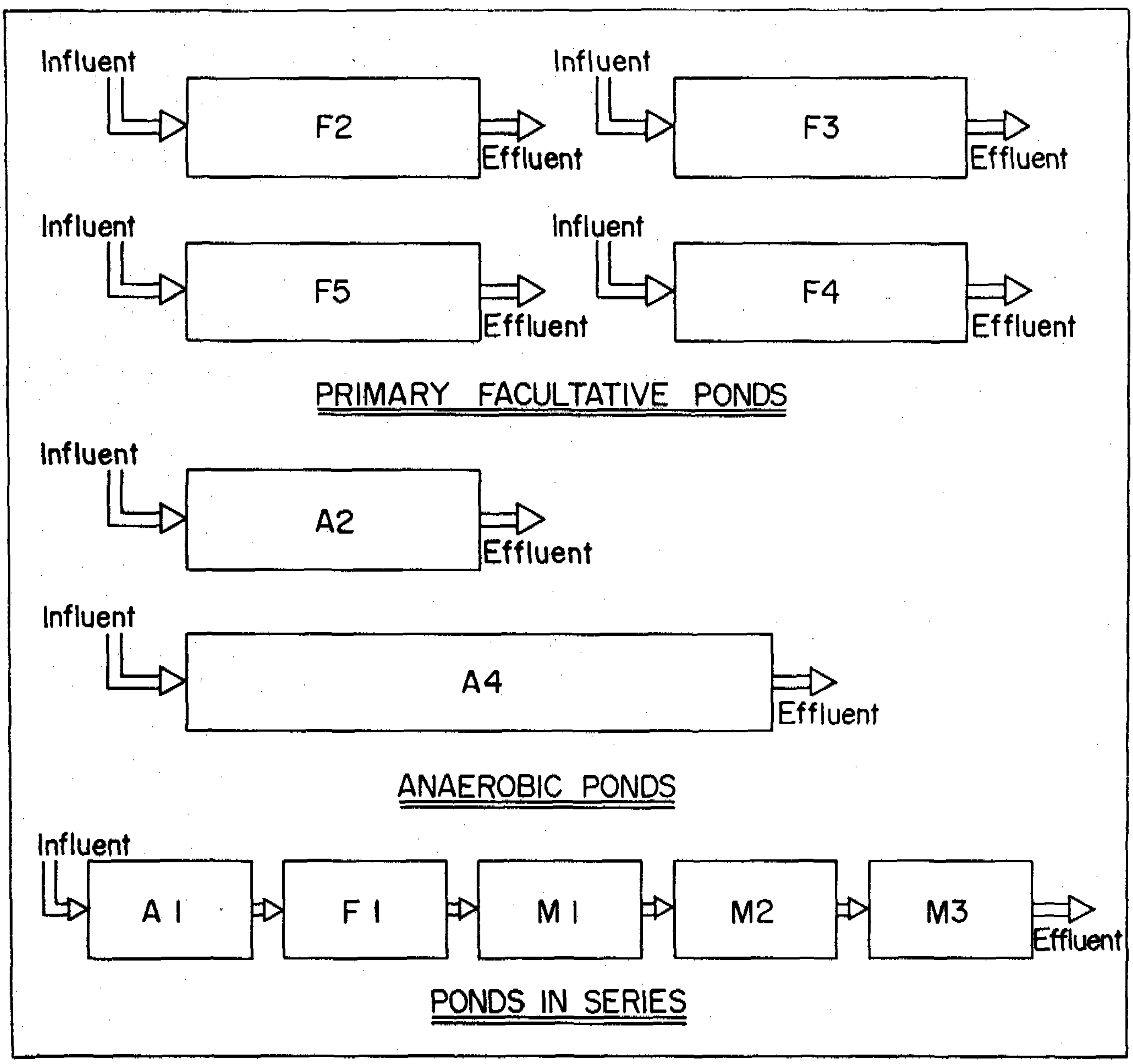

Fig. I. Waste Stabilization Ponds Layout

Components of the Program

The program was intended to determine percentage reductions (PR), surface removal with and without evaporation (SL and WL), volume loading with and without evaporation (VL and XL), volume removal with and without evaporation (VR and XR), plug-flow kinetic constants (PF), completely-mixed kinetic constants (CM), and dispersed-flow kinetic constants (DF) of BOD, COD, SS, FC and FS.

Tables 1 and 2 summarise the various parameters, their dimensions, and abbreviations for input and output, respectively.

Table 1: Input Parameters

Parameter	Dimension	Abbreviations
Biochemical oxygen demand, BOD_5	mg/l	Z1
Chemical oxygen demand, COD	mg/l	Z2
Suspended solids, SS	mg/l	Z3
Faecal coliforms, FC	No/100 ml	Z4
Faecal streptococci, FS	No/100 ml	Z5
Dispersion number	–	DN
Pond length	m	W
Pond width	m	B
Pond depth	m	D
Net monthly (evaporation - rainfall) EVAP	mm	Z8
Air temperature, TAIR	^oC	Z7
Water temperature, TWAT	^oC	Z6
Monthly sunshine hours, SH	hrs	Z9
Monthly sunlight intensity, LA	Langleys	V1
Flow rate	m^3/day	Q

Table 2: Output Parameters

Parameter	Abbreviation					Dimension
	BOD	COD	SS	FC	FS	
Percentage reduction;	PRZ1	PRZ2	PRZ3	PRZ4	PRZ5	–
Surface loading; without evaporation (WE)	SLZ1	SLZ2	SLZ3	-- SLZ4	-- SLZ5	kg/ha-day billions/ha-day
with evaporation (E)	WLZ1	WLZ2	WLZ3	-- WLZ4	-- WLZ5	kg/ha-day billions/ha-day
Volume loading; WE	VLZ1	VLZ2	VLZ3	-- VLZ4	-- VLZ5	g/m^3-day $millions/m^3$-day
E	XLZ1	XLZ2	XLZ3	-- XLZ4	-- XLZ5	g/m^3-day $millions/m^3$-day
Surface removal; WE	SRZ1	SRZ2	SRZ3	-- SRZ4	-- SRZ5	kg/ha-day billions/ha-day
E	WRZ1	WRZ2	WRZ3	-- WRZ4	-- WRZ5	kg/ha-day billions/ha-day
Volume removal; WE	VRZ1	VRZ2	VRZ3	-- VRZ4	-- VRZ5	g/m^3-day $millions/m^3$-day
E	XRZ1	XRZ2	XRZ3	-- XRZ4	-- XRZ5	g/m^3-day $millions/m^3$-day
Kinetic constants; completely mixed	CMZ1	CMZ2	--	CMZ4	CMZ5	day^{-1}
plug flow	PFZ1	PFZ2	--	PFZ4	PFZ5	day^{-1}
dispersed flow	DFZ1	DFZ2	--	DFZ4	DFZ5	day^{-1}

The complete computer package with subroutines is given in Appendix A. The input data to the computer program is given in Appendix B. The pond dimensions, flow rate and dispersion number are given in Table B-1. Meteorological data (TAIR, EVAP, SH, LA) are listed in Table B-2. Subsequent tables show the monthly pollution parameters (BOD_5, COD, SS, FC, FS and TWAT) of raw sewage and each of the other ponds.

INPUT DATA SEQUENCING

Ponds were divided into three systems according to Table 3.

Table 4 summarises the sequence of data arrangement and components in the data sets.

Table 3: System of Ponds

Pond symbols	Pond type	Category
F2, F3, F4, F5	Primary facultative	System I
A2, A4	Anaerobic ponds	System II
A1, F1, M1, M2, M3	Series of ponds	System III

Table 4: Sequence of Data Arrangement

Description of data set	Components in the data set	Sequence of feeding	End card remarks
Pond dimensions and operating parameters	W, B, D, Q, DN	Syst. I, II, III	No end card is needed
Meteorological data	TAIR, EVAP, SH, LA	Common for all ponds	At the end of the set print 111.1, 111.1 with correct format as first 2 numbers
Pollution data	BOD, COD, SS FC, FS, TWAT	Syst. I, II, III	At the end of the data set of each pond print 111.1, 111.1 with correct format as first 2 numbers

If the number of ponds that are to be analysed is less than the stipulated number in the program, zeros should be substituted for the absent ponds. The correct sequence as given in Table 2 should be strictly followed in substituting zeros. However, data obtained for any number of months can be analysed without alterations.

Input and Output Formats

Input and output formats can be changed according to user's requirements. For instance, for FC and FS, different output formats can be used to increase the precision of the results.

FORMULAE USED IN THE PROGRAM

Completely-mixed and plug-flow kinetic constants were calculated using the models of Marais (1). Dispersed-flow kinetic constant calculations were based on Thirumurthi (2). Surface and volume loading and removal calculations were based on mass balance of the ponds.

The equations used for calculations of various parameters are given below. The dimensions of the input and output parameters are given in Tables 1 and 2, respectively. The formulae for BOD, COD and SS are given in terms of BOD (Z1) only; for COD and SS, Z1 should be replaced by Z2 and Z3. Similarly, for FC and FS, equations are given in terms of only Z4; to arrive at Z5, all Z4 should be replaced by Z5. The following abbreviations were also used in the equations.

eq. Z1' - Influent BOD
Z1 - Effluent BOD

Parameters without Evaporation and Rainfall

a. BOD, COD and SS

Surface loading SL;

$$SLZ1 = 10.0\,(Z1')\,(Q/WB) \tag{1}$$

Surface removal SR:

$$SRZ1 = 10.0\,(Z1' - Z1)\,(Q/WB) \tag{2}$$

Volume loading VL;

$$VLZ1 = Z1'\,(Q/WBD) \tag{3}$$

Volume removal VR;

$$VRZ1 = (Z1' - Z1)\,(Q/WBD) \tag{4}$$

b. FC and FS

Surface loading SL;

$$SLZ4 = Z4' (Q/10WB) \quad (5)$$

Surface removal SR;

$$SRZ4 = (Z4' - Z4) (Q/10WB) \quad (6)$$

Volume loading VL;

$$VLZ4 = 10^{-2} Z4' (Q/WBD) \quad (7)$$

Volume removal VR;

$$VRZ4 = 10^{-2} (Z4' - Z4) (Q/WBD) \quad (8)$$

Parameters with Evaporation and Rainfall

Flow rates of the ponds are affected by evaporation and rainfall. Based on mass balance, the following equations were formulated to determine the influent and effluent flow rate changes. Since evaporation and rainfall changes monthly, flow rate changes monthly accordingly for each pond.

In the equations for flow rates the following symbols are used:

Q1 (i, j) - initial flow rate to the pond
QE (i, j) - final flow rate
AQ (i, j) - change in flow rate

Where i - pond and j - month.

AQ (i, j) - is determined by equation (9)

$$AQ(i, j) - (\text{evaporation} - \text{rainfall})\ 10^{-3} (W_i * B_i) \quad (9)$$

Q1 (i, j) and QE (i, j) equations are given in Table 5.

a. BOD, COD and SS

Surface loading SL;

$$SLZ1_{ij} = (Z1'_{ij} \times Q1_{ij}) (10/W_iB_i) \quad (10)$$

Surface removal SR;

$$SRZ1_{ij} = \frac{(Z1'_{ij} \times Q1_{ij}) - (Z1'_{ij} \times QE_{ij})}{(10/W_iB_i)} \quad (11)$$

Volume loading VL;

$$VLZ1_{ij} = (Z1'_{ij} - Q1_{ij})/W_iB_iD_i \quad (12)$$

Volume removal VR;

$$VRZ1_{ij} = \frac{(Z1'_{ij} - Q1_{ij}) - (Z1_{ij} \times QE_{ij})}{W_i B_i D_i} \tag{13}$$

Table 5: Q1(i, j) and QE(i, j) Values

Pond	Q1(i, j)	QE(i, j)
F2, F3, F4, F5 A2, A3	Q(F2, J)	Q1(F2*, j) – AQ(F2*, j) *To obtain other ponds F2 should replaced by pond symbol.
A1	Q(A1, j)	Q1(A1, j) – AQ(A1, j)
F1	QE(A1, j)	QE(A1, j) – AQ(F1, j)
M1	QE(F1, j)	QE(F1, j) – AQ(M1, j)
M2	QE(M1, j)	QE(M1, j) – AQ(M2, j)
M3	QE(M2, j)	QE(M2, j) – AQ(M3, j)

b. FC and FS

Surface loading SL;

$$SLZ4 = (Z4'_{ij} \times Q1_{ij})/10W_i B_i \tag{14}$$

Surface removal SR;

$$SRZ4 = \frac{(Z4'_{ij} \times Q1_{ij}) - (Z4_{ij} \times QE_{ij})}{10W_i B_i} \tag{15}$$

Volume loading VL;

$$VLZ4 = (Z4'_{ij} \times Q1_{ij})/100\ W_i B_i D_i \tag{16}$$

Volume removal VR;

$$VRZ4 = \frac{(Z4'_{ij} \times Q1_{ij}) - (Z4_{ij} \times QE_{ij})}{100W_i B_i D_i} \tag{17}$$

SPECIMEN OUTPUT RESULTS

The observations obtained in the ponds during the twenty four-month period were analysed by the computer package. Printouts were obtained in tabular form for each parameter for each ponds. These results proved to be very useful and informative than the raw data. Especially direct comparisons can be made on different ponds in different regions, due to the linearity of results.

Output printouts are tabulated in Appendix C. Actual residence times of the ponds were also generated by the program. These values can be compared with the hydraulic retention times of the ponds.

In this paper, no attempt was made to discuss the results obtained from the program. The data were used only to generate to specimen calculations.

The results obtained using this package can also be used for regression analysis and other forms of mathematical modelling to obtain the kinetics of organic and bacterial removal. They can be effectively used in conjunction with algal concentration sunlight intensity, sunlight duration TWAT, TAIR, and hydraulic detention time to obtain comprehensive models, as pointed out by Dissanayake (8), Bowles et al. (9) and Uhlmann (10).

CONCLUSIONS

a) The proposed package program is useful in analysing raw data of anaerobic, facultative and maturation waste stabilization ponds.

b) The package is capable of analysing up to four independent primary facultative ponds, three independent anaerobic ponds and five ponds in series.

c) For each pond, the package is capable of generating the values of percentage reductions; surface loading and removal with and without evaporation and rainfall; volume removal and loading with and without evaporation and rainfall, of BOD_5, COD, SS, fecal coliforms and fecal streptococci. The package is also capable of generating the values of plug-flow, completely-mixed and dispersed-flow kinetic constants of BOD_5, COD, FC and FS.

d) The results generated by the package proved to be more informative than the raw data and these results can be effectively and more meaningfully used to compare the performance of different ponds from different regions.

e) The generated results can be used with other parameters such as algal concentration, air and pond temperatures, and sunlight intensity and duration to formulate comprehensive models to describe the waste stabilization pond kinetics.

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Appendix A

COMPUTER PACKAGE

```
C     PROGRAM TO ANALYSE WASTE STABILIZATION POND DATA
C     PROGRAMMED BY MALWILA DISSANAYAKE
C     READ  DIMENSIONS ,METEC.DATA ,BOD,COD DATA FOR EACH POND
C     SEPERATELY AFTER MET.DATA AND EACH BOD DATA INCLUDE SPECIAL CARD
      DIMENSION Z1(50 ,13),Z2(50 ,13),Z3(50 ,13),Z4(50 ,13),Z5(50 ,13)
     X,Z6(50 ,13)
     X,PRZ1(50 ,12),PRZ2(50 ,12),PRZ3(50 ,12),PRZ4(50 ,12),PRZ5(50 ,
     X 12),PRZ6(50 ,12),
     XSLZ1(50 ,12),SLZ2(50 ,12),SLZ3(50 ,12),SLZ4(50 ,12),SLZ5(50 ,12)
     X,SRZ1(50 ,12),SRZ2(50 ,12),SRZ3(50 ,12),SRZ4(50 ,12),SRZ5(50,12)
     X,R1(12),R2(12),R3(12),R4(12),R5(12),R6(12),R7(12),R8(12),
     XVLZ1(50 ,12),VLZ2(50 ,12),VLZ3(50 ,12),VLZ4(50 ,12),VLZ5(50 ,12),
     XVRZ1(50 ,12),VRZ2(50 ,12),VRZ3(50 ,12),VRZ4(50 ,12),VRZ5(50 ,
     X 12),WLZ1(50 ,12),WLZ2(50 ,12),WLZ3(50 ,12),WLZ4(50 ,12),WLZ5(50 ,
     X12),
     XWRZ1(50 ,12),WRZ2(50 ,12),WRZ3(50 ,12),WRZ4(50 ,12),
     XWRZ5(50 ,12),XLZ1(50 ,12),XLZ2(50 ,12),XLZ3(50 ,12)
     X ,XLZ4(50 ,12)
     X,XLZ5(50 ,12),XRZ1(50 ,12),XRZ2(50 ,12),XRZ3(50 ,12),XRZ4(50
     X,12),XRZ5(50 ,12),CMZ1(50 ,12),CMZ2(50 ,12),CMZ4(50 ,12),CMZ5
     X(50 ,12),PFZ1(50 ,12),PFZ2(50 ,12),PFZ4(50 ,12),PFZ5(50 ,12),
     X DFZ1(50 ,12),DFZ2(50 ,12),DFZ4(50 ,12),DFZ5(50 ,12),W(12),
     X B(12),D(12),Q(12),DN(12),Z7(50 ),Z8(50 ),
     XZ9(50),V1(50),QE(50,12),DT(12),V2(50,13),AV(12),QEDT(50,12)
C     CREATION OF W,B,D,Q,DN FILES
C    ,W(12),B(12),Q(12),DN(12)
C     WRITING AND READING OF POND DIMENSIONS
C     DIMENSIONS ARE READ IN THE ORDER OF F2,F3,F4,F5,A2,A3,A4,A1,F1,
C     ,M1,M2,M3
      DO  111   IIJ=1,3
      WRITE(6,200)
  200 FORMAT(5X,'POND NO',3X,'LENGTH',2X,'BREADTH',2X,'DEPTH',3X,'FLOW
     X RATE',2X,'DISP NUMB')
      DO 10 J=1,12
         READ(5,110)  W(J),B(J),D(J),Q(J),DN(J)
  110 FORMAT(2X,5(F7.2,2X))
      WRITE (6,201)J,W(J),B(J),D(J),Q(J),DN(J)
  201  FORMAT(5X,I3,5X,3(F7.2,2X),2X,F7.2,2X,F7.2)
   10 CONTINUE
C     READING 12 SETS OF DATA FOR 12 PONDS ONLY
C     READ AND WRITE METEOROLOGICAL DATA
      WRITE (6,202)
  202 FORMAT (2X,'METEORLOGICAL DATA')
      CALL REME (Z7,Z8,Z9,V1,M3)
C     READING AND WRITING DATA SET FOR EACH POND
C     EG,A1-BOD,COD,SS,FS,FC,TWAT
C     READ IN THE ORDER OF F2,F3,F4,F5,A2,A3,A4,F1,M1,M2,M3
      DO 30 J=1,13
         M=1
  510     READ(5,100) Z1(M,J),Z2(M,J),Z3(M,J),Z4(M,J),Z5(M,J),
     X Z6(M,J),V2(M,J)
  100   FORMAT(2X,3(F6.1,2X),E8.1,4X,E9.1,3X,F5.1,2X,F7.4)
      IF(Z1(M,J).EQ.111.1.AND.Z2(M,J).EQ.111.1) GOTO 29
         M=M+1
         GOTO 510
   29    M1=M-1
   30 CONTINUE
C       WRITE EB DATA
```

```
      WRITE(6,212)
212   FORMAT(2X,'EB')
      CALL HE
      CALL WRIT,Z1,Z2,Z3,Z4,Z5,Z6,M1,13)
C     WRITE  A1 DATA
      WRITE(6,214)
214   FORMAT,2X,'A1')
      CALL HE
          CALL WRIT(Z1,Z2,Z3,Z4,Z5,Z6,M1,8)
C     WRITE F1 DATA
      WRITE(6,215)
215   FORMAT(2X,'F1')
      CALL HE
      CALL WRIT(Z1,Z2,Z3,Z4,Z5,Z6,M1,9)
C      WRITE M1 DATA
       WRITE(6,216)
216    FORMAT(2X,'M1')
       CALL HE
       CALL WRIT(Z1,Z2,Z3,Z4,Z5,Z6,M1,10)
C     WRITE M2 DATA
      WRITE,6,217)
217   FORMAT(2X,'M2')
      CALL HE
      CALL WRIT,Z1,Z2,Z3,Z4,Z5,Z6,M1,11)
C     WRITE M3 DATA
      WRITE(6,218)
218   FORMAT,2X,'M3')
      CALL HE
      CALL WRIT(Z1,Z2,Z3,Z4,Z5,Z6,M1,12)
C      WRITE F2 DATA
      WRITE(6,219)
219   FORMAT(2X,'F2')
      CALL HE
       CALL WRIT(Z1,Z2,Z3,Z4,Z5,Z6,M1,1)
C      WRITE F3 DATA
      WRITE(6,220)
220   FORMAT(2X,'F3')
      CALL  HE
      CALL WRIT(Z1,Z2,Z3,Z4,Z5,Z6,M1,2)
C      WRITE F4 DATA
      WRITE(6,221)
221   FORMAT(2X,'F4')
      CALL HE
      CALL WRIT(Z1,Z2,Z3,Z4,Z5,Z6,M1,3)
C     WRITE F5 DATA
      WRITE(6,222)
222   FORMAT,2X,'F5')
      CALL HE
      CALL WRIT(Z1,Z2,Z3,Z4,Z5,Z6,M1,4)
C     WRITE  A2 DATA
      WRITE(6,223)
223   FORMAT(2X,'A2')
      CALL HE
      CALL WRIT(Z1,Z2,Z3,Z4,Z5,Z6,M1,5)
C      WRITE A3  DATA
      WRITE,6,224)
224   FORMAT(2X,'A3')
      CALL HE
```

```
          CALL  WRIT(Z1,Z2,Z3,Z4,Z5,Z6,M1,6)
C         WRITE  A4 DATA
      WRITE(6,225)
  225 FORMAT(2X,'A4')
      CALL HE
        CALL WRIT(Z1,Z2,Z3,Z4,Z5,Z6,M1,7)
C     CALCULATION OF PERCENTAGE REDUCTIONS
C     BOD  PERCENTAGE REDUCTIONS
      CALL PR(PRZ1,Z1,M1)
      WRITE(6,240)
  240 FORMAT(2X,'BOD PERCENTAGE REDUCTIONS')
      CALL HEAD
      CALL WRE(PRZ1,M1)
      CALL AVE(PRZ1,AV,M1)
      CALL WAVE(AV)
C     COD PERCEN REDUCTIONS
      CALL PR(PRZ2,Z2,M1)
      WRITE(6,242)
  242 FORMAT(2X,'COD PERCENTAGE REDUCTIONS')
      CALL HEAD
      CALL WRE(PRZ2,M1)
      CALL AVE(PRZ2,AV,M1)
      CALL WAVE(AV)
C       SS PER. REDUCTIONS
      CALL PR(PRZ3,Z3,M1)
      WRITE(6,243)
  243 FORMAT(2X,'SS PERCENTAGE REDUCTIONS')
      CALL HEAD
      CALL WRE(PRZ3,M1)
      CALL AVE(PRZ3,AV,M1)
      CALL WAVE(AV)
C       FS PER. REDUCTIONS
      CALL PR(PRZ4,Z4,M1)
      WRITE(6,244)
  244 FORMAT(2X,'FS PER REDUCTIONS')
      CALL HEAD
      CALL WRE(PRZ4,M1)
      CALL AVE(PRZ4,AV,M1)
      CALL WAVE(AV)
C       FC  PER  REDUCTIONS
      CALL PR(PRZ5,Z5,M1)
      WRITE(6,245)
  245 FCRMAT(2X,'FC PERCENTAGE REDUCTIONS')
      CALL HEAD
      CALL WRE(PRZ5,M1)
      CALL AVE(PRZ5,AV,M1)
      CALL WAVE(AV)
C      CALCULATION OF SUREVOL LOADING WITHOUT EVAPORATION
C      BOD
      CALL WEV(SLZ1,Z1,Q,W,B,SRZ1,VLZ1,D,VRZ1,M1)
C      COD
       CALL WEV(SLZ2,Z2,Q,W,B,SRZ2,VLZ2,D,VRZ2,M1)
C      SS
       CALL WEV(SLZ3,Z3,Q,W,B,SRZ3,VLZ3,D,VRZ3,M1)
C      FC
       CALL WEV(SLZ4,Z4,Q,W,B,SRZ4,VLZ4,D,VRZ4,M1)
C      FS
       CALL WEV(SLZ5,Z5,Q,W,B,SRZ5,VLZ5,D,VRZ5,M1)
```

```
C      FC AND FS  VALUES DIVIDED BY 100.0 TO GET IN BILLIONS
       CALL CCN(SLZ4,SRZ4,VLZ4,VRZ4,50,12,M1)
       CALL CCN(SLZ5,SRZ5,VLZ5,VRZ5,50,12,M1)
C       WRITING SUR. VOL. LOADINGS AND REMOVALS WITHOUT EVAP
C       BOD
        WRITE(6,246)
 246    FORMAT(5X,'BOD')
        CALL WWA
        CALL HEAD
        CALL WRE(SLZ1,M1)
       CALL AVE(SLZ1,AV,M1)
       CALL WAVE(AV)
        CALL WWB
        CALL HEAD
        CALL WRE(SRZ1,M1)
       CALL AVE(SRZ1,AV,M1)
       CALL WAVE(AV)
        CALL WWC
        CALL HEAD
        CALL WRE(VLZ1,M1)
       CALL AVE(VLZ1,AV,M1)
       CALL WAVE(AV)
        CALL WWD
        CALL HEAD
        CALL WRE(VRZ1,M1)
       CALL  AVE(VRZ1,AV,M1)
       CALL  WAVE(AV)
C      COD
        WRITE(6,251)
 251    FORMAT(5X,'COD')
        CALL WWA
        CALL HEAD
        CALL WRE(SLZ2,M1)
       CALL  AVE(SLZ2,AV,M1)
       CALL  WAVE(AV)
        CALL WWB
        CALL HEAD
        CALL WRE(SRZ2,M1)
       CALL  AVE(SRZ2,AV,M1)
       CALL  WAVE(AV)
        CALL WWC
        CALL HEAD
        CALL WRE(VLZ2,M1)
       CALL  AVE(VLZ2,AV,M1)
       CALL  WAVE(AV)
        CALL WWD
        CALL HEAD
        CALL WRE(VRZ2,M1)
       CALL  AVE(VRZ2,AV,M1)
       CALL  WAVE(AV)
C       SS
        WRITE(6,851)
 851    FORMAT(5X,'SS')
        CALL WWA
        CALL HEAD
        CALL WRE(SLZ3,M1)
       CALL  AVE(SLZ3,AV,M1)
       CALL  WAVE(AV)
```

```
      CALL WWB
      CALL HEAD
      CALL WRE(SRZ3,M1)
      CALL  AVE(SRZ3,AV,M1)
      CALL  WAVE(AV)
      CALL WWC
      CALL HEAD
      CALL WRE(VLZ3,M1)
      CALL  AVE(VLZ3,AV,M1)
      CALL  WAVE(AV)
      CALL WWD
      CALL HEAD
      CALL WRE(VRZ3,M1)
      CALL  AVE(VRZ3,AV,M1)
      CALL  WAVE(AV)
C       FC
      WRITE(6,252)
  252 FORMAT(5X,'FC')
      CALL WWA
      CALL HEAD
      CALL FWRE(SLZ4,M1)
      CALL  AVE(SLZ4,AV,M1)
      CALL  FWAVE(AV)
      CALL WWB
      CALL HEAD
      CALL FWRE(SRZ4,M1)
      CALL  AVE(SRZ4,AV,M1)
      CALL  FWAVE(AV)
      CALL WWC
      CALL HEAD
      CALL FWRE(VLZ4,M1)
      CALL  AVE(VLZ4,AV,M1)
      CALL  FWAVE(AV)
      CALL WWD
      CALL HEAD
      CALL FWRE(VRZ4,M1)
      CALL  AVE(VRZ4,AV,M1)
      CALL  FWAVE(AV)
C        FS
      WRITE(6,253)
  253 FORMAT(5X,'FS')
      CALL WWA
      CALL HEAD
      CALL FWRE(SLZ5,M1)
      CALL  AVE(SLZ5,AV,M1)
      CALL  FWAVE(AV)
      CALL WWB
      CALL HEAD
      CALL FWRE(SRZ5,M1)
      CALL  AVE(SRZ5,AV,M1)
      CALL  FWAVE(AV)
      CALL WWC
      CALL HEAD
      CALL FWRE(VLZ5,M1)
      CALL  AVE(VLZ5,AV,M1)
      CALL  FWAVE(AV)
      CALL WWD
      CALL HEAD
```

```
      CALL FWRE(VRZ5,M1)
      CALL  AVE(VRZ5,AV,M1)
      CALL  FWAVE(AV)
C      STORE EVAPORATION+FLC. RATES IN QE(500,12)
       CALL QCE(QE,C,Z8,W,B,M1)
C      COMPUTATION OF SURFACE   VOL LOADINGS, REMOVALS
C      WITH EVAPORATION
C      BOD
       CALL EV(WLZ1,Z1,C,W,B,WRZ1,QE,XLZ1,D,XRZ1,M1)
C      COD
       CALL EV(WLZ2,Z2,C,W,B,WRZ2,QE,XLZ2,D,XRZ2,M1)
C      SS
       CALL EV(WLZ3,Z3,C,W,B,WRZ3,QE,XLZ3,D,XRZ3,M1)
C      FC
       CALL EV(WLZ4,Z4,C,W,B,WRZ4,QE,XLZ4,D,XRZ4,M1)
C      FS
       CALL EV(WLZ5,Z5,C,W,B,WRZ5,QE,XLZ5,D,XRZ5,M1)
C     FC AND FS  VALUES  DIVIDE  BY 100.0  TO  GET  IN BILLIONS
      CALL  CON(WLZ4,WRZ4,XLZ4,XRZ4,50,12,M1)
      CALL  CON(WLZ5,WRZ5,XLZ5,XRZ5,50,12,M1)
C     WRITING
C     BOD
      WRITE(6,260)
 260   FORMAT(5X,'SURFACE AND VOLUME LOADINGS AND REMOVALS WITH EVAPORAT
     XION'//5X,'BOD')
      CALL WWA
      CALL HEAD
      CALL WRE(WLZ1,M1)
      CALL  AVE(WLZ1,AV,M1)
      CALL  WAVE(AV)
      CALL WWB
      CALL HEAD
      CALL WRE(WRZ1,M1)
      CALL  AVE(WRZ1,AV,M1)
      CALL  WAVE(AV)
      CALL WWC
      CALL HEAD
      CALL WRE(XLZ1,M1)
      CALL    AVE(XLZ1,AV,M1)
      CALL    WAVE(AV)
      CALL WWD
      CALL HEAD
      CALL WRE(XRZ1,M1)
      CALL    AVE(XRZ1,AV,M1)
      CALL    WAVE(AV)
C     COD
      WRITE(6,261)
 261  FORMAT(5X,'COD')
      CALL WWA
      CALL HEAD
      CALL WRE(WLZ2,M1)
      CALL  AVE(WLZ2,AV,M1)
      CALL  WAVE(AV)
      CALL WWB
      CALL HEAD
      CALL WRE(WRZ2,M1)
      CALL  AVE(WRZ2,AV,M1)
      CALL  WAVE(AV)
```

```
      CALL WWC
      CALL HEAD
      CALL WRE(XLZ2,M1)
      CALL   AVE(XLZ2,AV,M1)
      CALL   WAVE(AV)
      CALL WWD
      CALL HEAD
      CALL WRE(XRZ2,M1)
      CALL   AVE(XRZ2,AV,M1)
      CALL   WAVE(AV)
C     SS
      WRITE(6,262)
  262 FORMAT(5X,'SS')
      CALL WWA
      CALL HEAD
      CALL WRE(WLZ3,M1)
      CALL  AVE(WLZ3,AV,M1)
      CALL  WAVE(AV)
      CALL WWB
      CALL HEAD
      CALL WRE(WRZ3,M1)
      CALL  AVE(WRZ3,AV,M1)
      CALL  WAVE(AV)
      CALL WWC
      CALL HEAD
      CALL WRE(XLZ3,M1)
      CALL  AVE(XLZ3,AV,M1)
      CALL  WAVE(AV)
      CALL WWD
      CALL HEAD
      CALL WRE(XRZ3,M1)
      CALL  AVE(XRZ3,AV,M1)
      CALL  WAVE(AV)
C     FC
      WRITE(6,263)
  263 FORMAT(5X,'FC')
      CALL WWA
      CALL HEAD
      CALL FWRE(WLZ4,M1)
      CALL   AVE(WLZ4,AV,M1)
      CALL   FWAVE(AV)
      CALL WWB
      CALL HEAD
      CALL FWRE(WRZ4,M1)
      CALL   AVE(WRZ4,AV,M1)
      CALL   FWAVE(AV)
      CALL WWC
      CALL HEAD
      CALL FWRE(XLZ4,M1)
      CALL   AVE(XLZ4,AV,M1)
      CALL   FWAVE(AV)
      CALL WWD
      CALL HEAD
      CALL FWRE(XRZ4,M1)
      CALL  AVE(XRZ4,AV,M1)
      CALL  FWAVE(AV)
C         FS
      WRITE(6,264)
```

```
  264   FORMAT(5X,'FS')
        CALL WWA
        CALL HEAD
        CALL FWRE(WLZ5,M1)
        CALL  AVE(WLZ5,AV,M1)
        CALL  FWAVE(AV)
        CALL WWB
        CALL HEAD
        CALL FWRE(WRZ5,M1)
        CALL  AVE(WRZ5,AV,M1)
        CALL  FWAVE(AV)
        CALL WWC
        CALL HEAD
        CALL FWRE(XLZ5,M1)
        CALL  AVE(XLZ5,AV,M1)
        CALL  FWAVE(AV)
        CALL WWD
        CALL HEAD
        CALL FWRE(XRZ5,M1)
        CALL  AVE(XRZ5,AV,M1)
        CALL  FWAVE(AV)
C       KINETIC CONSTANTS COMPLETELY MIXED
C       AND PLUG FLOW CMZ1,PFZ1,DFZ1 FILES
C       CREATE DT FILE DT-DETENTION TIME
        DO 70 J=1,12
                IF(Q(J).EQ.0.0)  GO TO   311
        DT(J)=(W(J)*B(J)*D(J))/Q(J)
              GOTO  70
  311           DT(J)=0.0
   70   CONTINUE
C       FOR BCD
        CALL PLUC(PFZ1,CMZ1,Z1,DT,M1)
C       FOR CCD
        CALL PLUC(PFZ2,CMZ2,Z2,DT,M1)
C       FOR FC
        CALL PLUC(PFZ4,CMZ4,Z4,DT,M1)
C       FOR FS
        CALL PLUC(PFZ5,CMZ5,Z5,DT,M1)
C       WRITING
C       BCD
        WRITE(6,270)
  270   FORMAT(2X,'BCD')
        CALL KPA
        CALL HEAD
        CALL WRE(PFZ1,M1)
        CALL  AVE(PFZ1,AV,M1)
        CALL  WAVE(AV)
        CALL KPB
        CALL HEAD
        CALL WRE(CMZ1,M1)
        CALL  AVE(CMZ1,AV,M1)
        CALL  WAVE(AV)
C       CCD
        WRITE(6,272)
  272   FORMAT(2X,'CCD')
        CALL KPA
        CALL HEAD
        CALL WRE(PFZ2,M1)
```

```
      CALL  AVE(PFZ2,AV,M1)
      CALL  WAVE(AV)
      CALL KPB
      CALL HEAD
      CALL WRE(CMZ2,M1)
      CALL   AVE(CMZ2,AV,M1)
      CALL   WAVE(AV)
C     FC
      WRITE(6,273)
  273 FORMAT(2X,'FC')
      CALL KPA
      CALL HEAD
      CALL WRE(PFZ4,M1)
      CALL  AVE(PFZ4,AV,M1)
      CALL  WAVE(AV)
      CALL KPB
      CALL HEAD
      CALL WRE(CMZ4,M1)
      CALL  AVE(CMZ4,AV,M1)
      CALL  WAVE(AV)
C     FS
      WRITE(6,274)
  274 FORMAT(2X,'FS')
      CALL KPA
      CALL HEAD
      CALL WRE(PFZ5,M1)
      CALL   AVE(PFZ5,AV,M1)
      CALL   WAVE(AV)
      CALL KPB
      CALL HEAD
      CALL WRE(CMZ5,M1)
      CALL   AVE(CMZ5,AV,M1)
      CALL   WAVE(AV)
C     MAIN SECTION
C     CALL FOR  BCD
      CALL DF(DFZ1,Z1,DT,CN,M1)
C     CALL FOR CCD
      CALL DF(DFZ2,Z2,DT,CN,M1)
C     CALL FOR FC
      CALL DF(DFZ4,Z4,DT,CN,M1)
CC    CALL  FOR  FS
      CALL DF(DFZ5,Z5,DT,CN,M1)
C     WRITING
C     BCD
      WRITE(6,280)
  280 FORMAT(2X,'BCD')
      CALL KPC
      CALL HEAD
      CALL WRE(DFZ1,M1)
      CALL   AVE(DFZ1,AV,M1)
      CALL   WAVE(AV)
C     CCD
      WRITE(6,281)
  281 FORMAT(2X,'CCD')
      CALL KPC
      CALL HEAD
      CALL WRE(DFZ2,M1)
      CALL   AVE(DFZ2,AV,M1)
```

```
      CALL   WAVE(AV)
C     FC
      WRITE(6,282)
 282  FORMAT(2X,'FC')
      CALL KPC
      CALL HEAD
      CALL WRE(DFZ4,M1)
      CALL   AVE(DFZ4,AV,M1)
      CALL   WAVE(AV)
C     FS
      WRITE(6,283)
 283  FORMAT(2X,'FS')
      CALL KPC
      CALL HEAD
      CALL WRE(DFZ5,M1)
      CALL   AVE(DFZ5,AV,M1)
      CALL   WAVE(AV)
C      PRINT  DETENTION TIMES
       WRITE (6,549)
 549   FORMAT(2X,'POND NO IN THE ORDER OF F2,F3,F4,F5,A2,A3,A4,A1,F1,
     X   M1,M2,M3'/2X,'POND NO',3X,'DET TIME')
       DO   6  I2=1,12
         WRITE(6,550) I2,DT(I2)
 6     CONTINUE
 550   FORMAT(2X,I3,3X,F7.2)
            DO  301  J=1,12
                DO 302  I=1,M1
                   IF(QE(I,J).EQ.0.0)  GOTO  303
                   QEDT(I,J)=W(J)*B(J)*D(J)/QE(I,J)
                   GOTO 302
 303               QEDT(I,J)=0.0
 302            CONTINUE
 301        CONTINUE
C       WRITE ACTUAL RESIDENCE TIME
       WRITE(6,285)
 285   FORMAT(2X,'ACTUAL  RESIDENCE TIME')
       CALL  HEAD
       CALL WRE(QEDT,M1)
 111  CONTINUE
      STOP
      END
```

```
      SUBROUTINE EF (Y1,Y2,Y3,Y4,M1)
C     Y1-DFZ1,Y2-Z1,Y3-DT,Y4-CN   SUB-19
C     SUB TO  CALCULATE  DISPERSED FLOW   K-VALVES
      DIMENSION Y1(50 ,12),Y2(50 ,13),Y3(12),Y4(12)
        DO  90  J=1,8
           DO 91 I=1,M1
             IF(Y4(J).EQ.0.0) GOTO 88
            IF(Y2(I,J).EQ.0.0.OR.Y2(I,13).EQ.0.0)GOTO 88
             YK=0.0001
                  DO  30  L=1,10000
                  YK=YK+0.025
                  A=SQRT(1.0+(4.0*YK*Y3(J)*Y4(J)))
                 RHS=4.0*A*(EXP(1.0-(A/2.0*Y4(J))))/((1.0+A)
     X                *(1.0+A))
                 FHS=Y2(I,J)/Y2(I,13)
                 IF(RHS.LE.FHS) GOTO 31
 30            CONTINUE
 31          Y1(I,J)=YK
             GOTO 91
 88          Y1(I,J)=0.0
 91        CONTINUE
 90     CONTINUE
        DO 95 J=9,12
           J1=J-1
           DO 96 I=1,M1
             IF(Y4(J).EQ.0.0) GOTO 89
             IF(Y2(I,J).EQ.0.0.OR.Y2(I,J).EQ.0.0)GOTO 89
             YK=0.0001
               DO  32  L=1,10000
                  YK=YK+0.025
                  A=SQRT(1.0+(4.0*YK*Y3(J)*Y4(J)))
                  RHS=4.0 *A*(EXP(1.0-(A/2.0*Y4(J))))/((1.0+A)*(1.0+A))
                  FHS=Y2(I,J)/Y2(I,J1)
                  IF(RHS.LE.FHS) GOTO 33
 32            CONTINUE
 33            Y1(I,J)=YK
               GOTO 96
 89            Y1(I,J)=0.0
 96        CONTINUE
 95     CONTINUE
        RETURN
        END
```

```
C      SUB TO COMPLTE SUR VOL LOADINGS/REMOVALS WITH EVAPORATION SUB-12
C      Y1-WL Y2-71 Y3-Q Y4-W Y5-B Y6-WR Y7-QE Y8-XL Y9-9-D Y10-XR M1-DATA
       SUBROUTINE EV(Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,M1)
        DIMENSION Y1(50 ,12),Y2(50 ,13 ),Y3(12),Y4(12),Y5(12),Y6(50 ,12),
     X  Y7(50 ,12),Y8(50 ,12),Y9(12),Y10(50 ,12)
            DO  46  J=1,8
                DO  47 I=1,M1
                    IF(Y2(I,13).EQ.0.0.OR.Y2(I,J).EQ.0.0) GOTO 86
                    IF(Y7(I,J).EQ.0.0) GOTO 86
                    Y1(I,J)=(Y2(I,13)*Y3(J)*10.0)/(Y4(J)*Y5(J))
                    Y6(I,J)=((Y2(I,13)*Y3(J))-(Y2(I,J)*Y7(I,J)))/(Y4(J)
     X                        *Y5(J))
                    Y8(I,J)=Y1(I,J)/(10.0*Y9(J))
                    Y10(I,J)=Y6(I,J)/(10.0*Y9(J))
                    GOTO 47
 86                 Y1(I,J)=0.0
            Y6(I,J)=0.0
            Y8(I,J)=0.0
            Y10(I,J)=0.0
 47         CONTINUE
 46       CONTINUE
          DO  48  J=9,12
            J1=J-1
          DO   49  I=1,M1
            IF(Y2(I,13).EQ.0.0.OR.Y2(I,J).EQ.0.0) GOTO 87
            IF(Y7(I,J).EQ.0.0)  GOTO 87
     Y1(I,J)=(Y2(I,J1)*Y3(J)*10.0)/(Y4(J)*Y5(J))
            Y6(I,J)=((Y2(I,J1)*Y3(J))-(Y2(I,J)*Y7(I,J))
     X               )/(Y4(J)*Y5(J))
            Y8(I,J)=Y1(I,J)/(10.0*Y9(J))
            Y10(I,J)=Y6(I,J)/(10.0*Y9(J))
            GO TO 49
 87          Y1(I,J)=0.0
             Y6(I,J)=0.0
             Y8(I,J)=0.0
             Y10(I,J)=0.0
 49         CONTINUE
 48       CONTINUE
          RETURN
          END

C          PRINT HEADER        SUB-14
          SUBROUTINE  KPA
          WRITE (6,271)
          RETURN
 271      FORMAT(5X,'PLUG FLOW K-VALUES')
          END
```

```
C      PRINT HEADER       SUB -15
       SUBROUTINE KPB
       WRITE(6,272)
       RETURN
 272   FORMAT(5X,'COMPLETELY MIXED K-VALUES')
       END

C     PRINT  HEADER    SUB-17
      SUBROUTINE HEAD
      WRITE(6,231)
      RETURN
 231   FORMAT(6X,'A1',8X,'F1',7X,'M1',7X,'M2',7X,'M3',7X,'F2',
     X          8X,'F3',7X,'F4',7X,'F5',6X,'A2',7X,'A3',8X,'A4')
      END

      SUBROUTINE PLUG(Y1,Y2,Y3,Y4,M1)
C     YI-PFZI Y2-CMZI,Y3-ZI, Y4
C     YI-PFZI Y2-CMZI,Y3-ZI, Y4-DT, MI-NUNBER OF DATA
C     SUB-13 TO CALCULATE  PLUG AND CCM MIXED KINETIC CONSTANTS
      DIMENSION    Y1(50 ,12),Y2(50 ,12),Y3(50 ,13),Y4(12)
              DO  70 J=1,8
                  DO 71 I=1,M1
                       IF(Y3(I,J).EQ.0.0.OR.Y3(I,13).EQ.0.0) GOTO 88
               IF(Y4(J).EQ.0.0)     GO TO  88
               Y1(I,J)=(-ALOG(Y3(I,J)/Y3(I,13)))/Y4(J)
               Y2(I,J)=((Y3(I,13)/Y3(I,J))-1.0)/Y4(J)
                       GO TO 71
 88            Y1(I,J)=0.0
               Y2(I,J)=0.0
 71                CONTINUE
 70           CONTINUE
            DO 72  J=9,12
               J1=J-1
               DO 73  I=1,M1
                   IF(Y3(I,J).EQ.0.0.OR.Y3(I,J1).EQ.0.0) GOTO 89
               IF(Y4(J).EQ.0.0)     GO TO  89
                   Y1(I,J)=(-ALOG(Y3(I,J)/Y3(I,J1)))/Y4(J)
                   Y2(I,J)=((Y3(I,J1)/Y3(I,J))-1.0)/Y4(J)
               GOTO 73
 89                Y1(I,J)=0.0
                   Y2(I,J)=0.0
 73            CONTINUE
 72          CONTINUE
             RETURN
             END
```

```
C      SUB TO WRITE AVERAGES IN E FORMAT
       SUBROUTINE FWAVE(Y1)
       DIMENSICN Y1(12)
          WRITE(6,200)Y1(8),Y1(9),Y1(10),Y1(11),Y1(12),Y1(1),Y1(2),Y1(3)
      X     ,Y1(4),Y1(5),Y1(6),Y1(7)
       RETURN
 200   FORMAT(2X,'AVERAGES'//2X,12(E8.1,1X))
       END
```

```
C      SUBROUTINE  TC  WRITE  R-VALUES    SUB-23
C      SUB-23
       SUBROUTINE  RWRIT(R)
       DIMENSICN R(12)
           WRITE(6,220)
            DO  30  J=1,12
               WRITE(6,221) J,R
 30         CONTINUE
       RETURN
 220   FORMAT(2X,'POND NCS ARE F2,F3,F4,F5,A2,A3,A4,A1,F1,M1,M2,M3'//
      X 2X,'POND NC',5X,'CCR CCEF')
 221   FORMAT(2X,I3,7X,F7.3)
       END
```

```
C      SUB-18  ADOPTED FRCM SUB WRE FOR E FORMAT
C      WRITING A MATRIX IN CCLUMN RESHUFFLED ORDER IN E FORMAT
       SUBROUTINE  FWRE(Y1,M1)
       DIMENSICN Y1(50 ,12)
            DO  5  I=1,M1
              WRITE(6,284)Y1(I,8),Y1(I,9),Y1(I,10),Y1(I,11),Y1(I,12),
      X            Y1(I,1),Y1(I,2),Y1(I,3),Y1(I,4),Y1(I,5),Y1(I,6),Y1(I,
      X            7)
 5          CCNTINUE
            RETURN
 284       FORMAT(2X,12(E8.1,1X))
           END
```

```
C      PRINT HEADER  SUB-16
       SUBROUTINE  KPC
       WRITE(6,273)
       RETURN
 273   FORMAT(5X,'DISPERSED FLCW K-VALUES')
       END
```

```
C       SUB-6  SUB TO COMPUTE SURFACE &VOLUME LOADING&REMOVALS
C       WITHOUT EVAP  V1-SURLOA(SL) V3-Q V4-W,V5-B,V6-SR,V7-VL
C       V8-D,V9-VR M1-NO OF DATA-MONTHS
        SUBROUTINE WEV(V1,V2,V3,V4,V5,V6,V7,V8,V9,M1)
        DIMENSION V1(50 ,12),V2(50 ,13),V6(50 ,12),V7(50 ,12),
      X V9(50 ,12),V4(12),V5(12),V8(12),V3(12)
             DO  39 J=1,8
                DO 40 I=1,M1
               IF(V2(I,13).EQ.0.0.OR.V2(I,J).EQ.0.0)  GOTO 82
                   V1(I,J)=(V2(I,13)*V3(J)*10.0)/(V4(J)*V5(J))
        V6(I,J)=((V2(I,13)-V2(I,J))*V3(J)*10.0)/(V4(J)*V5(J))
                   V7(I,J)=V1(I,J)/(10.0*V8(J))
        V9(I,J)=V6(I,J)/(10.0*V8(J))
                   GO TO 40
 82             V1(I,J)=0.0
                V6(I,J)=0.0
                V7(I,J)=0.0
                V9(I,J)=0.0
 40           CONTINUE
 39          CONTINUE
             DO  41 J=9,12
                J1=J-1
                DO 42 I=1,M1
               IF(V2(I,J1).EQ.0.0.OR.V2(I,J).EQ.0.0) GOTO  83
                   V1(I,J)=(V2(I,J1)*V3(J)*10.0)/(V4(J)*V5(J))
                   V6(I,J)=((V2(I,J1)-V2(I,J))*V3(J)*20.0)/(V4(J)*V5(J))
                   V7(I,J)=V1(I,J)/(10.0*V8(J))
        V9(I,J)=V6(I,J)/(10.0*V8(J))
            GO TO 42
 83         V1(I,J)=0.0
            V6(I,J)=0.0
            V7(I,J)=0.0
                V9(I,J)=0.0
 42        CONTINUE
 41     CONTINUE
        RETURN
        END

C        PRINT HEADER    SUB-8
         SUBROUTINE WWB
         WRITE(6,248)
         RETURN
  248    FORMAT(5X,'SURFACE REMOVAL')
         END

C        WRITING HEADER    SUB-7
         SUBROUTINE WWA
         WRITE(6,247)
         RETURN
  247    FORMAT(5X,'SURFACE LOADING')
         END
```

```
C       SUBROUTINE  TO  DIVIDE 4 SERIES VALUES BY 100.0 FOR FC AND FS
C       SUB-24
C       SUB-
         SUBROUTINE  CCN(Y1,Y2,Y3,Y4,N1,L1,M1)
        DIMENSION Y1(N1,L1),Y2(N1,L1),Y3(N1,L1),Y4(N1,L1)
           DO  30  J=1,12
             DO 31 I=1,M1
                Y1(I,J)=Y1(I,J)/100.0
                Y2(I,J)=Y2(I,J)/100.0
                Y3(I,J)=Y3(I,J)/100.0
                Y4(I,J)=Y4(I,J)/100.0
 31          CONTINUE
 30        CONTINUE
           RETURN
           END

C       PRINT HEADER  SUB-9
        SUBROUTINE WWC
        WRITE(6,249)
        RETURN
 249    FORMAT(5X,'VOLUME LOADING')
        END

C       CALCULATION OF EVAPORATION QUE    SUB-11
C       Y1-QE,Y2-Q,Y3-Z8-EV Y4-W,Y5-B,M1-NO OFMONTHS
        SUBROUTINE QQE(Y1,Y2,Y3,Y4,Y5,M1)
        DIMENSION Y1(50 ,12),Y2(12),Y3(50 ),Y4(12),Y5(12)
              DO  48  J=1,12
                  DO  49  I=1,M1
                      IF(Y3(I).EQ.0.0) GO TO 85
              IF(Y2(J).EQ.0.0) GOTO  85
                      Y1(I,J)=Y2(J)-(Y3(I)*Y4(J)*Y5(J)*0.001)
                      GOTO 49
 85               Y1(I,J)=0.0
 49               CONTINUE
 48           CONTINUE
        RETURN
        END

C       PRINT HEADER   SUB/10
        SUBROUTINE WWD
        WRITE(6,250)
        RETURN
 250    FORMAT(5X,'VOLUME REMOVAL')
        END
```

```
C      SUB FOR PERCENTAGE  REDUCTIONS    SUB/4
C      Y1-PRZ1,PRZ2.. Y2-Z1,Z2,...
       SUBROUTINE PR(Y1,Y2,M1)
       DIMENSION Y1(50 ,12),Y2(50 ,13)
          DO 35  J=1,8
             DO 36 I=1,71
              IF(Y2(I,13).EQ.0.0.OR.Y2(I,J).EQ.0.0)GOTO 80
                Y1(I,J)=((Y2(I,13)-Y2(I,J))*100.0)/Y2(I,13)
                GOTO 36
80              Y1(I,J)=0.0
36           CONTINUE
35        CONTINUE
          DO 37  J=9,12
             J1=J-1
            DO  38 I=1,M1
              IF(Y2(I,J1).EQ.0.0.OR.Y2(I,J).EQ.0.0)GOTO 81
                Y1(I,J)=((Y2(I,J1)-Y2(I,J))*100.0)/Y2(I,J1)
                GOTO 38
81              Y1(I,J)=0.0
38           CONTINUE
37         CONTINUE
           RETURN
           END
```

```
C       SUB TO CALCULATE AVERAGES
        SUBROUTINE  AVE(Y1,Y2,M1)
        DIMENSION  Y1(50,12),Y2(12)
          DO 10  J=1,12
              SUM    =0.0
                 MM =0
              DO   11 I=1,M1
                 IF(Y1(I,J).EQ.0.0) GOTO 11
                 SUM    =SUM    +Y1(I,J)
                 MM=MM+1
11            CONTINUE
              IF(SUM    .EQ.0.0) GOTO 20
              Y2(J)=SUM    /MM
              GOTO 10
20            Y2(J)=0.0
10        CONTINUE
          RETURN
          END
```

```
C       SUB  TO WRITE AVERAGES IN F FORMAT
        SUBROUTINE  WAVE(Y1)
        DIMENSION Y1(12)
           WRITE(6,201)Y1(8),Y1(9),Y1(10),Y1(11),Y1(12),Y1(1),Y1(2),Y1(3)
     X     ,Y1(4),Y1(5),Y1(6),Y1(7)
        RETURN
201     FORMAT(2X,'AVERAGES'//2X,12(F8.2,1X))
        END
```

```
C       READ 2 WRITE METEOROLOGICAL DATA   SUB1
C       Y1-Z7-TAIR Y2-Z8-EV Y3-Z9-SUN Y4-V1-LANG M3-NO OF MET DATA
        SUBROUTINE REME(Y1,Y2,Y3,Y4,M3)
        DIMENSION Y1(50 ),Y2(50 ),Y3(50 ),Y4(50 )
         N=1
         WRITE(6,208)
 510     READ(5,111)Y1(N),Y2(N),Y3(N),Y4(N)
         IF(Y1(N).EQ.111.1.AND.Y2(N).EQ.111.1) GO TO 530
        WRITE(6,202)N,Y1(N),Y2(N),Y3(N),Y4(N)
         N=N+1
         GOTO 510
 530     M3=N-1
         RETURN
 111     FORMAT(2X,4(F6.1,2X))
 208     FORMAT(2X,'MONTH',4X,'TAIR',5X,'EVAP',4X,'SUN',4X,'LANG')
 202    FORMAT(3X,I3,3X,4(F6.1,2X))
        END
C       SUB TO PRINT HEADER BOD,COD,ETC...SUB-2
        SUBROUTINE HE
        WRITE(6,211)
        RETURN
 211    FORMAT(2X,'MONTH',3X,'BOD',5X,'COD',6X,'SS',8X,'FC',9X,'FS',4X,'T
       XWAT')
        END
C       WRITING  OF EACH COLUMN OF SIX FILES SUB-3
C                    Y1,Y2,Y3,Y4,Y5,Y6-FILE NAMES-Z1,Z2...Z6 M1DATA
C       N1-COLUMN NUMBER  ALL ROWS,BUT ONE COLUMN FROM EACH FILE
        SUBROUTINE WRIT(Y1,Y2,Y3,Y4,Y5,Y6,M1,N1)
        DIMENSION  Y1(50 ,13),Y2(50 ,13),Y4(50 ,13),Y5(50 ,13)
       X,Y6(50 ,13),Y3(50 ,13)
        DO 28 I=1,M1
        WRITE(6,213) I,Y1(I,N1),Y2(I,N1),Y3(I,N1),Y4(I,N1),Y5(I,N1)
       X,Y6(I,N1)
 28     CONTINUE
        RETURN
 213    FORMAT(3X,I3,2X,3(F6.1,2X),2(E10.1,2X),F5.1)
        END
C       SUB-5  FOR WRITING VALUES OF A FILE
C       COLUMNS RESHUFFLED  Y1-FILE NAME,M1-NO OF DATA
        SUBROUTINE WRE(Y1,M1)
        DIMENSION Y1(50 ,12)
            DO 42 I=1,M1
               WRITE(6,241)Y1(I,8),Y1(I,9),Y1(I,10),Y1(I,11),Y1(I,12),
       X       Y1(I,1),Y1(I,2),Y1(I,3),Y1(I,4),Y1(I,5),Y1(I,6),Y1(I,7)
 42         CONTINUE
        RETURN
 241    FORMAT(2X,12(F8.2,1X))
        END
```

PROBLEMS RELATED TO WATER SUPPLY & SEWERAGE TREATMENT FOR NEW PROJECTS IN HONIARA

G. Leve

Health Inspector
Honiara Town Council

Honiara - the only urban settlement and the capital of the Solomon islands - has a population of approximately 22,000. The problems faced regarding water supply and sewerage projects are by no means unique. The present water supply for the town is taken from four sources treated at various parts of the town.

ROVE SOURCE

This source is obtained by tapping the seepage from a hill and feeding it into an open reservoir. The water is pumped into a chlorination plant after which the water is pumped further uphill and stored in tanks from where it is gravity-fed to the main pipe that supplies about one third of the town.

TUVARUHU SOURCE

This source presents some problem regarding quantity as well as quality. During drought periods which could be as long as 4-5 months, the seepage from the hill tends to dry out, thus affecting the capacity of the system. Areas which are situated on high grounds could only receive intermittent supply for days. Water therefore has to be rationed.

The Honiara water supply is sampled monthly for bacterial testing. The Rove supply does show occasional faecal contamination.

The other 3 sources are bore-holes. They present very little problem regarding quantity and quality. Although the quantity of water appears to be sufficient at present, it is obvious that within the next 15-20 years further sources will be required, according to the present rate of population growth.

The Ministry of Transport, Communications and Public Utilities, which is responsible for water supply, is undergoing the construction of a new water supply project which caters for the population increase within the next 15-20 years.

The work involves trapping the source of a small river by constructing a dam. The water will then be pumped into a chlorination plant before taken to large storage tanks, ready for distribution to consumers.

Troubles started when tests were carried out fortnightly to find out whether the water was bacteria-free. The results of the series of tests carried out were all showing high concentrations of faecal coli.

It was clear that the source is not a spring as it appeared to be but an underground river.

An argument then started between MTC & GU who is concerned with the provision of sufficient quantity of water to the population of Honiara, and the MHMS who is concerned not only with the quantity but also the quality of water.

Up till now the water will not go through some form of filtration before being chlorinated. The MHMS insisted on the provision of a said filter to this system.

However, this is going to be proved later when the system is in operation. Whether to provide a filter before chlorination or to chlorinate the unfiltered water will be sufficient to make the water safe for human consumption.

SEWAGE TREATMENT

It had been proved that the sewage discharge at various points along Honiara sea front caused high pollution of the sea which in the future could provide danger to people eating fish and sea shells caught near these sewerage outfall.

With this large housing estate at Naha Valley which will have a population of up to 2,000 people, the problem of human waste disposal is going to be greater than what it is at present.

The SIG is seeking the assistance from a consultant from overseas to study the situation and to draw a proposal for a better sewage disposal to prevent further pollution of the sea. Such a proposal for sewage treatment - including oxidation ponds, etc. - will be included in the investigation.

UTILIZATION AND OPTIMIZATION OF "LA FERIA" WASTE PIT

Jorge C. Martinez

Department of Quality Control
Gas Consumer Company (GASCO)

Guido A. Concha
Franklin O. Banados

Department of Analytical Chemistry
Catholic University of Chile

ABSTRACT - The "La Feria" pit is a controlled municipal refuse dumping. It occupies an old excavation of sand, gravel, and rubble. It has a depth of 12-15 m and and area of 30 ha, and is located in the commune of "San Miguel" at Santiago city. Urban raw wastes - a mixture of unshredded trash, rubbish, refuse, garbage, animal solids, and organic materials - began to fill up the excavation from 1975 onwards. The urban raw wastes were accumulated and compacted in layers of 3.5 m thick and sealed with a sanitary landfill, a mixture of clay, gravel and soil of 50 cm thick. This procedure was continued until to day. In 1979, the pit began to produce methane. The gas was burned in situ in order to avoid troubles in the neighborhood. It is assumed that the amount of wastes accumulated will yield 1 million m^3/yr of gas for approximately 10 years. In 1981, the Gas Consumer Company (GASCO) decided to industrialize the gas production. The volume produced is 1,000 m^3/h with a concentration of 60% methane and 40% carbon dioxide.

Initially, GASCO planned to introduce the purified methane into the domestic pipeline gas. This is possible only to a certain limit. Beyond that, the mixing would produce problems in the artifact burners connected to the domestic pipeline gas. As an alternative for the excess of CH_4 and CO_2 produced, GASCO has planned the cracking of gases to obtain H_2 and CO. These gases can be mixed with the domestic gas without burner troubles. The adduction of gases is performed by 40 pipes 24 cm in diameter evenly distributed into the pit. These pipes are perforated in their lower parts with holes of 1 cm in diameter, and connected to the main collector. This gas adduction system covers one third of the total pit area.

The purpose of this work is to develop a computer program to allow optimization of this unproperly designed but operative digestor.

INTRODUCTION

The sanitary landfill "La Feria" is the first experience in the use of a different type of energy source, very far from the traditional ones. This exploitation, under the control of the Gas Consumer Company at Santiago (GASCO), is still in the experimental stage, but even in these circumstances yields daily 240,000 m^3 of gas with a superior calorific value of 5,000 $Kcal/m^3$ at S.T.P.

This gas cannot be used in its natural state. It goes through a 3 km pipe to the main gas plant, where it is mixed with GASCO own gas mixture, a catalytic cracked light gas oil.

The composition of "La Feria" biogas after four months of exploitation of 39 gas pits has been rather constant at 50-58% CH_4, 40-45% CO_2, 0.40-0.43% N_2 and 0.35-0.40% O_2.

Because the emanation of gas began to endanger the surrounding neighbourhood, gas exploitation was started hastily. As this exploitation is in the first stage, there is a lack of knowledge about the composition and characteristics of the refuse.

Nevertheless, the conditions of humidity, climate, the quality of the raw waste, and the pH of the landfill, all render this exploitation profitable at the present time.

In the future, the same complex could be used in other waste pits of the city of Santiago. Also, GASCO considers the removal of the CO_2 from the biogas, and the possibility of a catalytic cracking.

LANDFILL DESIGN AND OPERATION

The "La Feria" pit was never designed or constructed to be a biogas plant. The digester size was not determined for the quantity of gas required or the amount of waste material available. Furthermore, the parameters that govern the process of anaerobic digestion were not considered as a criterion for this biogas plant. The pit happened to be there, and it was used as a waste dumping site.

The collection and transportation of the domestic refuse to the pit is performed by trucks with a compressor box and by open ones.

Some years ago, the pit was in the outskirts of the city, but nowadays is enclosed by blocks of houses. For this reason, the municipality decided to transform this excavation into a complete sanitary landfill and to utilize the gas produced. The solid waste produced daily by the inhabitants of the communes around the pit is 2,000-2,500 kg. The problems of its disposal, odor control, flies and rodents were coped with by the sanitary landfill.

The CH_4 produced from this sanitary landfill is very economical, no shredding or separation is carried out, and the pit has a high rate of methanogenesis.

The amount of biogas produced has been more or less constant since 1979 onwards. Probably the nature of wastes, the loading rates, the average temperature and the period of digestion have not varied significantly throughout the years. These conditions have nursed an appropriate type of bacteria for the anaerobic process.

The leachate, a dark green liquid with a pH of 7.5 indicates that a balanced digestion exists. This liquid seeps through the waste layers producing the raw material decomposition.

ECONOMIC STUDIES

The dumping of the refuse began to fill up the pit in 1975. During 1979, the pit began to produce CH_4 and CO_2, adding to odor problems, flies and rodents to the neighbourhood. The municipality decided to transform this unsanitary refuse dumping into an hygienic one, and also solicited GASCO to carry out studies on the evaluation of gas potential and the feasibility of its utilization.

The results of gas analysis from the first perforated pit were 55-60% CH_4 and 40-45% CO_2. These concentrations were similar to other foreign landfills (1). These results prompted GASCO to install a gas plant for industrialization of the gases and thus avoiding air contamination in the neighbourhood.

METHODS OF GAS RECOVERY

GASCO has built a gas plant with three 55-Hp gas compressors, three gas meters (CH_4, CO_2 and O_2), plus sensors necessary to measure concentrations, temperatures, flows and calorific value at S.T.P.

GASCO pays 1.4 cents per m^3 of gas of 5,000 Kcal to the municipality.

The biogas is mixed with domestic gas, or is cracked to produced H_2 and CO before it can be mixed with domestic gas.

EXPERIMENTAL CRACKING CONDITIONS

The catalytic pilot plant was a glass pyrex tube in a U form, packed with a given amount of D.A.N. catalyzer (5% Ni-supported on clay material), a water vapour generator, two wet gas meters, and a controlled electrical oven.

The biogas was passed through the tube at 750-780 °C in different conditions as follows:

a) Without water vapour
b) With an excess of water vapour
c) With a little amount of water vapour
d) Same as c) but simulating Onia-Gegi cyclic process.

The results of these experiments are shown in Table 1.

The composition of cracked gases A, B, C and D are rather similar to the cracked topping light gas oil by the basic Humphreys and Onia-Geni processes shown on Table 2. These systems use the same D.A.N. catalyzer. Nevertheless, the uncracked biogas showed a different position on the Weaver diagramme: wobbe index "W" versus speed of the flame "S". This situation do not permit mixing the biogas with the domestic gas.

SUMMARY OF DATA OF MUNICIPAL REFUSE

Available data (2) are shown in Tables 3 and 4. Some of the values on these tables will be used in a computer program.

Assuming no significant changes on the type of wastes of the inhabitants, these data will be useful for necessary calculations.

Table 1: Results of Cracking Experiment

Gas Component	Biogas	A	B	C	D
CO_2	40.8	12.4	26.00	15.80	11.80
H_2	-	39.26	50.44	13.44	37.38
N_2	0.43	0.63	0.43	2.67	15.37
O_2	0.40	0.20	0.40	0.80	0.20
CO	-	27.25	9.92	22.54	25.82
CH_4	58.37	20.36	12.81	14.75	9.43
calorific value Kcal/m³	5563	3951	3059	3411	2819
$D_{Air}=1$	0.956	0.601	0.608	0.598	0.662
W	596	533	411	462	363
S	10.65	34.41	38.80	37.1	31.94

COMPUTER PROGRAMMING

The computer program is shown in Appendices A and B. Data of the chemical composition of waste are not available. Also, the program uses the following assumptions:

a) 0.028 m³ biogas with methane content of 55 per cent will provide 138.60 Kcal.
b) 0.454 kg of cow dung 20-35 per cent dry solids yields 0.028 m³ of gas (3).

The program, written in BASIC II, allows calculation of "Estimated CH_4 Production Time".

This program requires the following parameters as input data: percentage of methane, waste density, total pit volume, percentage of dry solids, starting pit volume, flow rate (m³/h) of methane, and feeding rate (kg/h) of waste to the pit.

Table 2: Composition of Gas Obtained by Other Processes

Gas Component	HUMPHREYS and GLASGOW Process	ONIA-GEGI Process
CO_2	9.8	12.9
H_2	57.0	56.7
N_2	13.7	10.2
O_2	0.4	0.3
CO	14.8	13.5
CH_4	2.6	2.6
C_2H_6	0.5	0.5
C_3H_8	-	0.2
C_3H_6	0.1	0.7
C_4H_{10}	-	-
C_5	0.4	0.6
Superior calorific value Kcal/m³	2805	3188
$D_{Air}=1$	0.511	0.540
W	411	454
S	46.0	44.9

The output consists of energy yields (J/m³ and kWh/m³), total waste quantity, predicted yield of methane (m³ per kg of waste), total predicted volume (m³) of methane, total predicted energy, and the estimated methane production time.

Finally, a simulated situation is presented to compare the volume (m³) of CH_4 produced with the estimated one from the amount of wastes received in the pit.

The basic data of the La Feria pit are presented in Table 5.

Table 3: Municipal Refuse Composition (1950/51)

	Mean value
% Moisture	62.44
% Dry matter	37.56
Refuse components on dry basis	100 %
Food/Garden wastes	69.7
Paper Products	14.9
Plastic/Leather/Rubber	0.9
Textiles	2.6
Wood	1.9
Metals/Glass/Ceramics	8.3
Bones	1.7

Table 4: Municipal Refuse Characteristics (1950/51)

Density kg/l	Moisture %	Organic Matter %	Ashes %	Calorific Value, Kcal/kg Wet Superior	Wet Inferior	Dry Superior
Mean 0.293	62.09	23.08	14.83	1031	602	2710
Maximum 0.341	73.50	34.90	21.54	1535	1169	2940
Minimum 0.215	43.56	17.18	9.82	759	344	2089

Table 5: 'La Feria' Gas Recovery Data

Year fill began	Year fill completed	Refuse in place kg X 10^9	Surface area ha	Ave. thickness of refuse, m	Predicted CH_4 extraction rate l/sec'	Annual CH_4 production per kg of refuse l/kg/yr
1975	still filling	0.12	30	13.5	275	2.3

CONCLUSIONS

The following conclusions results from this work:

1. The experimental cracking conditions demonstrated the feasibility of this procedure and the possibility of using the biogas produced by mixing with the domestic gas without burners problems.

2. A computer program for predicting the energy, the total volume of CH_4 and production time for "La Feria" landfill was developed, and tested with the available data. The calculated gas recovery data is similar with other foreign landfills (4), proving that the assumptions and the tested data were satisfactory and sufficient enough for this study.

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4. Ibid 2, 43 pp.

Appendix A
COMPUTER PROGRAM

```
10    REM*ESTIMATED CH4 PRODUCTION TIME*
20    CLS
30    INPUT "% METHANE"; M
40    A= 10* M* 37242.6458
50    PRINT "JOULE/M3="; A
60    B= A* 2.7778 E-7
70    PRINT "KWH/M3="; B
80    INPUT "WASTE DENSITY (KG/M3)"; C
90    INPUT "TOTAL PIT VOLUME (M3)"; D
100   E= C*D
110   PRINT "TOTAL WASTE QUANTITY (KG)="; E
120   INPUT "% DRY SOLIDS"; F
130   G= F*0.00312
140   PRINT "PREDICTED M3. CH4/KG WASTE="; G
150   H= E*G
160   PRINT "TOTAL PREDICTED M3-CH4="; H
170   I= A*H
180   PRINT "TOTAL PREDICTED ENERGY (JOULE)="; I
190   J= B*H
200   PRINT "TOTAL PREDICTED KW/H="; J
210   INPUT "STARTING PIT VOL. RILLED (M3)"; L
220   O= C*L*G
230   INPUT "M3-CH4/H MEASURED"; P
240   INPUT "KG/H WASTE TO PIT"; Q
250   R= Q*G
260   S= P-R
270   IF S≥ø THEN T= H/P
280   IF S<ø THEN T= O/(-S)
290   U= T/24
300   PRINT "ESTIMATED CH4 PRODUCTION TIME (DAYS)="; INT(U+0.5)
310   END
```

Appendix B
INPUTS AND OUTPUTS

INPUT DATA VALUES:

CH_4= 50.0%

WASTE DENSITY= 310 kg/m^3

TOTAL PIT VOLUME= 3.85 x $10^6 m^3$

DRY SOLIDS= 37.56%

STARTING PIT VOLUME FILLED= 0.8 x $10^6 m^3$

CH_4 MEASURED= 1000 m^3/H

WASTE TO PIT= 104 kg/H

OUTPUT DATA VALUES:

ENERGY= 1.8 x 10^7 J/m^3

ENERGY= 5.17 Kw/H

TOTAL WASTE= 1.19 x 10^9kg

PREDICTED YIELD= 0.117 $m^3 CH_4$/Kg WASTE

PREDICTED CH_4 VOLUME= 1.39 x $10^8 m^3$

TOTAL PREDICTED ENERGY= 2.5 x 10^{15} J

= 7.2 x 10^8 kW/H

ESTIMATED PRODUCTION TIME= 16 yr:

These values were used to calculated the predicted CH_4 extraction rate, and the Annual CH_4 Production per kg of refuse shown on Table 5.

IMPLEMENTATION ASPECTS IN HUMAN WASTE MANAGEMENT: THE INDONESIAN EXPERIENCE

Drs. S. Tarigan

Department of Home Affairs
Jakarta, Indonesia

Drs. Siti Markamah

Department of Home Affairs
Semarang, Indonesia

BACKGROUND

Indonesia faces immense sanitation problems in urban areas. Nearly 30% of the population (over 40 million people), are estimated to live in towns and cities, usually in conditions of over-crowding and minimal infrastructure. City-wide sewerage and treatment systems do not exist. As a result, well over half of human waste is disposed of in open drains and canals. All the larger and densely populated cities are also subject to frequent flooding, with the result that water-borne diseases are still at unacceptable levels.

Financial resources are limited and there is no prospect of the cities being able to afford sophisticated disposal and treatment systems.

CURRENT POLICY AND PROGRAMS

Over the last decade, sustained efforts have been made to upgrade poorer neighbourhoods through the Kampung Improvement Program (KIP). This program is now being implemented in all cities with over one million population and is being expanded to cover 200 cities. One component of KIP is the construction of public toilets and washing structures (MCK) for approximately 50% of the lower-income population. The Department of Health also has a program of communal latrines. The scope of this program is limited and less than 1% of the urban population have access to these facilities.

This present policy is for scattered individual units. To extend this approach to all lower-income groups is problematical due to shortages of land and danger of further polluting the water table.

IMPLEMENTATION PRACTICE AND CONSTRAINTS

Acceptability

On the whole, MCK and communal latrines have been well received. In some areas, notably Jakarta and Surabaya, the use of MCK has sharply reduced the level of waste going into open drains. The program does face a number of constraints, notably maintenance problems. It is often unclear who is responsible for managing the units after construction. This is complicated by the fact that the units are public and open to users from outside the community where they are located. In some areas, there are cultural inhibitions on the use of public facilities.

Affordability

This is not an issue at the local or community level in Indonesia nor is it a criterion for selecting target populations. From the national perspective, the internal rate of return for KIP, of which sanitation is a component, is sufficiently high to justify further loans from institutions such as the World Bank.

Extension

Extension activities related to sanitation are very limited at the present time and the Department of Health has yet to initiate a program of guidance on sanitation problems. One systematic activity is a series of courses in cities receiving KIP to motivate local government leaders to involve the population in maintenance of KIP construction and general improvement of the environment. This course is concerned with sanitation only to the extent that MCKs are a KIP component which focuses on physical maintenance of the facilities.

An additional program stressing community participation is the UNICEF-supported program of block grants for projects developed by the communities in low-income areas in seven cities. The program has stimulated a higher level of awareness of local needs and problems, and cooperative activities to overcome them. While being a promising approach, the population benefited is very small.

Training Needs

Probably the most pressing need is for the development of a system of health cadre to overcome problems of ignorance concerning health and sanitation. Trail programs of this nature have had positive results in the city of Surabaya.

FUTURE POLICY

Future policy is still in the process of articulation preparatory to the 4th Five Year Plan (PELITA IV). It appears that PELITA IV will have a greater emphasis on social programs and that KIP will be greatly expanded. Since it is unlikely that the KIP component will be significantly modified, the prospect is for an expanded number of MCKs.

The future direction of the Department of Health is unclear. Communal latrines are still in the pilot project stage and have turned out to have high unit costs. Thus, the prospect is that latrines will remain a relatively minor component of the Department's strategy, if they are in fact continued.

SEPTIC TANK DESIGN, THEORY AND PERFORMANCE

Robert W. Seabloom
Professor

Dale A. Carlson
Professor and Dean Emeritus

Jogeir Engeset
Predoctoral Research Associate

Department of Civil Engineering
University of Washington
Seattle, Washington 98195, U.S.A.

ABSTRACT - While generally thought of as a very simple concept, the septic tank is actually a very complex physical, chemical and biological system. The septic tank provides for the separation, storage, and digestion of suspended solids as well as for the growth, reproduction and death of large numbers of anaerobic organisms. During the sedimentation process in a septic tank it is likely that the four general types of settling phenomena occur simultaneously. For a discrete particle settling, the removal rate is independent of depth and detention time but is directly related to the surface overflow rate. Thus, a septic tank with the greater surface area is more effective than one with a smaller surface area if the volume is the same. Although previous studies indicated some advantage to septic tank compartmentation in terms of BOD and SS removal, recent studies suggest just the opposite. Experimental stressing of single chamber and double chamber septic tanks to simulate wash day, vacation, and a week-end party of house guests, revealed no observable effect on the quality of the effluent.

INTRODUCTION

Sedimentation is one of the most widely used unit processes in wastewater treatment, which involves the separation of suspended particles that are heavier than water by gravitational settling. The septic tank is a gravitational settling device that provides a space for sedimentation to take place to improve the wastewater quality prior to disposal in the subsurface absorption field. While the septic tank is a very simple concept, in reality it is a very complex physical, chemical, and biological system.

PROCESSES WITHIN THE SEPTIC TANK

Septic tanks are intended to perform the following basic functions :

Separation of Suspended Solids

This is the primary purpose of the septic tank. Relative quiescent conditions allow settleable solids to sink to the bottom and floatable solids to rise to the top.

Storage

Ample volume is provided within the septic tank so that sludge and scum may be stored without undue disturbance of the sedimentation process.

Digestion

Anaerobic decomposition of the organic sludge and scum takes place, first forming volatile acids which are then eventually converted mostly to water, carbon dioxide and methane. Soluble organic matter is also stabilized by anaerobic bacteria by a similar process. The result is a reduction of sludge volume of up to 40 percent (1).

Growth of Microorganisms

Large numbers of intestinal organisms suffer and die in the adverse environment of the tank. Many other facultative and anaerobic bacteria grow, reproduce, and die in the tank. Many of these organisms are carried up by rising gas bubbles so as to seed the liquid contents and enhance the anaerobic decomposition of the remaining organic material.

SEDIMENTATION THEORY

In general, four types of settling phenomena have been defined :

Type 1. Discrete particle
Type 2. Flocculant
Type 3. Hindered (also called zone)
Type 4. Compression

During the sedimentation process in a septic tank it is quite likely that all four types of settling are occurring simultaneously. The four types of settling are described in Table 1.

Table 1 - Types of Settling Phenomena Involved in a Septic Tank (Adapted from Reference 2)

Type of Settling Phenomena	Description	Occurrence in Septic Tank
(Type 1) Discrete Particle	Sedimentation of particles suspension of low settle as individual entities, with little or no interaction with adjacent particles.	Remove heavier discrete irregular particles.
(Type 2) Flocculant	Individual particles tend to coalesce, or flocculate, iincreasing their mass and settling rate.	Removes lighter particles that flocculate into heavier particles.
(Type 3) Hindered	The particles tend to remain to fixed positions with respect to each other, a solids-liquid interface develops at the top of the settling mass, which settles as a unit.	Occurs if biological floc develops.
(Type 4) Compression	Consolidation and compression of sediment takes place from the weight of the particles which are constantly being added. Further settling can occur only by compression of the structure.	Occurs in the lower sludge mass.

ANALYSIS OF DISCRETE PARTICLE SETTLING

A discrete particle is one that does not alter its size, shape, and weight during the settling process. While the residential wastewater entering the septic tank contains irregular particles and, therefore, does not fit the strict definition of a suspension of discrete particles, the analysis of the settling of discrete particles yields some very important results. The classic laws of sedimentation by Newton and Stokes state that a discrete particle settling in a quiescent fluid will accelerate to a terminal vertical velocity at which time the frictional resistance, or drag, equals the gravitational force. The frictional drag force is a function of the particle velocity, fluid density, fluid viscosity, particle diameter and drag coefficient (2). The gravitational force depends upon the density of the particle and the fluid, the acceleration of gravity and the volume of the particle (2). Hazen (3) and Camp (4) presented excellent treatises on sedimentation theory. They analyzed the settling of discrete particles in a so called "ideal basin", based upon the following three assumptions : a) the direction of flow is horizontal with a uniform velocity; b) the concentration of suspended particles of each size is uniform over the depth at the inlet end; and c) the particles reaching the bottom remain there.

For an analysis of the path of a discrete particle settling in a rectangular septic tank and definition of terms, refer to Figure 1. For a given Q in order for a particle to settle, the actual settling velocity v_s must be equal to or greater than v_o. Where v_o is the velocity of a particle that falls through h in time t.

Since: $v_o = h/t$

$t = C/Q$

$C = hA$

$h = C/A$

therefore:

$$v_o = \frac{C/A}{C/Q} = \frac{Q}{A}$$

v_o is called the surface overflow rate (SOR) or surface loading rate (SLR). Similarly, particles with v_s less than v_o will be removed in the ratio:

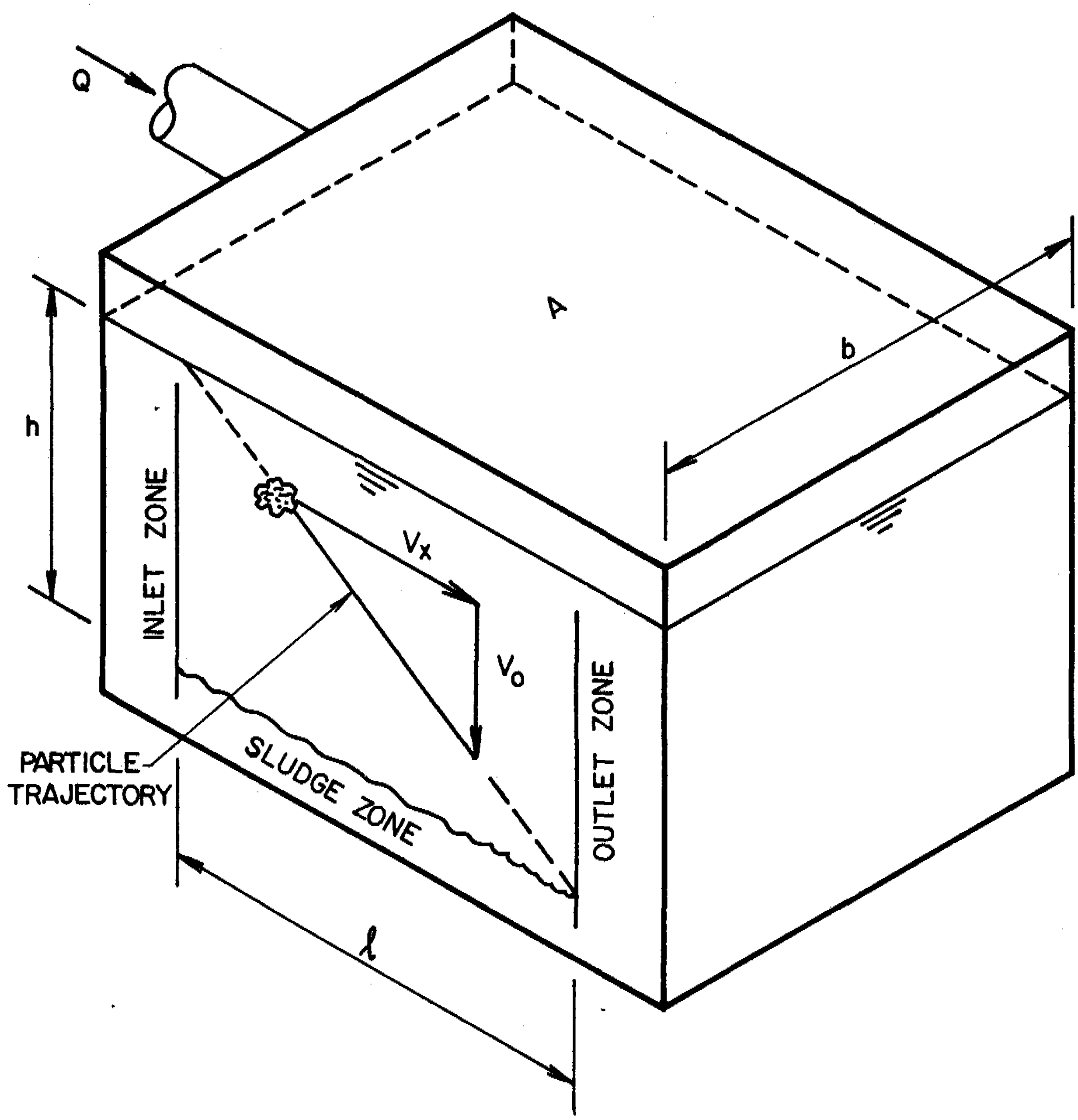
$$X_R = v_s/v_o.$$

Thus, for Type I settling in an "ideal basin" it is independent of depth and detention time but is directly related to the surface overflow rate.

That suspended solids removal is not a function of depth can be demonstrated by considering a septic tank exactly the same as that of Figure 1, with the same Q, but half full of sludge as shown in Figure 2. The actual settling velocity v_s would remain unchanged with the same wastewater but since the detention time and depth are half that in the previous example, the same ratio of particle removal,

$$XR = v_s/v_o$$

would be accomplished.



Q = Quantity of Flow
C = Volume of Tank
A = Surface Area of Settling Zone
h = Depth of Liquid
t = Detention Time
ℓ = Length

V_s = Actual Settling Velocity
V_o = Velocity of Particle that Falls through h in Time t
V_x = Horizontal Velocity
b = Width

Figure 1 : Ideal Settling in a Septic Tank

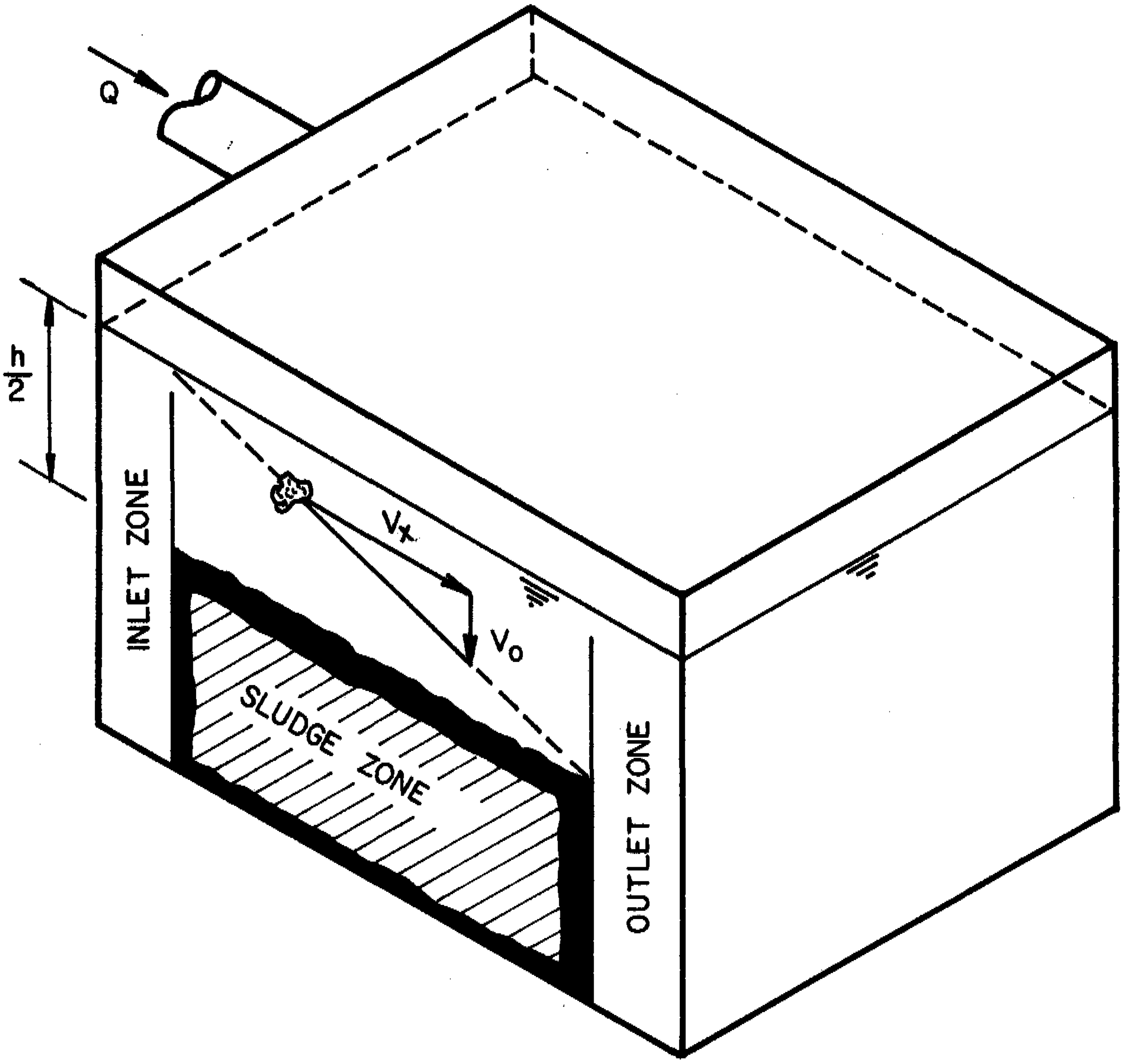


Figure 2: Ideal Settling in a Septic Tank Half Full of Sludge

In actual practice the effects of inlet and outlet turbulence, thermal currents, short circuiting, hydraulic surges, and resuspension of settled solids by biological decomposition will influence the performance of the tank.

Despite the clear relationship of SOR to sedimentation removal efficiency, there appears to be little application of these principles in the formulation of rules and regulations pertaining to septic tanks and comparing their performance. Clearly a septic tank with the greater surface is more efficient than one with a smaller area, even if the volume is the same.

COMPARTMENTATION

There are conflicting findings about whether compartmentation of septic tanks is beneficial or not. Some investigators have stated that the benefit of dividing a septic tank into compartments is insignificant, while others report that a two-compartmented tank is better than a single-compartment tank of equal capacity. Some experimental studies dating back to 1922 at the University of Illinois by Lehmann, Kelleher, and Buswell (5), at Victoria, Australia in 1933 and 1936 by Hepurn (6), and in 1949 by Weibel, Straub, and Thoman (7) indicated some advantage to compartmentation. The Manual of Septic Tank Practice (8) and the EPA's Design Manual - On-site Wastewater Treatment and Disposal Systems (9) state that while the single-compartment tank would give acceptable performance, a two-compartment tank would provide better suspended solids removal. This is presumably due to the trapping action of the second compartment which allows settling of particles scoured out of the first compartment (10). Recalling basic sedimentation theory, the compartmentation of a septic tank actually results in two smaller tanks connected in series and, thus reduces the surface area and increases the surface overflow rate. Theoretically, particles, other than those resuspended by scouring or gasification, certainly will not settle out in the final compartment if they did not do so in the first and larger compartment.

Based upon some previous work at the Glide, Oregon, pressure sewer system, Bowne (14) reported in 1982 that single compartment tanks are satisfactory but inferior to multiple compartment tanks in terms of suspended solids retention. Bowne subsequently modified his stand to reflect later information (15). Bowne pointed out the questionable economics of increasing the cost of an US$ 850 septic tank anywhere from US$ 175 to US$ 275 just to provide compartmentation. Bowne also state compartmentation adds complexity to an otherwise simple tank, the need for which is minimal when compared with the need for a watertight tank. Some other investigators have stated that the benefit of compartmentation is insignificant (11, 12) and data presented herein indicate the superiority of a single chamber tank.

NATIONAL SANITATION FOUNDATION (NSF) AND UNIVERSITY OF WASHINGTON (UW) COMPARTMENTATION STUDIES

Since the whole question of compartmentation seemed to suffer from a lack of recent definitive data concerning its benefit, or lack of benefit, a study was conducted by the National Sanitation Foundation (NSF) for the University of Washington (UW) at their Ann Arbor, Michigan test site. The study was financed by the U.S. Department of Housing and Urban Development (HUD) and the Washington State Department of Social and Health Services (WSDSHS). The purpose of the study was to determine the treatment efficiency of a single-chamber 1,000-gallon septic tank and a double-chamber 1,000-gallon septic tank when operated under parallel conditions. The two septic tanks were installed as shown in Figure 3 using comminuted raw sewage from the City of Ann Arbor. To simulate a typical single family residential use, the wastewater dosing to each unit is shown in Figure 4. Over a six-month period, effluents from the septic tanks were sampled with automatic sampling devices, and with the exception of dissolved oxygen and temperature which were measured in situ, all measurements were from 24-hour composite samples. A statistical summary of water quality parameters determined is shown in Table 2. It can be observed from Table 2 and Figure 5, the influent BOD averaged 184 mg/l, and after detention in the single-compartment tank, it was lowered to 85 mg/l for a 54 percent removal, and was diminished to 99 mg/l for a 46 percent removal in the compartmented tank. Also, as shown in Table 2 and Figure 5, the influent suspended solids, averaged 234 mg/l, were lowered to 44 mg/l for an 81 percent reduction in the single-compartment tank, and to 123 mg/l for a 48 percent reduction in the compartmented unit. The variability in the BOD and SS removal percentages is shown in Figure 5, from which it can be seen that the single-compartment tank was much more consistent than the compartmented tank. In fact, at times both the BOD and SS of the compartmented tank exceeded that of the influent. Weibel (130 has previously noted that increased liquid surface area increases surge storage capacity because a given inflow volume creates a smaller rise in water depth and a slower discharge rate and exit velocity. Thus, surges of flow through the septic tank are dampened as surface area increases, which allows a longer time for separation of sludge and scum that may be mixed by turbulence resulting from the influent surge (13). The superior sedimentation capability of the single-chamber tank over the two-compartment tank was also evidenced in the reduction of the 16.9 mg/l settleable solids in the influent to 0.2 and 0.6 mg/l, respectively.

Table 5. Summary of Data from Simulated Party/House Guests Study

Time	Influent		Effluent			
			Single-Chamber Septic Tank		Double-Chamber Septic Tank	
	BOD_5 mg/ℓ	SS mg/ℓ	BOD_5	SS	BOD_5	SS
− 1 Day	260	304	114	52	130	50
First 24-Hour Surcharge of Aerobic System (1)	205	238	118	56	104	54
Second 24-Hour Surcharge Aerobic; First Surcharge, Anaerobic	175	158	126	46	117	46
Second Surcharge Anaerobic; Aerobic at Design Flow (1)	231	314	111	50	124	52
+ 1 Day	271	236	118	41	(2)	(2)
+ 2 Days	183	280	121	46	104	56
+ 3 Days	292	280	119	56	133	42
+ 4 Days (1)	235	296	103	78	128	44
+ 5 Days	212	228	134	50	129	36
+ 6 Days	201	170	134	37	143	62

(1) *See dosing comments*
(2) *Freezing; no samples*

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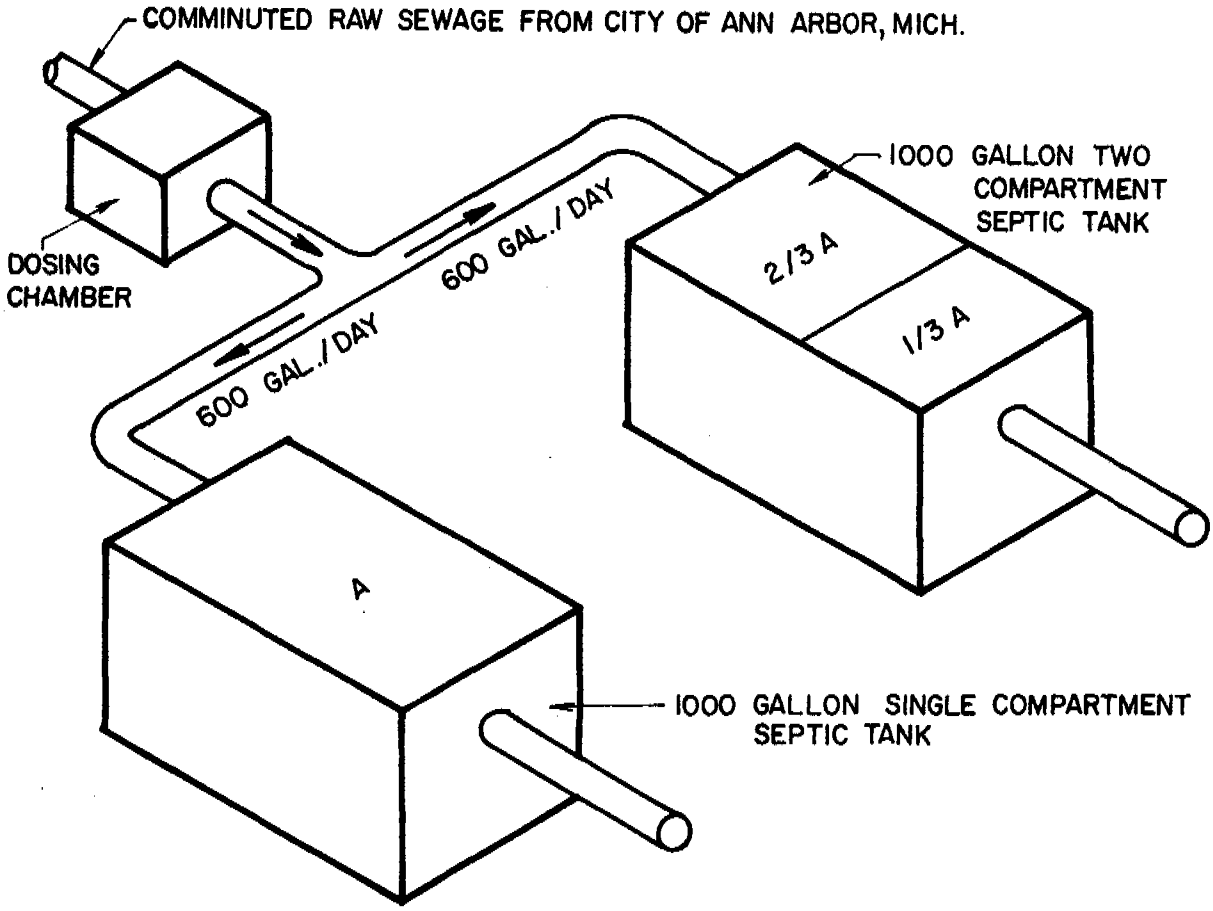

Figure 3: Experimental Septic Tank Study Setup

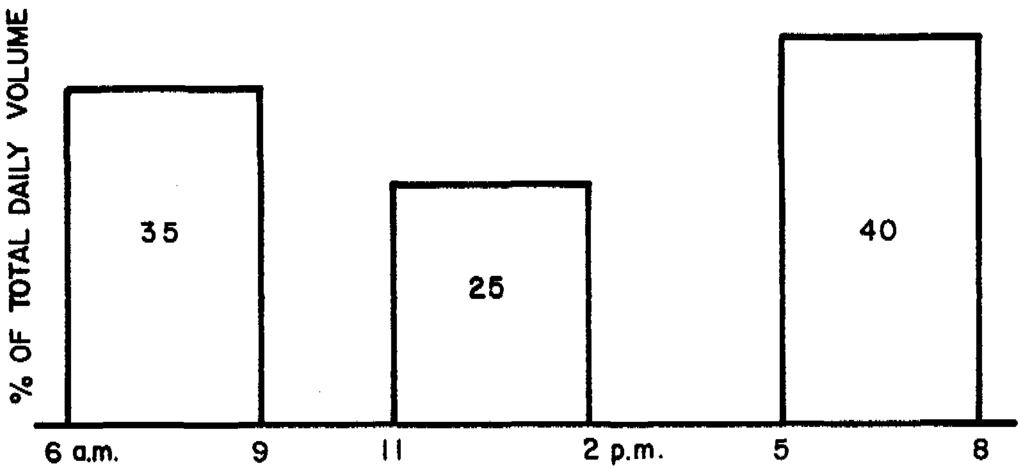

Figure 4: Flow Dosing Pattern (600 gpd)

Table 2. Statistical Summary; Influent, Single–Chamber Septic Tank and Double–Chamber Septic, Effluents.

Characteristic or Parameter		Influent (1)			Single–Chamber (2) Effluent			Double–Chamber (3) Effluent		
		Mean	Median	Std. Dev.	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
Temperature	^{o}C	18.9	19.4	2.6	17.5	17.8	2.8	18.0	18.2	2.9
pH		7.4	7.3	0.1	7.3	7.3	0.2	7.5	7.4	0.2
Biochem. Oxygen Demand	mg/ℓ	184	175	42	85	88	12.3	99	93.5	31.7
Sus. Solids	mg/ℓ	234	201	96.7	44	39.5	11.8	123	50.0	254.5
Vol. Sus. Solids	mg/ℓ	178	157	58.0	34	31.3	8.3	56	37.5	41.6
Settleable Solids	mg/ℓ	16.9	15.5	10.1	0.2	0.1	0.1	0.6	0.1	0.1
Ammonia Nitrogen NH_3 – N	mg/ℓ	19.0	18.3	3.1	18.8	18.7	3.3	18.1	17.9	3.5
Nitrate Nitrogen NO_3– N	mg/ℓ	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.0
Chloride	mg/ℓ	92	90.8	8.1	91	91.5	10.2	90	91.1	12.0
Diss. Oxygen	mg/ℓ	*	*	*	*	*	*	*	*	*
Alkalinity as $CaCO_3$	mg/ℓ	232	210	37.2	253	249.3	22.8	262	253	28.7
Acidity as $CaCO_3$	mg/ℓ	23.4	22.5	5.6	29.6	29.7	8.0	23.5	22.4	6.2

(1) *n* = *41*
(2) *n* = *41*
(3) *n* = *41*

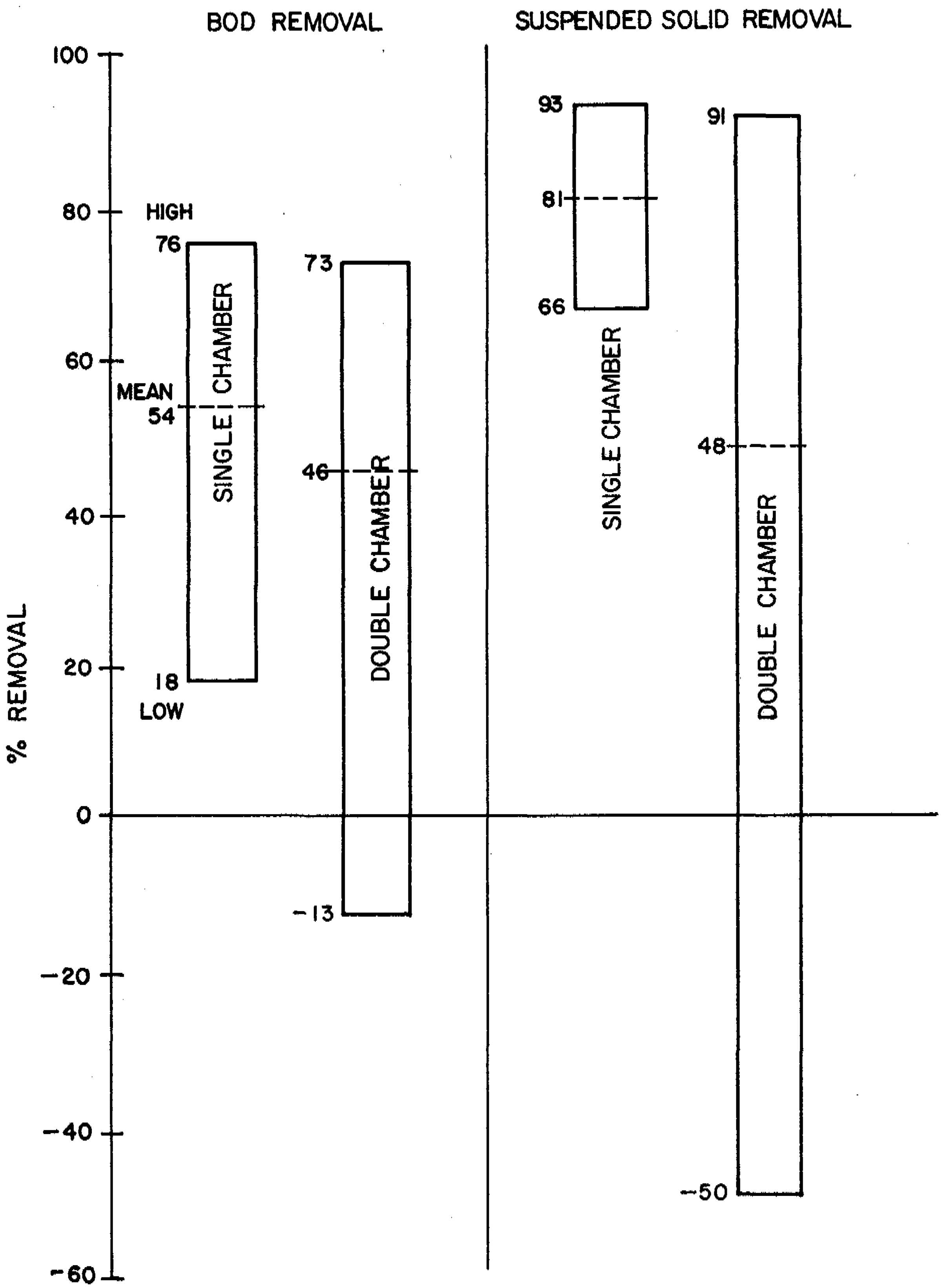

Figure 5 : Variability of Effluent Quality

HYDRAULIC STRESSING OF SEPTIC TANKS

Stressing to simulate the effects of wash day loadings, vacations, and house guests were also investigated.

Simulated Wash Day

In addition to the regular wastewater loading, a special testing sequence was carried out to simulate the addition of three complete washer loadings (wash plus two rinse cycles). Accordingly, each unit was dosed with 105 gallons of water plus one cup of powdered household detergent. Effluent grab samples were taken one hour and three hours after the addition of the simulated laundry wastes. A third sample from each test unit was a 24-hour effluent composite starting immediately after the three-hour grab sample was obtained. The data from these tests are summarized in Table 3, from which it can be seen that, in terms of BOD and SS, no serious disruption of the treatment processes was noted.

Table 3. Summary of Data from Simulated Laundry Study

	Influent		Effluent			
			Single-Chamber Septic Tank		Two-Compartment Septic Tank	
Time	BOD_5 mg/ℓ	SS mg/ℓ	BOD_5	SS	BOD_5	SS
– 1 Day Composite	211	250	120	80	139	56
+ 1 Hour Grab	*	*	120	62	154	78
+ 3 Hours Grab	*	*	130	52	143	63
+ 1 Day	247	238	108	44	126	46
+ 2 Days	225	264	121	50	125	44
+ 5 Days	297	360	131	64	160	100
+ 8 Days	260	394	112	62	128	71

* *Not Measured*

Simulated Vacation Period

The relative impact of nonuse on the two units was studied by simulating a one-week family vacation. Both systems were dosed normally until recovery from earlier stress testing (i.e., wash day simulation) was assured. It was assumed that before leaving on vacation, a family would experience short-term heavy water usage; therefore, 40 percent of the total daily design flow was dosed over a three-hour period. No flow was dosed to the two units over the next seven consecutive days (November 11-18). Effluent samples for November 11 were grab samples collected near the end of the three-hour, 40 percent of flow dosing cycle. The influent sample was a composite of the three-hour flow. It was further assumed that heavy water use occurs immediately when a family arrives home after an extended period of absence. Test units received 80 percent of their rated daily capacities in three hours on November 18. Effluent grab samples were collected immediately when available, and after 30 minutes, one hour, two hours, and 24-hour composite. Normal loading was resumed immediately following the three hours of stressing; therefore, flow data for the period of composite sampling was significantly greater than the design capacities. The influent data refers to a composite of the three-hour flow. Results of this sequence are summarized in Table 4. The data from Table 4 show that the two test units were not materially affected by the simulated vacation loading. In addition, the high levels of both BOD and SS in the influent noted on days 5, 6, and 8 had no observable effect on the quality of the effluents from any of the test units.

Simulated House Guests

To simulate the effects of a week-end party of house guests at two times normal occupancy, the test units were dosed at twice their rated capacities over a 48-hour period. Results of this study are summarized in Table 5. With reference to Table 5, the influence of the surcharge on the single-chamber and double-chamber septic tank was not observable.

CONCLUSIONS

In spite of its apparent simplicity the septic tank is actually a very complex system. There are conflicting data regarding the benefit or lack of benefit of septic tank compartmentation, although the data presented herein suggest the latter. Thus, the authors question the need for compartmentation, since it actually reduced the effectiveness of the septic tank, and added substantially to the cost. Finally, the septic tank demonstrated a remarkable ability to withstand any disruption in performance caused by the hydraulic stressing of wash day, vacation, and week-end party.

Table 4. Summary of Data from Simulated Vacation Study.

Time	Influent BOD$_5$ mg/ℓ	Influent SS mg/ℓ	Effluent Single–Chamber Septic Tank BOD$_5$	Effluent Single–Chamber Septic Tank SS	Effluent Two–Chamber Septic Tank BOD$_5$	Effluent Two–Chamber Septic Tank SS
– 1 Day	260	394	112	62	128	71
Prevacation 30% Loading Period	244	288	129	52	142	61
Post Vacation 80% Loading Period						
Initial	167	228	96	34	89	76
+ 30 Min.	167	228	88	30	94	40
+ 1 Hour	167	228	94	42	92	26
+ 2 Hours	167	228	100	40	91	20
+ 1 Day	186	218	110	42	126	54
+ 2 Days	195	246	107	40	124	60
+ 3 Days	267	322	106	52	113	76
+ 4 Days	223	264	118	60	129	86
+ 5 Days	466*	1050*	106	46	128	42
+ 6 Days	516*	1180*	129	43	142	44
+ 7 Days	261	292	123	44	120	50
+ 8 Days	432*	615*	122	52	128	48
+ 9 Days	132	162	103	46	111	50
+ 10 Days	217	226	107	35	131	50
+ 11 Days	260	304	114	52	130	50

**Believed to have resulted from high strength accumulations in the sewers washed out by precipitation.*

ACKNOWLEDGEMENTS

Portions of the material in this report came from a study supported by a grant from the U.S. Department of Housing and Urban Development (HUD) and the Washington State Department of Social and Health Services (WSDSHS). The writers would like to thank Gary Plews and Dave Lenning (WSDSHS) who were largely responsible for conceiving the study of the single- and double-compartmented septic tanks conducted by the National Sanitation Foundation.

WOMEN AS MANAGERS OF HUMAN WASTE

(TRAINING FOR NEW ROLES AND RETRAINING FOR OLD ROLES)

Prepared by:

Mary Elmendorf, Ph.D.*

Consulting Anthropologist

Presented at

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*601 Tyler Drive, Sarasota, Florida 33577, USA.

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INTRODUCTION

This paper goes beyond the rhetorical issue of women's participation as a key to improving projects and suggests ways that training and education can make this potential a reality in achieving Decade goals.

The goals of the Decade are more and safer water not just more wells; more and better sanitation, not just more latrines. Engineers know how to design appropriate systems. But, how to assure that they are used, maintained and continue to operate is still the problem. Account must be taken of the human elements - the operators of the systems, the designers and planners, and most importantly, the users of the systems. We must go beyond access to improved water and sanitation systems to the sociocultural factors which influence their acceptance, rejection or misuse. In order to understand these constraints and motivations, we must have access to women and women must have more than access to the new facilities.

COMMUNITY PARTICIPATION AND INVOLVEMENT OF WOMEN

The need for community participation for successful improvements in water supply and sanitation is well known and increasingly accepted,[1] but the importance of women's involvement as a part of community participation in order to achieve program objectives is less evident.[2] How to relate training to these two objectives is even less understood.[3] In the beginning, we should say that our objective is not to segregate the women but to search for appropriate models for adult learning which will be most effective in increasing total participation of men and women to increase effective utilization of improvements in water and sanitation. By recognizing women as primary managers of water and human waste, special training materials and workshops can be designed which will give them needed information to perform their old roles better and their new roles more effectively. The training itself will enhance their status by giving importance to their many sanitation related tasks as mothers, wives, kinswomen and community members.

The tasks women carry out in relation to domestic water and household sanitation draw on four key roles:[4]

- Women as acceptors of technologies - traditional, old and new.
- Women as users of improved facilities.
- Women as managers of water supply and sanitation programs.
- Women as agents of behavioral change in the use of improved facilities.

WOMEN, CHILDREN AND THE MANAGEMENT OF EXCRETA

The widely held belief that children feces are "harmless"[5] can be a continuing link in chains of reinfection whether the feces are thrown on a nearby garbage heap or baby diapers are washed with dishes in an urban home with a newly installed standpipe. These practices and perceptions should be understood and analyzed as part of the preparation of messages for communication and training. Evidence shows that as mothers begin to understand the dangers of infant feces -- not necessarily the "germ theory" -- but the cause/effect relationship between sanitation and diarrhea they will change their habits, if acceptable options are available.

In the Yucatan as in many developing countries no diapers are used so diaper washing is not the problem. Mothers there are so attuned to their children's needs, that they merely hold the babies away from them, usually over the dirt floor of the hut or just outside to urinate or defecate.[6] The contaminated soil continues the reinfection of everyone, especially other children.

In many parts of the world children defecate on the floor or ground because they are afraid of falling through the large opening of latrines or because the latrines are far away and the interiors are dark. These two problems have been solved in a very innovative way in Sri Lanka where especially designed low cost small water-seal latrines are available. These squatplate latrines are installed without any walls under the eaves of the home just outside the kitchen door so that mothers can easily train todlers to use it. Bath water is used to flush the latrine, which doubles as an informal bathing area for children.[7] Is this a model which could be adapted to other areas?

WOMEN AND SANITATION: THE FECAL/ORAL ROUTE OF INFECTION

Even though the oral-fecal reinfection route is well known, there has been very little designing of facilities and effective health education to help break this vicious circle. Until women's involvement as a part of total community participation is applied to breaking the oral/fecal route of infection, we cannot expect much improvement in health even with new facilities in the poverty areas of the world.

Village mothers will not know how to break this vicious circle until they have some important bits of information and equipment -- primarily soap and a hand basin, adequate carrying and storage containers, along with conveniently located non-malodorous, safe latrines. Water alone does not bring sanitation or health. Nor do latrines alone.

Along with the introduction of improved community facilities there should be provision for new appropriate household equipment to maximize effective use. If there is only one pail and no money to buy another of course it will be used for everything. If there is no top for the pail, a covering with leaves is a poor substitute. If there has been only a minimum of water available, there will be no tradition of hand washing. If latrines are not appropriately designed to fit customary habits they will be unused. If used followed by handwashing their positive health report can be greatly increased.[8]

BREAKING THE ORAL/FECAL ROUTE

Making available ancillary kitchen, laundry, bathroom equipment and soap at inexpensive, subsidized prices or even as rewards in recognition of graduation from a short training course, will make it possible for women to take advantage of the improved interventions in water and sanitation. Audio-visual messages and health information should be related specifically to local custom as well as the effective use of the new equipment -- both community and household -- so that people can efficiently use new facilities with pride and pleasure, and enjoy better health and productivity.

As more water is made available from pumps or standpipes, there will be a need for appropriate vessels and patterns of use or reuse of water to enhance the health aspect. When women have washed their clothes on stones in a running stream what will they need and/or want with piped water? If water is being used for laundry and bathing, can it be reused in an aqua-privy? Do we only think of bathroom planning for elite urban areas?

How can water for handwashing be made easily available to the latrine? How might people be successfully motivated to adopt hygienic practices, such as handwashing? How can hands be washed adequately with a minimum of water? A minimum of soap? No brushes? Where dried? What are the usual local behavior patterns? Can there be more dialogue with the women with respect to where they wash clothes/dishes/hands/children/themselves? Why? All of these activities can be a part of the reinfection route unless adequate precautions are taken.

With respect to the introduction of excreta disposal facilities, limited attention has been given to matters of pride and aesthetics, and the related cleanliness. A case study of water supply and excreta disposal in Colombia revealed that families preferred brightly colored cement stools and slabs over drab gray facilities.[9] And in Yucatan, women also cited their preference for an aesthetically attractive latrine with a shiny porcelain seat or a brightly painted cement floor or stool. Not only were these choices less drab than the rough, gray cement stools usually installed, but easier to keep clean and sanitary.[10]

WOMEN AS CHANGE AGENTS

Behavioral mapping, as well as participant observation, are needed as we work with women on designing culturally acceptable solutions and appropriate training materials. If water supply and sanitation facilities are to have successful impact, considerable attention must be paid to the sociocultural patterns at the community level. Basic equipment as well as training in the use of community and household facilities must be made available to the women so they can become better "managers of human waste". It is important to recognize that the community may accept facilities without altering their personal hygienic behavior. For this reason, planners must stress the relevance of creating participatory educational probrams which focus upon the "intended" as well as "perceived" benefits if development efforts are to exceed the mere acceptance of the new facilities.

The "germ" theory is not enough. If women are to be successful as change agents they must have a reason and be willing and able to make the desired changes. Until planners, agencies and leaders involve women who accept the importance of good sanitation, we can expect limited acceptance. Once the women understand, they can play key roles in household decisions relating to changing behavioral patterns and to socializing children in similar behavior and attitudes in areas such as personal hygiene and sanitation.

WOMEN AS TRAINERS

Parents, fathers and mothers, but especially mothers, will make sacrifices, even change their traditional habits to prevent illness and death of their children. Attendance of mothers at maternal child clinics shows clearly that women will come early and stay late to get help for their sick children although not as often for themselves. Women may continue their traditional healing practices but they will supplement these with modern medicines if there is any evidence of success.

At the November 1982 meeting of the IDWSSD Steering committee, James Grant, Director of UNICEF, opened the session by commenting on the two greatest health breakthroughs in the last century - Handwashing and Oral Rehydration! Both of these need water. Both of these need women. We should dramatize some of the new techniques, such a simple thing as handwashing, which can be linked to increased availability of water and sanitation. Both of these are simple procedures which will require many changes in basic beliefs, perceptions and habits. Both require learning and training. The women are the ones who are the trainers, the socializers of the children, the food and water handlers, the managers of human waste. We need to have trainers trained to train these trainers.

HOW TO FIND TRAINERS OF TRAINERS

Women trainers are needed as are appropriate techniques. There must be trainers of these trainers and preparation of special health information, communication and audiovisual materials. All training of women should relate to their existing roles, help in alleviating unnecessary burdens and improve the quality of life for them, their households, and communities.

As we have said above, women, as wives and mothers, play key roles in water use and management, as well as basic hygienic practices. The many women who are heads of households, de facto or real, are especially important to be reached. They, with their "25 hour days", will be especially motivated to accept improvements that save them time and energy. Any training/learning for women must be compatible with their demanding schedules. Many husbands migrate for work part of the year or, even when they are stationary agriculturalists, leave the details of home budgeting and management to their wives.

RETRAINING OF TRAINERS

Along with training at the regional and community level for field staff there needs to be retraining and refresher courses for planners and engineers in the supervising agency, with the promotion of reorientation and attitudinal changes on issues related to women in health and development. Linkages with support for community participation and retraining of existing field staff to increase communication skills with women is also needed. In order to effectively communicate with village women, particularly in traditional societies where personal habits such as bathing and excreta disposal are often taboo subjects, training of women from the local region is preferable to having outside women or men.

One of the greatest problems in going beyond access to new facilities is access to women who must understand how to use the new technologies and have incentives for changing behavior in order to break the tragic oral--fecal route of infection with its accompanying diarrhea, continuing illness and death for many children. And along with access there must be appropriate training methods and materials.

TRAINING MODULES IN WATER SUPPLY AND SANITATION

First a survey of existing training programs procedures and information modules is needed, then an evaluation of their techniques and an assessment of their materials. Special supplementary modules should be prepared to be used to extend the learning into the homes. Other modules can be prepared to be used in existing programs to train other outreach workers, such as nutrition agricultural extension, and especially as part of the school curriculum or primary health programs.

TRAINING MODULES

Training modules in household management of water supply and sanitation should include, among other things, the following:

- Water use and Reuse
  - Drinking
    - Humans
    - Animals
  - Washing
    - Hands
    - Dishes/Jars
    - Vegetables
    - Children
    - Clothes
    - Floors
  - Bathing
    - Humans
    - Animals
  - Watering
    - Vegetables
    - Flowers
    - Patios
- Excreta
  - Defecation
    - Actual and preferred practices
    - Sex, Age, Class, Prohibitions
    - Anal cleansing
  - Infant Care & Training
    - Bathing
    - Diapers, nappies, or nothing
    - Laundry of soiled clothing
  - Handwashing
    - When
    - How
    - Where
  - Care of Toilet
    - Daily
    - Monthly
    - Yearly
  - Reuse
    - Appropriate
    - Casual: pigs, dogs, fish, other

WOMEN AS TRAINEES

Effective training of women will require an adaptation of training methods to the traditional ways in which new skills are acquired in local systems of learning.[11] The degreee to which women can assume roles within the management of community facilities will depend of course on the degree to which the local culture can adjust to a more public role for women. However, within their homes, as the household managers of water and sanitation, women nearly everywhere need and want training in use of the new facilities which should be part of planning for improvements in water supply and sanitation. The training period is only the beginning. Women can be introduced to problem-solving skills and new tasks, but provision should be made for support and supervision after training so that the trainees can continue to learn and the new behaviors are reinforced, become habits and are rewarded in some way.

TRAINING/LEARNING SITES

Certain sites may also lend themselves for more effective communication with and education of women than others: markets, clinics, hospitals, washing sites, grain grinding sites, etc. At each of these sites where women gather, user education including health information can be shared with a group which will provide the individual woman with peer support in her new learning.[12]

SCHOOLS AS DEMONSTRATION SITES

Care also needs to be taken that rural schools have adequate hand-washing and excreta disposal facilities. In fact, schools hould be demonstrations of appropriate technologies. Instead the school latrines are often less sanitary than the primitive facilities used by the community - even if it is only the open air. Through a process of education and example, children can learn the importance of washing their hands after defecation and before eating. A simple facility, such as a barrel with a spigot, can be placed near the school latrine, or a special dipper can be used.

Teachers and other community-level agents should use these public facilities to reinforce the hygienic messages being promoted within a classroom setting. Hopefully, the same behavior would be repeated in the home, and reinforced by community health and sanitation programs with parents, especially mothers.

Teachers, particularly those in rural areas, nearly everywhere in the world are overworked, underpaid, and without adequately prepared educational units in sanitation even though it is a part of most primary school curriculum. For an exceedingly well organized national program in environmental sanitation which was decentralized but locally coordinateed see Margarita Cardenas' detailed description of the SENASA (The National Service of Environmental Sanitation) in Paraguay.[13]

The SENASA progamme is based on community participation in preliminary surveys, in the decisions as to the types of services provided in community wide and school sanitation education programmes, all being carried on while improvements in water supply and sanitation are being implemented. The members of the locally elected Water Board, which is entrusted with the responsibility for the management, receive a special training course, as do other members of the community. The school teachers, the personnel of the health center, and the members of the Water Board become instructors for the local courses.

Educational units, including drinking water, waste disposal, and fights against parasites, are prepared for the schools which are presented to all grades during a one month project, with community involvement at all levels.

HEALTH CENTERS AS DEMONSTRATION SITES

Just as in the village school, the sanitary facilities at the health clinic should be appropriate, and used as demonstrations of behavior desired in the homes. In some areas health clinics are built with flush toilets - sometimes without water! Such facilities might not be feasible or economically appropriate for the community. More thought should be given to low-cost demonstration facilities in health centers and how women can be given hands-on training in use of them.

When mothers meet for innoculations or wait for special treatment at the health center there is an opportunity for targeted training. Special groups, such as mothers' clubs, are eager to learn how to manage their children's health problems and special messages or demonstrations, can be prepared for them.

WOMEN'S ROLES: OLD AND NEW

Women should be thought of not as passive recipients of improved water supplies but as active participants in the use and management of household water, food hygiene practices and training.

Women's traditional roles as the primary water-drawers, haulers, carriers, and users should not limit their active participation in changing and improving water supplies and systems, both at household and community level.

Sex stereotyping of new roles with improvements and modernization should not overlook women as the obvious candidates for training in their maintenance and operation. Traditional roles will vary and appropriate new systems will be widely divergent. We cannot discuss roles, potentials and needs of women outside the cultural and social milieu in which they exist, nor the modernization process. The many hours formerly spent carrying water from source to home can now be devoted to income from small industries, handicrafts or to training for new work, perhaps specially related to the improvements in the water systems as pump "doctors", barefoot engineers, mechanics, plumbers, technicians of all kinds.

WOMEN AS COMMUNITY TECHNICIANS

Anecdotal material is available on cases where women have been trained and have successfully operated, maintained and repaired pumps, (Bolivia), have worked as water source monitors (Angola), have been selected for training as mechanics (Mali) and have carried out monthly disinfection of wells (Colombia).[14] Perhaps women are not the best personnel everywhere but they should be considered as primary human resources as we evaluate past failures in operation and maintenance.

In order to analyze and evaluate these examples more details are needed so that guidelines and/or materials can be prepared for use in other places. Selection criteria, community support mechanisms, follow-up training, etc. should be included in any study.

WOMEN AS PLANNERS

How would women in rural areas design a simple bathing area with a pour-flush toilet? Would women be willing to carry extra water to flush with? In Yucatan, the women were extremely interested, even the ones who had to carry water from a village stand-pipe. They and their families bathe daily and their hope was to combine a porcelain pour-flush toilet with a bathing room.[15]

Many planners assume that women do not want to carry extra water to flush toilets with. Women should be allowed to make this decision. With more low-cost piped systems being introduced into the rural areas, are women being asked if they would prefer a pour-flush latrine to a pit latrine? If they could have a water seal latrine where would they want it? Does it have to be so far from the house that children are afraid to use it? How can it be combined with handwashing and/or bathing so that "gray" water can be used for flushing? Will communities support and maintain piped systems even though they are expensive to build and require more care? Some communities particularly in hot climates, feel the cost is worth the extra benefits.[16]

WOMEN AS OPERATORS OF BIOGAS

And have women been adequately consulted about the possibilities of biogas? This technology, which can be so appropriate under certain circumstances, has often failed. Why? When we think of management of human waste, biogas is one of the most demanding. Perhaps women could assume more responsibility for the daily feeding of a methane producer if they were given adequate training. With the fuelwood crisis in many parts of the world, the availability of gas for cooking might be the needed incentive, but careful training is necessary as well as local acceptability of this use of human excreta.

SOME CONCLUSIONS:

A REDEFINITION OF ROLES AND TASKS

Even though understanding the many traditional roles of women as primary users of water and managers of human waste is important, the more important problem now is how to use this potential so that women can be responsible for the overall operation and maintenance of the new systems in their communities and in their homes. All too often there is a tendency to underestimate the extent to which women's roles can be increased and changed to bring greater benefits to women, their families and communities.

Sex-stereotyping of new roles often restricts women's full participation. Much can be done about education, consciousness-raising and training, so that the traditional roles of women are incorporated into operation, maintenance and effective use of new facilities.

DEVELOPMENT SUPPORT

- Formulation and implementation of projects in water supply and sanitation require the involvement of the whole community, men, women and children.
- Programs must emphasize the importance of women as an integral part of community participation.
- Women's involvement in the choice of culturally acceptable technologies, in project preparation, implementation and evaluation is critical.
- The many roles of women in shaping family behaviors - as the socializer of children, the manager of the household, and a primary decision-maker should be given special attention.
- The necessity to inform women and give them training to adopt new patterns of behavior must be understood if the water and sanitation services are to be properly used and maintained.
- A continuing dialog must be carried on with women within the broader contexts of primary health care, and environmental sanitation, so that they not only have access to the new facilities, but will effectively use them within their households.
- The new attitudes and behaviors must become the acceptable norm, approved by peers, sanctioned by leaders and reinforced by health workers, teachers and other respected outsiders, as women become the ultimate trainers and managers of human waste.

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SOCIO ECONOMIC ASPECTS OF

LOW COST SANITATION:

THE BOTSWANA EXPERIENCE

A PAPER PRESENTED BY

NOMTUSE MBERE
MINISTRY OF LOCAL GOVERNMENT AND LANDS
BOTSWANA

At the International Seminar on
Human Waste Management
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TABLE OF CONTENTS

ABBREVIATIONS

1	BOT V.I.P.:	Botswana Ventilated Improved Pit Latrine
2	E.S.P.P.:	Environmental Sanitation Protection Project
3	N.D.P.:	National Development Plan (Produced every 5 years)
4	R.E.C.II:	Revised Earth Closet
5	R.O.E.C.:	Reed Earth Odourless Closet
6	TYPE B:	A Botswana Aqua Privy
7	V.D.C.:	Village Development Committee

1 THE COUNTRY

Botswana gained its independence in 1966. It occupies 582 000 sq km, i.e. roughly the size of France or Kenya. It has a population of 936 000 (1981 National Census preliminary figures). This shows a 5% p.a. increase on the 1974 census figure of 574 094. The population density is 1,5 persons per sq km. The south East is the most densely populated with 15 persons per sq km, while the West, Ghanzi and Kgalakgadi are sparsely populated with 0,2 persons per sq km.

The country lies in Southern Africa, about 1 000 metres above sea level. It is a land-locked country with South Africa in the South and South East, Zimbabwe in the North and North East, Zambia in the North, Angola in the North West and Namibia in the West. The Kgalakgadi desert occupies a large part of central and southern areas of the country.

1.1 CLIMATE

The climate is semi-arid with a rainfall which is erratic and unevenly distributed, ranging from 250 mm in the South West to 710 mm in the North East. The annual rainfall is 475 mm; 90% of the rain falls in summer, November-April. The country is subjected to regular occurrence of droughts. Mean temperatures vary from 50°C to 38°C. The Eastern side of the country has good soils, rainfall that is sufficient in most years, good pasturage and the Limpopo river. These features result in 80% of the population settling in this area. The population is predominantly rural.

The last 10 years have witnessed an accelerated socio-economic transformation, most dramatically the growth of the urban population at 10,7% p.a. The present urban population is 150 000 (1981 National Census preliminary figures), compared to 54 416 in 1971. The increase is mainly due to migration. Urban population in 1981 accounts for 16% of the total population compared to only 8% in 1971.

2 THE COUNTRY'S COMMITMENT TO ENVIRONMENTAL PROBLEMS

In the current National Development Plan (N.D.P. V 1979-1985) the country states its commitment to the above problems; "Environmental health problems are common in all communities and to safeguard the health of the people attention must be paid to the disposal of wastes, the provision of clean water supplies and the protection of food and drink from contamination. To carry out these aims the Ministry of Health will participate in an increased effort to ensure that water supplies are protected from contamination in cooperation with the Ministry of Local Government and Lands and Mineral Resources and Water Affairs among others. Communities will be encouraged and assisted to construct acceptable forms of toilets for the dispersal of human waste". (1)

In the same publication, A Water Resources Policy and Investment programme is spelt out. "The Government is also mindful that the 1980's have been declared the International Drinking Water and Sanitation Decade by the United Nations with the objective of clean water to all by 1990.

Accordingly, the Government has adopted the following general objectives for the 1979-1985 period;

(i) to reduce drudgery and improve health levels.
- first by keeping existing water supplies operating
- second by installing new supplies so as to reach villages by 1985
- third by action against pollution
- fourth by allowing private connection in larger villages thus helping to redress the rural-urban imbalance.

(ii) to provide adequate domestic water to urban areas without subsidy". (2)

3 INTRODUCTION

It is accepted that any large scale toilet programme should necessarily be hygienically and environmentally safe, technically and scientifically appropriate, socially and culturally acceptable, and economically acceptable. The paper will deal with social and cultural aspects of acceptability.

The objectives of sanitation projects is lowering of morbidity and mortality rates, promotion of health and improvement of quality of life by the resultant increase in life expectancy and economic productivity. These would in turn raise the socio-economic status of the people.

Social and cultural factors influencing peoples acceptance or rejection of low cost excreta disposal technologies have been investigated in the urban areas of Botswana.

Involvement of beneficiaries is seen as crucial to the success of sanitation projects, and the three main aspects of project design that would seem to be enhanced by the involvement of beneficiaries are technology selection, its diffussion, and its adoption.

Sanitation facilities which are not acceptable will not be used, (Botswana has some experience of this) so determined efforts to find out likes and dislikes are necessary.

Involvement of the beneficiaries at the planning stage is almost equated to involvement in design, so the sanitation system is seen as theirs and will not be perceived as just a cheap alternative foisted on them by central government. (3). There are problems associated with involvement of beneficiaries which have been encountered in Botswana, but if beneficiaries are involved in planning, it also becomes easy for the community to be trained to operate and maintain the system.

A low cost sanitation project was implemented in Botswana's urban areas from 1976-1979 in which different prototype toilets were tested. The main thrust of this project was to test social acceptability of these prototypes with a view to recommending to the Government the low cost toilet that was felt to be acceptable. This paper will concentrate on the steps taken to involve the community and the recipients of the prototypes in planning and implementation of the project.

While this project concentrated on urban areas this does not mean the country has neglected the rural areas. Currently there is a project, the Environmental Sanitation Protection Project (E.S.P.P.), the objectives of which are to encourage environmental sanitation and practise of good health habits. In this context villagers in the six experimental villages (in two districts) were encouraged to dig rubbish pits, to wash dishes, cover food, and to build a low cost improved pit latrine. Technical assistance has been offered and the administration of the project has been decentralised to District Administration. At present more districts are requesting that the project be expanded to cover their districts. Other districts and villages are also encouraged, through the Health Inspectors, Health Assistants, Family Welfare Educators, to stress on the people the importance of owning and using a well built pit latrine.

The 1976-1979 Experimental Project recommended an aqua privy toilet, known in Botswana as a Type B; in those areas where the soil conditions were adverse, a Reed Earth Odorless Closet (R.O.E.C.) was recommended. Both toilets proved to be very expensive and to have other major problems. Type B is too technical for self help construction, while R.O.E.C's curving chute demands a lot of maintenance in the form of regular cleaning, failure of which leads to odours, flies, etc.

In 1980 it was decided that the Revised Earth Closet (R.E.C.) which is a pit latrine with two chambers which are used alternatively, should be accepted as the low cost toilet. The R.E.C. substructure is built in all plots to be allocated in the site and service areas. Construction companies tender for building these. The tenant is only required to build the superstructure before he builds his dwelling unit. The cost of the substructure is recovered in the monthly service levy.

This paper will highlight the advantages of a multidisciplinary approach to large scale toilet provision, as well as involvement of beneficiaries by using examples from Botswana. It will also discuss the problems encountered, so that others can learn from Botswana's experience.

The major theme of the paper is community participation or involvement of beneficiaries in low cost toilet provision. The format used is borrowed from a publication of the World Bank "Appropriate Technology for Water Supply and Sanitation - A Planners' Guide". (4)

In this publication community involvement is divided into 6 phases.

4 PHASES OF COMMUNITY INVOLVEMENT

4.1 FIRST PHASE

In this phase unstructured interviews are conducted with a few local leaders and a small number of households.

In the urban project these interviews were conducted with councillors (political leaders) of the wards (areas/constituencies within the township) in which the experimental toilets were to be built. In some areas kgotla meetings were addressed. From these discussions we were able to identify attitudes to technologies, present then, and to find out how sensitive people were in responding to questions about defecation. This consultation enabled the sociologist to draw up the questionnaire for the next phase, while the engineers could also try and design some acceptable technologies.

The disadvantage of approaching politicians in a project in which users contribute nothing, is that they demand complete, or as near as possible, complete, coverage of their own individual areas, in order to boost their own individual status, without many resources from them in terms of persuading their constituencies to cooperate, had self help been solicited.

4.2 SECOND PHASE

In this phase a community questionnaire is designed and tested. Information can be gathered in different ways - in Botswana we used social surveys to find out:

i) Community's desire for sanitation facilities.

ii) Their preferences to toilet type, whether these toilets should be individual or communal toilets.

iii) Their perception of the relationship of certain diseases to unsanitary conditions.

iv) Their attitudes to convenience i.e. distance walked to toilet or to water supply.

v) Aesthetic features of the facility that are preferred.

vi) Identify levels of hygiene development.

vii) Identify cultural factors influencing/determining hygiene practices and technology choice.

viii) Identify whether facilities are used by both sexes and by children.

4.3 THIRD PHASE

Structured interviews were conducted using the questionnaire developed in the second stage. The following is a brief summary of the findings of the survey:

i) There was a 100% desire for sanitation facilities and a 100% preference for a flush toilet. It was when asked if they could afford it that they chose the pit latrine as their next preference. Communal toilets were not preferred at all.

ii) There was a high percentage of awareness of the relationship between certain diseases and unsanitary conditions, even though some of their practices like forbidding children to use toilets do not conform to such awareness.

iii) Shorter distances to water supply were preferred actually on plot or in house water connections would be better.

iv) Aesthetic features: seating is preferred to squatting and a screen wall, even though in some cases where toilets were owned, there were no screen walls.

v) Defecation is perceived as private, so that one of the reasons for rejection of the Apex Aqua privy was the visibility of the act, symbolised by carrying water into the toilet for flushing. The door of this particular toilet was designed to be short at the bottom, for ventilation purposes, but then individuals' feet could be seen and this violated privacy. As recently as December 1982 Ms du Pradal (5) reports that her respondents in the E.S.P.P. complained of not having a door, even though there was a screen wall, as violating this privacy and her study was in rural villages. Therefore, in this case there is no difference between urban and rural attitudes.

vi) Levels of hygiene development. While they were aware that food and water should be covered, it was the former that was always covered, dishes were washed, and hands were not washed after every visit to the toilet.

vii) There were no peculiar cultural factors affecting hygiene practices as such, e.g. at that time there was no dominance of any religious or cultural practices that required water for abultion. In the urban areas there was no fear of witchcraft by use of stools, yet in Ms du Pradal's findings (6) in rural areas this seems evident.

viii) Facilities are used by both sexes for defecation, but a high percentage of males urinate outside or around the toilet, resulting in odours. The explanation for this is the fear that the toilet will fill up quickly, or that the seat will be fouled. Ms du Pradal's findings support this even in villages where it is felt that the seat is too short and the hole too narrow to avoid fouling.

Children are also prohibited from using the toilet, more especially those under 5, for fear of them falling in the pit or their fouling the seat. There is recent evidence (7) that this practice is slowly dying and more and more children are being allowed to use the toilet.

ix) Division of labour re maintenance of the toilet is evident with over 90% cleaned by females. Actually, it is only when there is no female that males will clean toilets. As a result of this finding, it is better to involve women in all stages of toilet provision.

There were other interesting findings during this phase, but those highlighted above should be adequate to show the importance of undertaking a social survey before large scale provision, so that attitudes, preference, cultural, religious and economic factors can be identified.

4.4 FOURTH AND FIFTH PHASES

These two phases were combined in the Botswana case. A meeting between project presonnel and the chosen recipients at which alternative technologies were presented was arranged. While such a meeting augurs well for involvement, it can sometimes lead to problems. In the Botswana case, we intended to test social acceptance and whether the technology itself works; but most recipients wanted the Type B, simply because it is the one technology nearest to a flush toilet. If after choosing the one they prefer, the recipients are given an alternative, there is bound to be resentment.

During the construction stage demonstration toilets can be built so as to ensure continued involvement of the community. In the urban project no demonstration toilets were built. Those constructed during the first phase served as demonstration as well; while in the E.S.P.P. demonstration toilets were built in prominent places.

The advantage of involving the community in the construction stage is that available construction skills can be tapped, or if there are no skills the community can acquire such skills from the project personnel. It is morally wrong to use self help (free labour) without at least leaving some skills in the community.

During the implementation stage villagers become more involved as more toilets need to be constructed. If public toilets have to be built, villagers can be contacted about site selection. In the E.S.P.P. project some of the material not available in the village were bought and brought to the villages using project finances and vehicles. A Sanitary Assistant in each village had the responsibility of distributing materials needed for construction of individual toilets. The world bank publication refers to organisation of work parties. In the E.S.P.P. work groups were formed to dig the pits. A group of 10 dug for one household first, then the next until all ten had been dug. There was continued technical assistance, in this case an engineer and sanitary assistants. The earlier urban project was not designed in this way, so there is no such experience from it.

As stated above the involvement of the community ensures that recipients can choose among technically feasible alternatives and can also determine methods of implementation. If any contributions are necessary, the community itself decides what these will be. They are also able to set up social controls for continued use and maintenance.

4.5 SIXTH PHASE

If the community has been involved in all previous stages then it is easy to obtain their help in the implementation stage. Their help is needed in various forms. The following are a few instances:

1) a) By keeping the toilet clean. In all our experimental types this was easy except for the R.O.E.C. which, because of its curving chute was difficult to keep clean, or required frequent cleaning. Failure to clean toilet results in odours, flies, etc.

b) For these toilets to be low cost, emptying should be done by the plot holders. In the Botswana case this was not possible and, therefore, for emptying purposes the municipal councils take the responsibility, even for the present option - R.E.C. II toilet. This does imply that plot holders must pay for this service, but in Botswana paying is more acceptable. The councils, therefore, have to plan for vacuum tanks, manpower, etc.

c) Other operation problems associated with the accepted technologies in the case of Botswana were:

   i) daily topping up of the water level in the aqua privy so that the water seal could be maintained. Some plot holders did this diligently, while others did not.

   ii) Addition of ash and other relevant materials in composting latrines so that the faecal matter should be stable. As the composting latrine was an unknown technology, recipients required a lot of education. These composting types were later discontinued due to the failure of both technology and operation. If they have to be re-introduced a lot of preparation for their acceptance would be necessary. Actually, a multidisciplinary approach would be called for.

   In the urban project performance was monitored by the project personnel and the recipients. Regular weekly vists were made in the beginning and as recipients became familiar with the technology the visits were reduced to monthly.

5. MAJOR CONSTRAINTS IN LARGE SCALE TOILET PROVISION

Botswana is able to share its experience of major constraints associated with sanitation provision. A few of these will be highlighted below.

5.1 COST

The cost of low cost toilet provision is still considerable. The following schematic table shows the comparison between options that have been tried.

TOILET TYPE	RURAL/ URBAN USE	SUBSIDISED COST SUPERSTRUCTURE	SUBSIDISED COST SUBSTRUCTURE	UNSUBSIDISED COST	TOTAL
Rec II	Present Urban Option	P 150,00	P 350,00		P 450,00* (1982 Prices)
R.O.E.C.	Urban	P 120,00	P 400,00		P 520,00 (1980 Prices) None built since 1980.
Type B	Urban	P 120,00	P 800,00		P 920,00 (1979 Prices) None built since 1979.
BOT V.I.P.	Rural E.S.P.P. Option	P 20,00	- P 30,00	P 206,00 + Price includes all labour & transport & materials	

* Prices vary greatly within the country: quoted above (urban options) are Gaborone prices. The same R.E.C. would cost
P 420,00 in Jwaneng ±220 km from Gaborone
P 500,00 in Kasane ±976 km from Gaborone

± P 206,00 is unsubsidised cost for BOT V.I.P. in those (9) districts nearer the rail line. It is likely to be more in the more remote village.

N.B. Figures given by Public Health Engineer.

The E.S.P.P. survey found that only 3% of households in non-experimental villages would get a latrine at the unsubsidised P 190,00 quoted by Kweneng District.

As can be seen from figure I Botswana's urban low cost sanitation is highly subsidised. It would cease to be reasonable to ask low income groups, who are invariably poverty stricken, to provide sanitation for themselves, so subsidisation of low cost sanitation must be seen as an attempt to redress the multifarious effects of poverty. It is therefore necessary to have governmental intervention, even if through subsidies. This does not mean low income groups should be made to be dependent on governmental intervention in all their needs.

5.2 DISTANCE

i) If the toilet is far, there will be reluctance to walk at night and during inclement weather.

ii) If close to the house, it might be felt that defecation is not adequately segregated. There is evidence of this from some Batswana respondents who did not like inside toilets.

iii) In high density areas it may be difficult to locate the toilet with sufficient privacy, for instance the back of the house can be seen as the ideal place, yet there may be no space and the toilet may have to be located in front.

iv) For those technologies that use hand flushing, distance from water supply can affect operation. This is clearly the case in the misuse of Botswana's Type B Aqua Privy.

5.3 COMFORT

i) In Botswana there is a cultural preference for sitting when defecating.

ii) There can also be a particular commitment to ablution material, water or toilet paper. Poverty may force beneficiaries to use other means of ablution.

iii) Anxieties about childrens' safety can be well founded.

iv) Addition of washing facilities to the toilet may make it attractive and more acceptable especially for those beneficiaries whose houses are small and overcrowded.

v) Privacy must be ensured; in the case of Botswana, doors are necessary.

vi) Beneficiaries' preference to private or communal toilets must be taken into account; in Botswana private facilities are preferred.

5.4 REUSE

Excreta has a special status, it is referred to with disrespect, it is a thing apart, despised and taboo. Cultural interpretation of excreta and defecation underlie peoples responses both to the disposition technologies and removal and reuse. (10). One of the objections to composting in Botswana is the negative perception of using human faeces as garden manure.

Research so far on reuse in Botswana has revelaed that it is unacceptable. The toilet which is being constructed on a large scale in Botswana's urban areas will in 3 years time lend itself to emptying problems. Municipalities will have the responsibility for this, but it is not known yet whether those involved in this process will not be stigmatised. It is known that people who by their occupation come into contact with excreta become themselves avoided. In many towns throughout the world sweepers and night soil removers are drawn from disadvantaged groups. Will this be a problem in Botswana? This remains to be seen.

5.5 Administrative and political policies may place constraints on options thereby affecting what is perceived as acceptable by beneficiaries.

5.6 A major constraint may be the one associated with public knowledge, practices and behaviour. This requires a multidisciplinary solution.

6 CONSEQUENCES OF NON-INVOLVEMENT OF THE COMMUNITY

6.1 NON-USE

Technology may have been provided but will not be used. Botswana has a bitter experience where in one area each plot was provided with substructures of the Apex Aqua Privy and the residents just dug them out and replaced them with pit latrines.

In the urban experiment 20% of the double vault toilets were not used because recipients rejected them.

6.2 MISUSE

Misuse can result because of lack of consultation or lack of logistical support like health education, or other extension work. In the paper presented in Tanzania in March/April 1982, the author of the present paper highlighted the problems associated with misuse in "Use and Misuse of low cost sanitation which can lead to social unacceptability". In this paper most instances of misuse were discussed; including poor maintenance.

6.3 CHOICE OF INAPPROPRIATE TECHNOLOGY

The technology may be inappropriate only because of lack of understanding or knowledge of how it is to be used, hence involvement of the community can help avoid this, by the community's own choice of what it feels is a feasible technology.

6.4 POLITICAL PRESSURES

One must always take account of this. The toilet provision programme might go smoothly in some areas, yet in others it might fail, owing to the fact that they may be constituences of the opposition parties. Involvement of the community will ensure that project personnel are aware of this and ways of overcoming political problems may even be suggested by the villagers themselves.

There are numerous instances in which failure to involve the community results in abandonment of a project which is worthwhile. It is necessary though for project personnel to be clear in their minds that involvement of the community is not a cloak for cheap labour.

7 CONCLUSION

Experience in provision of low cost technologies seem to indicate that soft ware should start to play a major role in these activities if governments or planners are to be sensitive to beneficiaries attitudes and preferences. For sometime now providers of these services have been using the "Victim Blaming Syndromé" (11) - that is if technology fails, the fault is that of the user and the user (victim) is the one who must change to incorporate the technology. This has been the attitude of orthodox engineers and it must cease.

Socio-cultural behaviours are entrenched in the culture of the people - if these must change then educational campaigns tantamount to brain washing or propaganda may be necessary. The expected change may not be achieved with the older generation, but with the younger, therefore, the latter must be the focus of educational campaigns. It is recommended that sanitation should be introduced in the curriculum of both primary and secondary school, if this is not being done yet. This will ensure that future adults will have been socialised into acceptable sanitary practices.

8 FOOTNOTES

(1) National Development Plan 1979-1985

(2) National Development Plan 1979-1985

(3) Appropriate Technology for Water Supply and Sanitation: A Planners Guide. World Bank Publication December 1980

(4) From (3)

(5) Ms Pia du Pradal
E.S.P.P. 1982 December

(6) From (5)

(7) From (5)

(8) From (3)

(9) From (5)

(10) From (3)

(11) From (3)

(12) Kgotla : A designated area in the village in which village consultation takes place: Can also be used as a Tribal Court.

LOW-COST SANITATION AND ENVIRONMENTAL PLANNING IN THE METROPOLIS: THE BANGKOK EXPERIENCE

by:

Surin Setamanit, Ph.D
Director, Institute of Environmental Research
Chulalongkorn University
Bangkok

LOW-COST SANITATION AND ENVIRONMENTAL PLANNING IN THE METROPOLIS : THE BANGKOK EXPERIENCE

ABSTRACT

Although there is no sewerage system to carry human waste and wastewater for treatment and disposal, the sanitation condition of the Bangkok Metropolitan Area is still liveable because of the general use of water seal pit latrines with cesspools or septic tanks and soil percolation. Problems arise due to the low and the non-permeable properties of the Bangkok soils in most areas, especially in the rainy season. The situation is saved from disaster because of the intricated network of canals and the large Chao Phya River, and the natural phenonmenon that is found to take place all over Bangkok. That is the emergence of stabilization and oxidation ponds wherever a piece of land is left vacant. Several master plans and reports concerning sewerage and drainage systems of Bangkok had been drawn up in the past, but were either abandoned or partially implemented. The problems encountered and alternative ways of handling them are discussed and explored in this paper.

1. INTRODUCTION

Bangkok, a city of about 5.1 million inhabitants, was founded 200 years ago on the flood plain of the Chao Phya River, at a distance of about 20 kilometers from the river mouth. Immediately after its establishment as the capital city, it was flooded for the first time in B.E. 2328 (A.D. 1885). From then on flooding appeared to be one of the main problems associated with Bangkok, which has not yet been solved up to the present time, despite the construction of several multi-purpose dams on some of the tributaries of the River. A recently completed research work involving a sum of no less than 20 million Baht covering a period of about three years, establishes that the land, in general, is subsiding to a varying degree. The eastern part of the City suffers most with the rate of subsidence of about 0.50 metre annually. Pumping of underground water to augment the water supply for this rapidly growing City at the rate of about 1.0 million cubic meters per day was pointed out as the main cause of the problem. The Government has since enacted an Underground Water Preservation Law to control the abstraction of the underground water, and the construction of deep wells in Bangkok Metropolitan Area. It has also been planned that underground water pumping will be suspended in the year B.E. 2530.

The natural ground surface of Bangkok lies at an average of 1.5 meter above mean sea level, which is the usual characteristics of the delta area. The top soil is invariably dark gray in colour, homogeneous and low in permeability. The average thickness of the top soil is about 0.5 - 3.0 meters and that of the soft and medium clays may be more than 10.0 meters in thickness. The top soil is more permeable and often cracked as a result of alternating wet and dry seasons. Rain water trapped in this layer of the top soil can move mostly in horizontal direction due to the more impermeable layer underneath and can cuase failure of most subsoil filters and leaching pools.

2. EXISTING PRACTICES IN HUMAN WASTE DISPOSAL

The most popular method of human waste disposal currently practised in Bangkok takes the form of simple pour-flush water seal pit latrines with cesspools for low cost residences. The toilet is flushed by hand with a small volume of water, 1 - 2 litres, after use, and equipped with shallow trap to provide the water seal between the privy and the device. This is quite adequate from the hygienic point of view as well as from water conservation and low volume of waste water generation angles. The cesspools are usually surrounded with few layers of granular materials where the liquid wastes are expected to percolate through the perforations in the cesspools walls and leach pass these materials into the soil.

For larger building such as apartments, hotels and offices, septic tanks are employed to remove the gross solids and suspended material which are settled and digested under anaerobic condition at tanks bottoms. The effluents are usually allowed to percolate into the soil by distributing it over a leaching field of granular material. This is essentially the method laid down in th Bangkok Metropolitan Authority by-law for building construction. It has been reported that approximately 70 percent of the population of Bangkok are served by cesspools while the remaing 30 percent are served by septic tanks.

Realizing the limitation of soil permeability while trying to comply with the by-law, designers have resorted to using septic tanks as primary treatment, but the treatment of the effluent varies. Activated sludge treatment has been used widely in the case of large office buildings, and hotels. For medium size buildings and where some land areas are available, modified subsoil filtration is also used. Where land area is limited, anaerobic filter has also been used.

National Housing Authority has been leading in the provision of sanitary sewers and waste treatment facilities for their housing development projects. Conventional activated sludge process, aerated lagoons, and oxidation ditches are predominant. There are 12 sewerage systems with treatment facilities constructed in the housing estates at present.

The Bangkok Metropolitan Authority and the Ministry of Health have also installed activated sludge treatment plants for several hospitals that come under their jurisdiction in the Bangkok area.

3. BMA'S FACILITIES WITH REGARDS HUMAN WASTE TREATMENT AND DISPOSAL

The Bangkok Metropolitan Authority maintains a fleet of 41 suction vehicles (2 to 5 cubic meters each) and 24 carriage vehicles (5 cubic meters each), which for a fee of 50 Baht per cubic meter will pump out the content of septic tanks and cesspools and transport them to the public sludge disposal sites at Soi On-Nooch and Nong Khaem. The BMA operates this desludging service 7 day a week with a capability of 350 - 400 cubic meters per day.

At Soi On-Nooch, a sludge treatment facility has been constructed, having a capacity of 600 cubic meter per day. The treatment process is a chemical one followed by an activated sludge process. But at the Nong Khaem Dump Site, night soil sludges are dumped into a lagoon located near the solid waste disposal site to be covered by the waste later on.

4. EXISTING LEGISLATIONS

Some clauses of the Bangkok Metropolitan Authority's Bye-Laws concerning with sanatation are as follows :

No. 85:Slope of drains: must not be less than 1:200.

No. 86:Refuse screen manhole: there must be a manhole with refuse screen installed before final discharges into public water ways.

No. 87:Wastewater treatment: wastewater from industries, hospitals, fresh food markets, restaurants, condominiums, hotels and other buildings dealing with objectionable goods, must be properly treated before discharges into public water ways.

No. 90:Latrines: must be water cleaning type with septic tank and leaching pool. Latrines constructed within 20.0 m. from public water ways must be non-percolating type.

No. 91:Refuse disposal facilities: condominiums and large buildings which are not row-buildings or row-houses, and which have total floor areas more than 2000 square meters, or hotels, must have refuse disposal facilities constructed in such a manner that they will not be objectionable and nuisance to those residing near-by.

Sanitation Clauses from the Building Control Act :

No. 60:Drain: slope must not be less than 1:200 and there must be manholes provided at every 30 meters and at every change of direction.

No. 65:Latrines which are of water-cleaning type can be constructed within the building: latrines of other types have to be constructed outside of the building.

Sanitation Clauses from the Regulation concerning land sub-division issued by the Land Sub-division Control Committee.

No. 9 (2) a : ---drains shall not be less than 0.30 meter--.
b : ---flow velocity shall not be less than 0.60 meter/second--.

In cases where drains from the sub-divided land are discharging into other drains or water ways which are not public sewers, the land sub-divider shall construct wastewater treatment system to treat the wastewater before discharging.

(3) : Wastewater treatment facilities: --land area, in one piece, of not less than one hundreadth of the sub-divided area shall be set aside for the construction of wastewater treatment facilities of the types approved by the Committee.

5. INFRASTRUCTURE PLANNING

The National Economic and Social Development Board is responsible for the overall development planning of the country, and the planning of various infrastructures is entrusted with several responsible government agencies. The Bangkok Metropolitan Authority has jurisdiction over the drainage and sanitation of Bangkok. Several report and master plans concerning with the drainage and sewerage problems of Bangkok had been carried out in the past. Most of them were either abandoned or partially implemented. Some accounts of them will now be given.

Litchfield Plan : Greater Bangkok Plan - 2533 (1990) - submitted on August 13, 2503 (1960).

The purpose of this study is to prepare master plan of water supply, drainage, sewerage, land use, transportation, schools and others for Greater Bangkok-Thonburi Metropolitan Area.

The resulted master plan recommended separate sewerage system with two wastewater treatment facilities.

Husband Report : Sewerage and Sewage Disposal for the Central Area of Bangkok, Including Reference to Associated Problems of Surface Water Drainage-submitted on September 10, 2505 (1962).

The purpose of this report was to review and make recommendation and provide cost estimates for sewerage and wastewater disposal scheme, and also to study the existing storm-water drainage system and to recommend facilities to overcome the periodic flooding.

The study recommended separate sewerage system with a single wastewater treatment facility.

Camp, Dresser & McKee (CDM) : Sewerage, Drainage and Flood Protection System, Bangkok & Thonburi, Thailand - submitted on *February 29, 2511 (1968).*

The purpose of this assignment was to review previous investigation ; to consider alternative schemes and to prepare a master plan.

The master plan resulted from this study recommended division of the area into 10 sewerage districts with gravity flow sewerage system to a main pumping station across the Chao Phya River from the southern tip of Bangkok. Separate sewerage system was recommended. Trunk sewers would be constructed partly as tunnels and partly as conduits in open cut trenches.

Japan International Copperation Agency (JICA) : Bangkok Sewerage System Project in Kingdom of Thailand - submitted in August 2524 (1981).

The purpose of this assignment was not only to prepare a master plan on sewerage system to meet the present demands and the future needs in the study area up to year 2543, but also to suggest interim measure to improve the existing environmental conditions until the sewerage system is completed and sources of pollution become under control.

The proposed sewerage system was basically a separate system except in the central area where public drains are already provided, the system would be a combined one. The area was divided into 10 sewerage zones, each with its own wastewater treatment facilities in addition to sanitary sewers and pumping stations. The treatment plants were proposed to be using aerated lagoons process except where land area was unavailable, modified aeration process was recommended.

Among the interim measures recommended included complete installation of septic tank system coupled with active desludging services, particularly in the houses located in the tributary area of deteriorated klongs.

6. THE PROBLEMS

A period of almost 23 years had lapsed since the first study concerning with drainage and sewerage systems had been undertaken. Not much had been carried out during this period. The Litchfield Plan and the Husband Report served as bases for CDM's Master Plan which was only implemented to a rather small degree. The Rama IV Project concerning with drainage resulted from this Master Plan.

JICA's master plan shares a great deal of common basic factors and assumptions as CDM's. Both planned for the year 2543 (A.D. 2000) and expected almost the same number of population, land area, and quantity and strength of wastewater. The major difference between the two master plans lies in the concept of centralization into one network as proposed by CDM and decentralization into 10 complete sewage districts independent from one another as proposed by JICA. The BMA has appointed a committee to study the advantages and disadvantages of the two proposed master plans, and the committee's finding is forthcoming.

There are a few points that are common to all these studies and master plans. They were all based upon the concept of water-borne sewage as commonly used in the West, and none takes much into account the existing human waste disposal system using septic tanks and cesspools as to the role they could play in the new system so that certain cost saving might be achieved. In all plans, about 30 - 40 percent of the population would not be served by the systems, and there was no indication with regard to the appropriate methods that should be provided. No comprehensive measures of water conservation and reduction of wastewater generation were given either. There are also other problems associated with the implementation of the plans. One is the lack of the sense of urgency among the decision-makers who have so many other problems on their hands. Flooding is given a higher priority than drainage and sewerage. This is probably because spetic tanks and drains have kept the living environment, although not highly satisfactory, from disastrous deterioration. Traffic congestion and traffic problems are so serious that major constructions that result in interruption of traffic flow are ofter avoided. As time passes by, Bangkok City soon outgrows the master plans and recommendations. Adjustment and modification of the plans are then necessary, causing further time delay. Sooner or later new plans are drawn up or offered resulting in further time delay during the period of review and comparison, and another decision-making.

Bangkok is thus a city left virtually sewerless under a situation now worse than it was 23 years ago , due to the fact that the city itself has since gown serveal time larger in terms of population and areas. The problem is further aggravated by the adoption of modern western sanitary fixtures which use larger amount of water, hence generating larger volume of wastewater, in place of the eastern type squat-plate water closet with shallow seal.

If one examines the situation carefully, one can see that mother nature is stretching herself in trying to save Bangkok from catastrophe and plays a very important role in environmental protection, especially with regard the problem of human waste disposal which might have escaped notice of the general public.

Almost in every housing complex, there are bound to be some pieces of lands left vacant nearby or within the project itself because the owners are not quite ready to build their houses, or because the owners are speculating for higher land prices and simply want to hold them for making profit in real estate business dealing. These areas are thus left in their original condition at a relatively low level while the near-by lands have been raised in level by filling up with laterite, earth and sand before house construction. As soon as the houses are completed and taken in occupancy, wastewater as well as septic tank effluent which cannot percolate into the soil will be discharged into these empty lands, either directly without owner's permission or indirectly. Very quickly marshy plants will flourish and help disposing these wastewater by using them for their own growth and by the process of evapo-transpiration. An equilibrium is soon established and the community lives comparatively happily apart from the presence of mosquitoes and other insects which are a nuisance everywhere, until those empty lands are no longer empty.

When new houses or buildings are to be constructed, the owners will, as before, raise the ground level higher than those in existence, including the ground level of the houses of their neighbours. One reason for this is that the ground will settle and the second important reason is to make sure that they can drain their storm water, wastewater and can let their septic tank effluents percolate into the ground, being at a higher level. One by one, owners of the houses that have been built previously who can afford it, will start raising their grounds and even the ground floors of the houses so that their drains will still function. Very soon the streets are flood, and as one may expect, sometime later the Bangkok Metropolitan Authority will come to raise the level of the flooded streets. Since during the whole process, no substantial improvement has been done to the general drainage and sewerage systems, houses will be flooded, and the levels have to be raised again. So the viscious circle goes on and on all over the City.

7. DISCUSSIONS

It can thus be seen from the past development activities concerning human waste and wastewater problems that the BMA is entrusted with the responsibility of the planning and implementation with regards sewerage and wastewater systems of the City of Bangkok, but confusion arises as to how to go about it. As time goes by, master plans after master plans became less relevant to the real situations which changes very rapidly and in a very uncontrollable way. The Bangkok Metropolitan Area is still left without the official city plan, although a great deal of effort has been put into its preparation. The plan still awaits approval from the Government. In the mean time, the Metropolitan Area grows in a rather hapazard way with little or no control, except for the effort of the BMA which tries to issue regulations concerning land use for specific areas which the BMA is empowered to do so.

If the JICA's recommendations with regard interim measures concerning the construction of proper septic tanks to handle human waste problems is adopted and the BMA is successful in enforcing its bye-laws concerning on site treatment of human waste and wastewater treatment, the future problems of the greater part of Bangkok, especially in the central areas will be more on the handling of septic tank effluents and effluents from those on-site treatment plants. The question which is now asked is whether it is approriate to design the sewerage system for the inner city to handle not the raw waste but rather the effluents. This means that the cost of the system will be greatly reduced, the construction much easier and perhaps pressure sewerage system can be employed to reduce the sizes of the sewers and the depth from the ground surface which it would otherwise require. There seems to be no other alternative than water-borne sewerage system, although question has also been asked whether the concept of waste holding and transportation by tankers is feasible.

For the suburban areas and the low-income communities which cannot be economically served by the sewerage system, one obvious solution is to try to reduce the volume of the waste, which could be achieved by either using less water in flushing the toilets, or, perhaps, by prohibiting the use of certain kinds of fixtures that require large amount of water, such as the western type water-closets, or the substitution of water seal pit latrines and septic tanks which are now in common use by compost toilets for example. But this will give rise to both technical and social problems since the Thai in general are so accustomed to the use of water for toilet flusing, and to use no water for their personal hygiene practice is probably unacceptable to the muslim communities.

Question which could be asked here is whether following the way nature is handling much of the wastewater problems in many areas by means of stabilization and oxidation ponds and the emergence of absorbent fields and marshy areas of the lands left vacant, will be an appropriate way of keeping the environment liveable, as it is more or less the case now. But this time it will be done in a systematic and scientific way as has been demonstrated elsewhere.

8. CONCLUSIONS

From the fore-going discussion, it appears that what the BMA can do best now is to follow the JICA's interim measures with regards the enforcement of the construction of proper septic tanks to handle human waste within the areas under its jurisdiction and to improve immediately its de-sludging services and sludge treatment facilities.

The BMA must decide as soon as possible which master plan is to be followed and what modification has to be made, and strongly recommend the Government to give it the necessary financial assistance. It appears that the plan to be implemented should be the one that is most flexible to future development of the Metropolitan Area since this problem is largely unsettled. The plan should also be practicable in terms of the socio-economic condition of the country. Due to the long time lag in implementing various components of the plans, they should be not only very flexible, but also independent from one another as much as possible. In this respect, it would appear that the concept of dividing the Area into several sewerage districts, independent from one another, is a very feasible one to adopt, since each components of the system could be modified at any time without affecting another that have been or to be implemented. It is also very feasible in terms of financing also.

Research activities, pilot and demonstrated projects in areas of reducing the volumes of the waste, the use of absorbent fields and septic tanks, compost toilets, and waterless waste disposal should be intensively carried out, and the feasibility of pressure sewerage systems carrying only septic tanks and other on-site treatment plants effluents should be further studied in details.

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WASTE MANAGEMENT IN PEASANT COLONIZATION SCHEMES

D.W. Abeywickrama

Project Manager
Kirindi Oya Irrigation Scheme
Land Commissioners Department
Sri Lanka

INTRODUCTION

Human settlement is not something new in Sri Lanka. With the arrival of the Ariyana 2500 years ago, human settlement was augmented and later was improved. At the beginning, human settlement was started in places where land and and water were available. All these settlements had an agricultural origin. With the advent of foreign invasion, these settlements were shifted to places of security. Extensive ruins of these places are an evidence of a well-developed system of town planning which encompassed dwelling houses, roads, and drainage facilities.

Health and sanitary facilities appear to have been carefully considered in the establishment of ancient human settlements. Ruins at various places provide an evidence of the existence of well-planned lavatories with water closets, soakage pits and a drainage system. This is revealed by a human excreta burial done hygienically (Appendix 1). The terracotta cover of the soakage pits was fabricated similarly to the dome of the present biogas unit. Though there is no evidence of sludge utilisation, it can be believed that the sludge had been used as fertilizer in agriculture (1).

There are ruins of urinal stones, found in various places, which reveal the use of water for hygiene and disposal of excreta (Appendix 2). So, historical evidence has revealed human waste management in Sri Lanka.

Due to the invasion of foreigners, the scattered pattern of settlement was changed and the population flocked together in arid zones, where more facilities were available. Due to this reason, many social problems arose at the end of the 19th Century. Therefore it was felt a need to develop lands in the dry zone.

SETTLEMENT IN DRY ZONE

From the end of the 19th Century to the fifth decade of the 20th Century, the main factor considered was the availability of water and land for cultivation. Therefore, the pattern of the settlement was spread along roadways. Though there were difficulties in providing infrastructural facilities, this was more convenient in health aspects. Due to this reason, the peasant could build a house with more ventilation, a well and a lavatory, and lived comfortably. The latest settlement scheme of the above pattern was the Udawalawa Irrigation Scheme, which was situated in the Southern part of Sri Lanka. The shortcoming of this settlement was a decrease in production due to long distance travelling from the paddy field to the homestead, and so the farmers had to cover for his services and supplies of day-to-day needs. Therefore, the farmer could not get a reasonable income from his products, and his living conditions were not improved. Due to these factors, the authority has now taken action to modify the settlement pattern into a cluster system. This system is adapted in the Mahaweli Settlement Scheme and the Kirindi Oya Irrigation Scheme in Sri Lanka. In this system, homesteads are in a concentrated place with a centre of infrastructural facilities (Appendix 3).

THE KIRINDI OYA IRRIGATION PROJECT

This scheme is the largest settlement one in the South of Sri Lanka. It is anticipated to irrigate 12,934 hectares of land, out of which 4,525 hectares - which are presently cultivated only one season - can be cultivated both seasons. It is proposed to settle 10,000 families in this scheme. It is planned to construct a reservoir of 183,795 acre-feet water capacity to provide water for irrigation. The estimated benefits at this project are (i) a minimization of the population congestion in the wet zone; (ii) an increase in feed production and job opportunities; and (iii) an improvement of the living conditions of the peasants. The cost estimate of this project is 1,300 million and the economic internal rate of return is 17.6% (2). When the project was appraised, the authorities did not give much consideration for social benefits which would be equal to economic benefits. Therefore, less attention has been given to health and human waste management in this scheme. The commencement of settlement was on the basis of advance alienation.

THE SETTLEMENT ACTIVITIES OF THE SCHEME

A socio-economic survey was done in 1980 and the criteria of selection of farmers were decided, according to the report. It is revealed that 80% of the farm families living in the command area did not possess the land on which they resided. 60% out of these families received an income of less than Rs. 3,600/- (3). This is the main reason which attributed for not improving the living conditions of these families, and this led to the decision to provide facilities. Each farmer of the settlement will get a 0.5-acre homestead and 2½ paddy allottment, and assistance in house construction, land clearance, agricultural implementation, planting material and World Food Aid, etc.

HUMAN WASTE AND THE RELATED PROBLEMS

In this scheme, homestead allottment is gathered on the highland where the soil is more permeable to rain water. Gathering of homesteads has an advantage of providing infrastructural facilities, but in the hygienic viewpoint there are more disadvantages, viz. ventilation of the house, drinking water and lavatory facilities. If any allottee constructs a well and a lavatory within his allottment, he will adversely effect the others. Therefore, wells must be constructed at a suitable place on each homestead. On the other hand, the farmer has no knowledge of using collected human waste on his land. The common waste, which can be found in colonization schemes, are paddy and coconut husks, leaves, decomposed trees, various kinds of stuble and straw, cow dung, and other types of refuse. To some extent, farmers have a knowledge of using these waste as energy and fertilizer sources. Paddy and coconut husks are used as energy sources in the houses, and ashes as fertilizer for plantations. Paddy straws are used as fodders for animals, but not in a scientific method or organized way.

Peasants do not know about the gravity of importing crude oil and fertilizer, and have no knowledge of any substitution. Table 1 (Appendix 4) shows the use of fuel within a year, and the kerosene use is nearly 20% of the total petroleum products. A major part of the kerosene is used in lighting and cooking, and this can be substituted by some other forms of energy, viz electricity or gas. On the other hand, though it reduces the quantity due to price increase, Table 2 (Appendix 5) shows the quantum of fertilizer use in each crop. (4). Considering the amounts of fertilizer used for paddy, subsidiary crops and other crops, the fertilizers can be substituted by organic matters.

Though we consider electricity as a substitute to fuel, fuel-operated generators cause a heavy burden on the economy. After the augmentation of the free-trade economy, more electrical goods are imported, and this is the reason of the increasing household electricity consumption (Table 3, Appendix 6).

Considering the rural economy, firewood is the main energy source. Due to the cultivation shifting practice in the village forests and opening up of new lands for paddy cultivation, the forests decreased by 15% within the last 40 years. Table 4 (Appendix 7) shows the importance of firewood in generating energy. Therefore Sri Lanka needs to switch to some other energy sources like biogas and sikar energy. The farmers of Kirindi Oya will face with an energy crisis in a near future due to the clearing of jungles for cultivation.

SCOPE OF BIOGAS PRODUCTION

There is a continued supply of raw cow dung for biogas production in the project area. According to the 1982 agricultural census, there is on average one cow per family (Appendix 8). The farmers make use of cattle only for ploughing paddy fields and milking. Therefore, the authorities have intended to improve the biogas production in the colonization scheme. With the concurrence of the Norwegian Government, the authorities have donated a few biogas plants to the colonists in the Udawalawe Development area, (Appendix 9). These farmers use only cow dung as the input to the biogas units. They are reluctant to use human excreta for biogas production. Therefore the Farm School of the Department of Agriculture has commenced a pilot project in Angunukolapellessa, Sri Lanka, in the use of human excreta and cow dung to educate the farmers (Appendix 10). At this plant, the sludge is used as a fertilizer for vegetables. The sludge can also be made use by farmers in attractive processing and educational purposes. Some farmers presently use the sludge as fertilizer for plantation and feed for pigs. Within and in the surrounding areas of the project, there is a remarkable supply of sea shells which can be mixed with sludge and used as feed for poultry.

COMPOST PRODUCTION

The farmers have little knowledge of using compost and green manure. When considering the contents of rural wastes like in India, about 80% of the materials are putrescible and paper (5). Therefore farmers can easily produce compost using refuse and green leaves. Though they are not aware of the advantage of the use of compost, some farmers use it without processing to tree crops. Therefore farmers must be educated in this matter.

ADMINISTRATION OF RURAL WASTE AND FARMERS EDUCATION

Due to the heavy cost of transport, it is not possible to collect all rural refuse to one place. Therefore it is easy to manage with the refuse on the farm. At the same time, administration-wise, it is convenient to collect excreta to a central place with a proper sewage system and then produce biogas. Due to the high capital investment, this system could not be implemented as proposed. Therefore, more consideration is given to small biogas units which are presently used to produce biogas in China (6).

On the other hand, all home appliances and agricultural machinery meant to use electricity or fuel must be changed to biogas. If radio, television, agricultural machinery or any other home appliances are meant to use biogas, the farmers can be motivated to produce more biogas.

A farmer's income is not sufficient to invest at once a large sum of money for a biogas plant. Therefore, some aid must be given to him as an incentive. If this is not possible, credit facilities with attractive conditions could be considered.

The most important factor in waste management is education for farmers. Without their participation, we cannot implement a successful project. We have to conduct training classes to educate them, both theoretically and practically. We must provide technical assistance till the farmers are familiar with the new technique. Other methods which can be used in farmer education are leaflets, television, radio and movies. Illustrations of models should be a part of training. Farmers must be dressed of the importance of biogas production as a means of environmental protection.

Farmers education can easily be done in conjunction with farmers' organisations which are presently used for farmers' activities. It is proposed to open an agricultural training school for farmers in the project area that can be used as a training centre for this purpose. There is a project coordinating Committee to coordinate all activities related to various agencies, which can liase as the coordinating and organizing agency of the whole project. In this manner, we may be able to face the energy crisis for the development of Sri lanka as a Third World nation.

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1. Mr. L.M. Samarasinghe

Advisor - Water Management Division
Ministry of Lands and Land Development
Colombo 7

2. Mr. Nanda Abeywickrema

Secretary - Ministry of Lands and Land Development
P.O. Box 500
T.B. Jayah Mawatha
Colombo 7

3. Mr. A.A. WIjetunga

Land Commissioner - P.O. Box 500
Colombo 1

4. Mr. D.A. Upawansa

The Principal - In-service Transmission School
Agricultural Department
Angunukelapellasa

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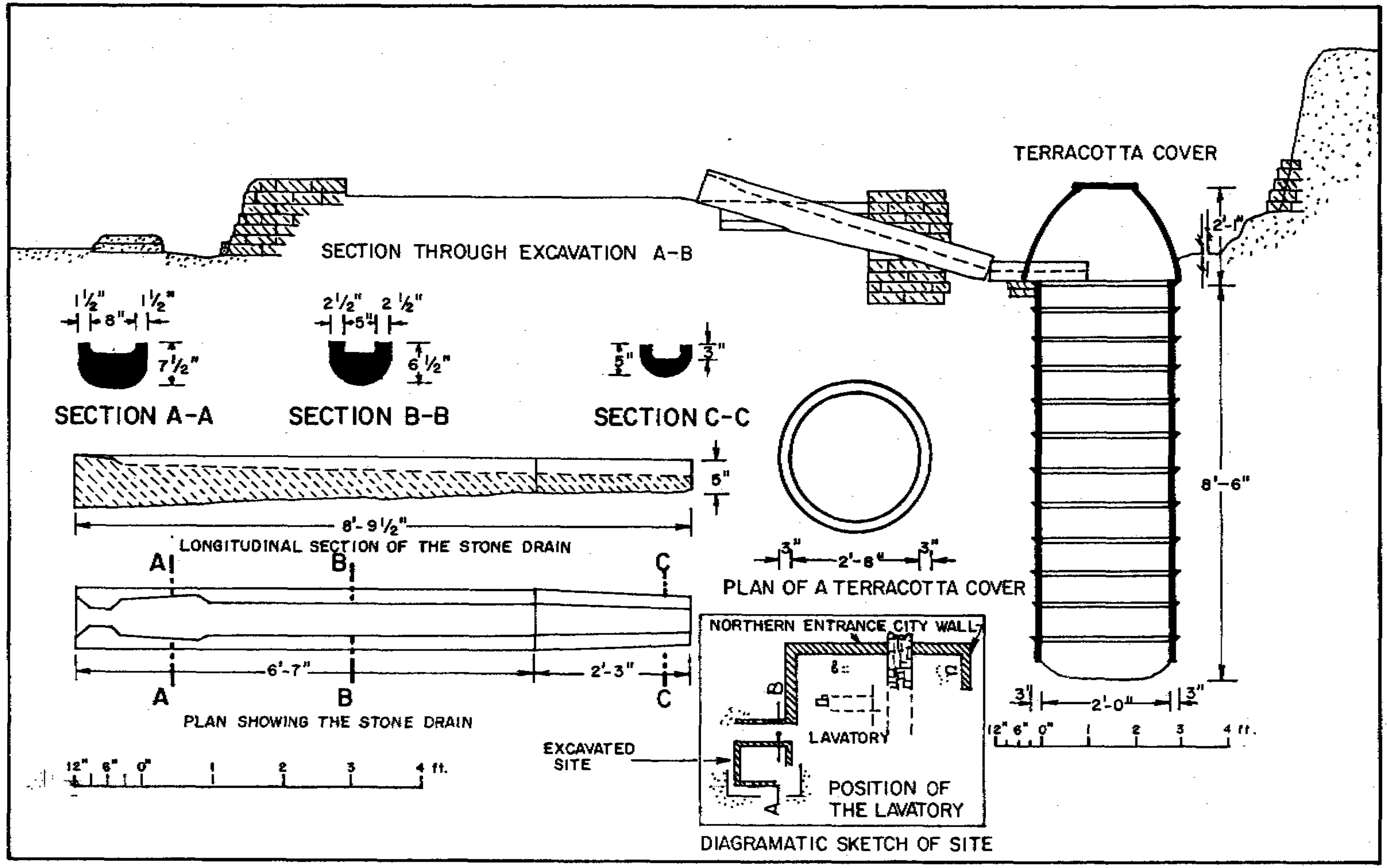
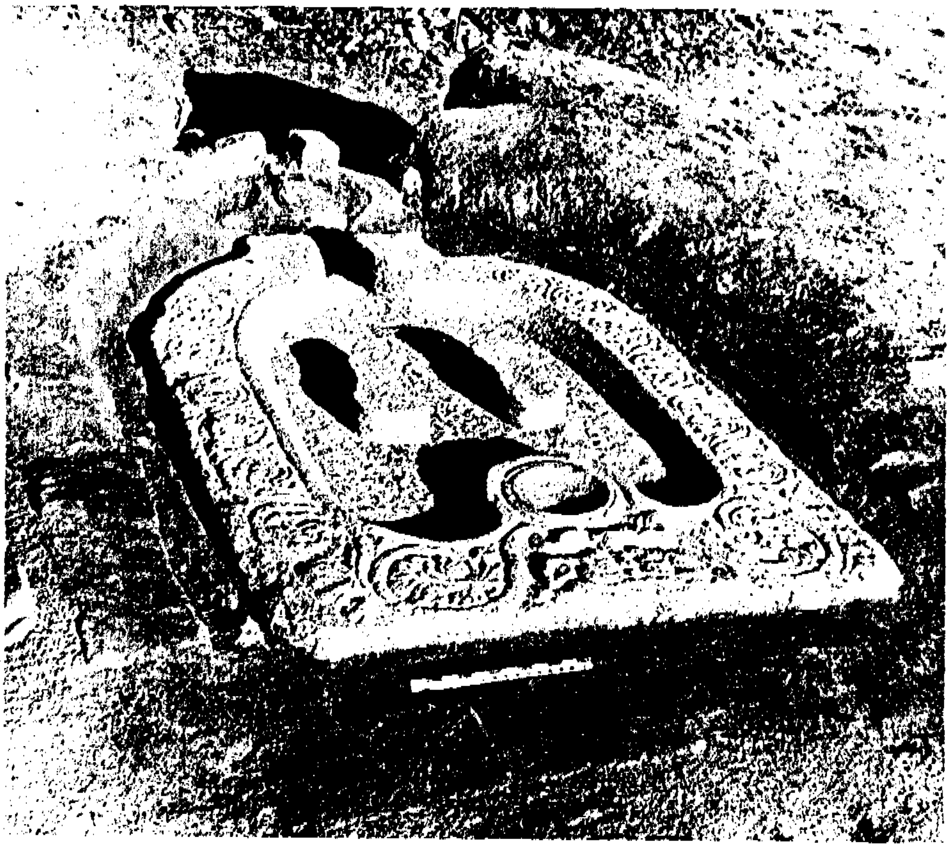


APPENDIX 1 Ancient Lavatory with Terracotta Rings Plonnaruwa - Sri Lanka

APPENDIX 2



Urination Stone Monaragala – Sri Lanka

APPENDIX 4

Table 1. Local Sale of Pretroleum Products 1977/1981 (Metric Tons)

(Abstracted from Economic Review 1981/Central Bank of Sri Lanka)

Year	Petrol	Kerosene	Disel	Heavy Disel	Furnace Oil	L.P. Gas
1977	111491	212886	261988	46245	135530	3108
1978	129994	244832	308792	62015	162556	2432
1979	115146	229918	349404	64188	182539	6404
1980	107691	188288	397710	63953	193800	7110
1981	109017	168248	421107	106625	244295	6645

Source - Sri Lanka Petroleum Corporation

APPENDIX 5

Table 2. Cropwise Fertiliser Issues 1978/1981 (Metric tons)

(Abstracted from Economic Review 1981/Central Bank of Sri Lanka)

Crop	1978	1979	1980	1981
1. Paddy	136.1	130.4	190.0	155.6
2. Tea	115.5	105.2	109.9	103.3
3. Rubber	20.9	23.2	22.0	16.8
4. Coconut	42.6	49.6	55.8	37.7
5. Subsidiary crops	–	–	–	14.8
6. Minor crops	–	–	–	3.2
7. Others	64.9 (q)	64.0 (1)	62.0 (q)	34.9
Total	380.0	372.4	439.7	366.3 ÷ =

1. Inclusive issues of subsidiary crops
Source – National Fertilizer Secretariat

APPENDIX 6

Table 3. Electricity Consumption (Percentage)

(Abstracted from Economic Review 1981/Central Bank of Sri Lanka)

Period	Household	Industrial	Commercial	Local Authority	Street Lightning	Total
1970 – 1977	9.3	52.5	13.0	23.8	1.4	100
1978 – 1981	12.6	47.4	14.9	23.9	1.2	100
1978	10.3	51.0	13.7	23.7	1.3	100
1979	11.8	48.7	15.5	22.8	1.2	100
1980	13.7	45.0	16.0	24.1	1.2	100
1981	14.3	44.9	14.5	25.2	1.1	100

Source – Sri Lanka Electricity Board

APPENDIX 7

Table 4. Estimated Energy Supply for 1981

Sources	Kw Hour	Percentage
Hydro-electricity	1600	15.7
Thermal power-electricity	3000	29.0
Firewood	5625	55.0
Others (Paddy husks, wind, biogas)	Not available	0.3
	10225	100.0

Source – Economic Review 1982 September, Peoples' Bank of Sri Lanka

APPENDIX 8

Table 5. Details of Livestock and Draft Animals

(Agricultural Census)

Group of Animals	Hambantota District	Krindioya Project Area	Within Tract I of Right Bank Area
Buffalo	27983	4632	985
Cows	51785	7232	2060
Poultry	Not available	Not available	252
Goat	– Do –	– Do –	14

No. of Farm Families Live in R.B. Tract 1 = 2417
Sources - Uncertified Data of the Census and Statistics Department

APPENDIX 9

Biogas Unit – Udawalawa Development Area

APPENDIX 10

Biogas Unit — Farm School, Angunu Kolapellessa

IMPROVEMENTS IN KAMPUNG SANITATION: THE BANDUNG EXPERIENCE

MINISTRY OF PUBLIC WORKS

INDONESIA

This paper describes the improvements to urban waste disposal being implemented in three kampungs in Bandung as part of the Bandung Urban Development Project (BUDP). Its relevance to the seminar lies in its attempt to solve the sanitation problems of low-income kampungs with conventional, relatively high-cost means.

THE CONTEXT

BUDP is a US$ 70 million urban development project being executed by the Indonesian Government with financial assistance from the Asian Development Bank. The project arises from a major study carried out in 1978 by an international consortium of consultants. It is based on the first-stage implementation program identified in the study and includes the following sectors:

* kampung improvement program (KIP)
* drainage
* sewerage
* solid waste management
* serviced housing plots with core houses

This paper is concerned with the upgrading of facilities under KIP.

Nearly 80% of Bandung's 1.5 million inhabitants live in kampungs. KIP is directed at three of the worst kampungs, selected by the study after evaluation on a number of social and physical indicators.

The three kampungs, housing some 110,000 people on about 240 hectares, exhibit all the classic features: very high density (up to 500 persons per hectare), low incomes, poor housing, frequent flooding, polluted water supply, inadequate sanitation, poor pedestrian and vehicular access, and lack of social facilities.

There is a wide range of disposal systems in use at present: private flush and non-flush toilets, communal toilets, drop latrines built over rivers and canals, and the direct use of rivers and canals (see Table 1). Apart from 12 ha in Nyengseret, there is no formal sewer network, although there are many informally constructed small sewers. Combined open drains carry most sullage and soil water to the nearest water course; flushing is generally inadequate and these drains are often blocked with solid waste. Flooding is a regular occurrence.

Table 1: Access to Sanitary Facilities (% of households) 1978

	Padasuka	Babakan Surabaya	Nyengseret	Total
Own facility	44	28	53	43
Shared private facility	23	25	25	25
Use communal facility	10	29	12	16
Other	22	18	10	16

Source: Bandung Urban Development and Sanitation Study, Background Paper No. 2, February 1979.

The majority of households obtain water from shallow wells or by hand pumps from heavily polluted aquifers. Solid waste is normally deposited straight into streams or drains which causes an obvious danger to public health, not only in the immediate areas but also further downstream. Similarly, the kampungs are affected by the dumping of solid waste in areas upstream. In this way, public health is threatened and the incidence of flooding increased over wide areas.

The basic KIP package consists of an extensive network of new or improved footpaths, each length incorporating local drainage, piped water supply, and minor sewers linked, as appropriate to the main, citywide network. In addition, communal ablution units (MCKs) and land for community facilities are provided.

The supporting infrastructure is provided by other sectors. A phased sewerage improvement/development program is under implementation which will eventually serve the whole city with a piped water-borne system. The drainage program aims at the upgrading of the natural river system to cope with a 1 in 20 years flood frequency, including the selective construction of new canals. The solid waste management program will cover the whole city, including KIP areas, with an integrated storage, collection, transfer and disposal system. Improvement to the city's water supply is being implemented under a parallel ADB-funded program.

KIP SEWERAGE INPUT

A basic network of minor sewers, at 230 metres per hectare, is being inserted along with the improved path network. These are connected to the main network of secondary and trunk sewers. This system is designed to allow for eventual connection to all houses; but it is recognised that, for a number of reasons, this will not be achieved in the short term.

House connection chambers to serve 5-house units are provided every 10-15 metres. Connections to the chambers from the houses, to acceptable specifications, are the responsibility of individual house-owners.

A total of 284 MCKs are being provided on land provided free by the community for those households which cannot have access to individual facilities. These incorporate a toilet, a bathing cubicle and an open washing area. There is a range of designs available to suit different locations and sites. The MCKs are connected to the area sewer network. They are "allocated" by local community leaders to a group of households which is responsible for cleansing, payments and minor maintenance works.

SOCIAL IMPACT

It is too early yet to make definitive pronouncements on the social impact of KIP. A number of post-implementation surveys have been carried out but the results are still under analysis. In any event, the nature of KIP means that improvement is a continuous process whose impact is not precisely measured at a point in time. However, it must be said that the areas have obviously benefited enormously, both in physical terms (the improvements to access, drainage, sanitation, etc.) and in terms of general confidence: the authorities' expression of support for these areas through major investments has clearly generated the self-improvement of housing by owners. A basic question, yet to be answered, concerns the impact of this improvement process on the target groups with lower incomes; and whether the scale of investment may in fact act against interests of these groups.

COSTS

The total cost of the Bandung KIP works, excluding sewerage and solid waste, will amount to US$ 16,690 per hectare. Direct comparisons justified by the increase in property values which are expected to result from the program of improvements.

A fundamental policy decision has been taken to tackle the urban sanitation problems through a piped sewerage system. It is certainly expensive; but, technically speaking, it is the most satisfactory and, arguably, the only satisfactory long-term solution to the sanitation problem in large urban centres. However, the very high costs mitigate against replicability, given financial constraints and the need for subsidy. A short- and medium-term strategy may therefore have to be evolved, based on the phased provision of services so that the capital costs are spread out over a longer period. Intermediate, lower cost techniques will be used (eg. open drains instead of deep sewers), which are consistent with subsequent physical integration into a comprehensive piped system. In any event, it is critical that, in the pursuit of public health goals through improved sanitation, the concern with cost factors does not result in the exclusion of low-income, informal housing areas from such programs on grounds of inferior economic viability.

RECYCLING METHODS : POTENTIAL OF LAND APPLICATION OF SEWAGE

B.N. Lohani

Associate Professor and Chairman
Environmental Engineering Division
Asian Institute of Technology
Bangkok, Thailand

INTRODUCTION

There are several options for recycling of human wastes. Land treatment is one of such options having an immense potential for developing countries. Figure 1 shows a schematic of various processes of recycling human wastes such as septic tanks, ponds (aquaculture), composting, biogas, etc. (1). It could be easily seen that land treatment forms an integral part of the overall recycling processes.

Land treatment of sewage (also known as sewage farming) is not a new technique but unfortunately it has not received the acceptance or recognition it deserves. The most outstanding example is to be found in China, where sewage (mainly nightsoil) has been used for this purpose from time immemorial and is still being used for this purpose. Historically documented data on land treatment of sewage shows its use as early as in 1559 in Bunzlau, Germany (2).

Many people equate land treatment with landfills, dumps, odorous overloaded sites and the like. Land treatment is not dumping of simple disposal but on the other hand it is an approach that rises and conserves the resources in the wastes (water, nutrients and organic matter) to enhance the soil and crop production. Unfortunately, there is still a lack in the appreciation of such a conception and therefore little work has been done on the development of effective methods of its management strategies and this is particularly so in the context of developing countries. In developing countries, land application of sewage could be a potential recycling and waste disposal option and hence should not be overlooked.

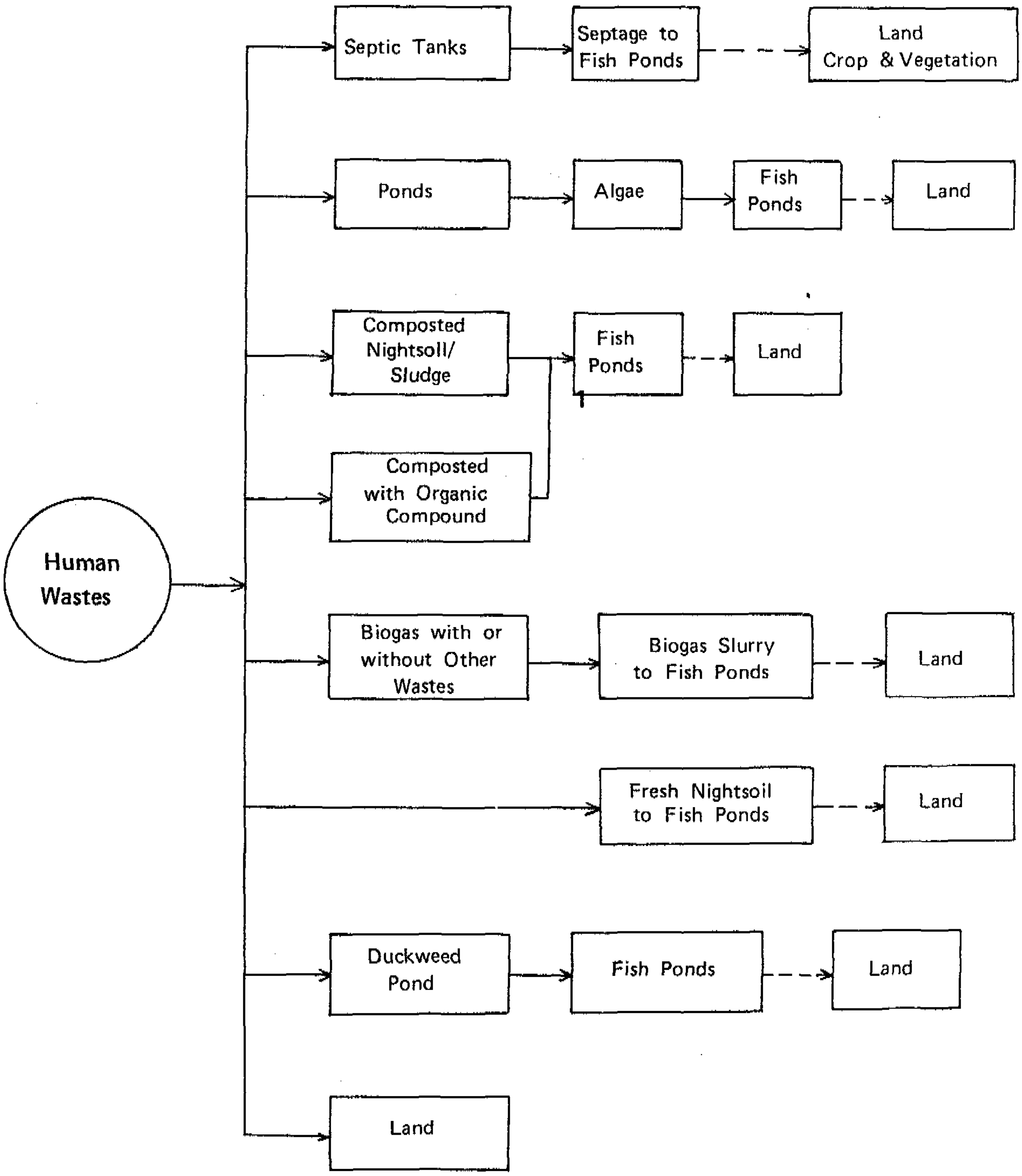


Figure 1. A Schematic Diagram Showing Various Option of Recycling

DESIGN CONSIDERATIONS

Land treatment of sewage is normally carried out in three different ways and these are slow rate (or irrigation), rapid infiltration and overland flow. The other processes which are less adaptable to large-scale use are wetland and subsurface.

Slow-Rate Process

In this process, the sewage is applied to crops or vegetation (including forest land) by sprinkling or surface techniques consisting of ridge-and-furrow and border strip flooding. The slow-rate process has the advantage of getting economic return from sewage by producing marketable crops, conserving water in irrigation, and preserving and enlarging green-belts and open spaces. It has the highest potential for removal of most of the pollutants, involving largest area and widest disposal of pollutants, and thereby has the minimum impact on soil and vegetation.

Overland Flow

Overland flow is a process in which the sewage is applied over the upper reaches of the sloped terraces and allowed to flow across the vegetates surfaces to run off collection ditches. This grass filtration system has following advantages :

- It requires less extensive sewage piping systems and less land area than the slow-rate process systems.

- In this case, land with less infiltration capabilities could be used.

- Since treated sewage remains on the soil surfaces, it facilitates monitoring of treatment effectiveness and the treated sewage is readily available for recycling and reuse.

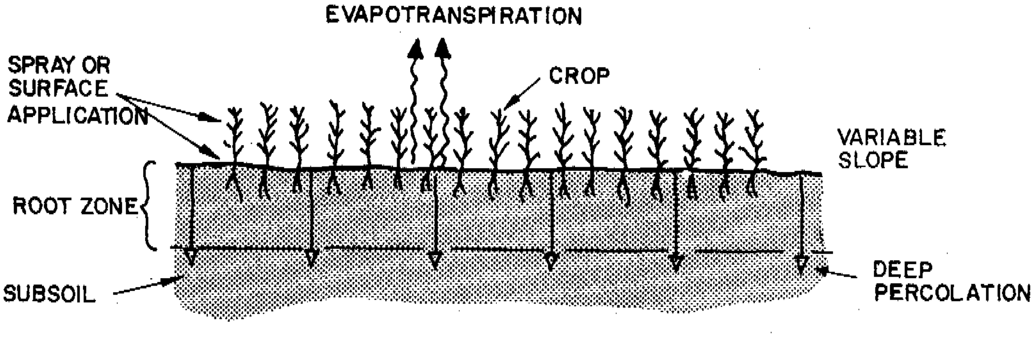
Rapid Infiltration

Rapid infiltration is a system in which most of the applied sewage percolates through the soil, and the treated sewage eventually reaches the groundwater. In this case, therefore, rapidly permeable soils, such as sands and loamy sands are used. Vegetation may or may not be used. The advantages of this system are :

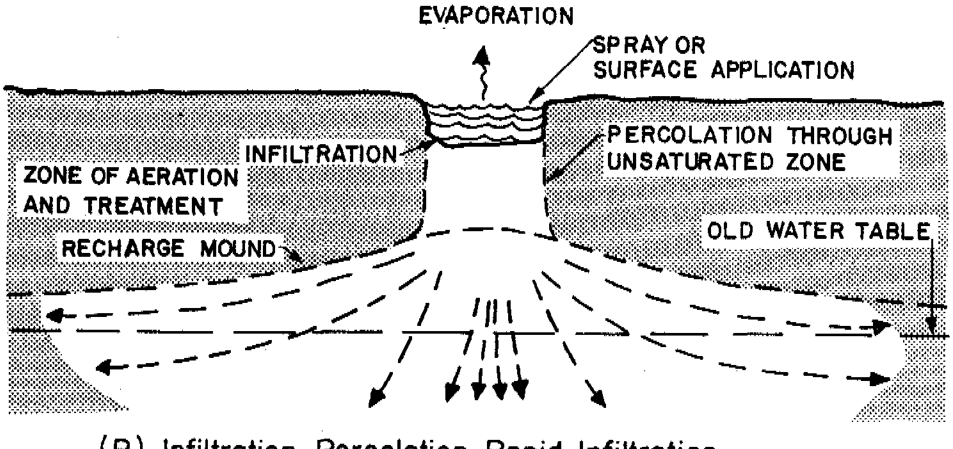
- Groundwater recharge and possibility of recovery of treated sewage by pumped withdrawal.

- Minimum land area required.

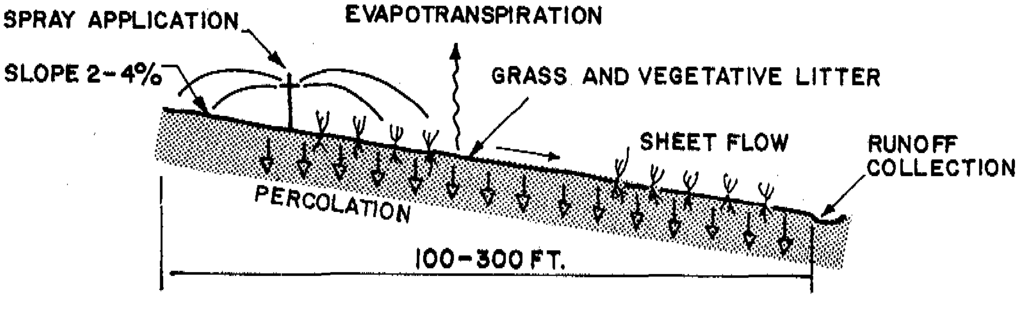
Figure 2 shows the basic mechanisms of the above three principal processes (5). Table 1 and Table 2 respectively present a comparison of the design features and site characteristics of the same (6).



(A) Slow-rate Process or Irrigation



(B) Infiltration Percolation Rapid Infiltration



(C) Overland Flow

Fig. 2 – Methods of Land Treatment of Sewage (5)

Table 1. Comparison of Design Features for Alternative Land Treatment Processes (6)

Feature	Irrigation	Rapid Infiltration	Overland Flow	Wetland Application	Subsurface Application
Application techniques	Sprinkler or surface[a]	Usually surface	Sprinkler or surface	Sprinkler or surface	Subsurface piping
Annual application rate, m	0.6–6.0	6–120	3–20	1–30	2–25
Field area required, ha[b]	22–226	1–22	10–44	4–113	5–56
Typical weekly application rate, cm	2.5–10	10–210	6–15[c] 15–40[d]	2.5–60	5–50
Minimum preapplication treatment provided	Primary sedimentation[e]	Primary sedimentation	Screening and grit removal	Primary sedimentation	Primary sedimentation
Disposition of applied wastewater	Evapotranspiration and percolation	Mainly percolation	Surface runoff and evapotranspiration with some percolation	Evapotranspiration, percolation, and runoff	Percolation with some evapotranspiration
Need for vegetation	Required	Optional	Required	Required	Optional

[a] Includes ridge and furrow and border strip.
[b] Field area in hectares not including buffer area, roads, or ditches for 0.044 m^3/s (1 Mgal/d) flow.
[c] Range for application of screened wastewater.
[d] Range for application of lagoon and secondary effluent.
[e] Depends on the use of the effluent and the type of crop.

Note: *cm x 0.3937 = in*
m x 3.2808 = ft
ha x 2.4711 = acre

Table 2. Comparison of Site Characteristics for Land Treatment Processes

Characteristics	Irrigation	Rapid Infiltration	Overland Flow	Wetland application
Climatic restrictions	Storage often needed for cold weather and precipitation	None (possibly modify operation in cold weather)	Storage often needed for cold weather	Storage may be needed for cold weather
Depth to groundwater, m	0.6–0.9 (minimum)	3.0 (lesser depths acceptable where underdrainage provided)	Not critical	Not critical
Slope	Less than 20%on cultivated land; less than 40% on noncultivated land	Not critical; excessive slopes require much earthwork	Finish slopes 2–8%	Usually less than 5%
Soil permeability	Moderately slow to moderately rapid	Rapid (sands, loamy sands)	Slow (clays, sites, and soils with impermeable barriers)	Slow to moderate

OTHER ASPECTS OF LAND TREATMENT

Vegetation Considerations

Vegetation has an important role in land treatment and particularly in the slow-rate and overland flow processes. In the case of slow-rate process, it serves as a nutrient extractor and in the case of overland flow, it also provides a matrix for the growth of organisms and reduces the erosion.

Selection of the type of vegetation is mainly based on the rate of water, nitrogen and phosphorus uptake, and its marketable value. Typical nutrient uptake rates for different crops are set out in Table 3 (3).

The quality of sewage to be applied over the vegetation, is often judged by examining the sodium adsorption ratio (SAR), total dissolved solids, bicarbonates, boron and other toxic substances. In certain cases therefore, the sewage needs to be treated (primarily or secondarily) or diluted such that these minimum standards are satisfied.

Table 3. Vegetation Considerations in Land Treatment of Sewage (3)

Crops	Uptake, kg/ha. yr**					
	Nitrogen	Phosphorus	Calcium	Ref.	Magnesium	Ref.
Barley	70.6	17				
	168	27				
Corn	174 - 193	19 - 28				
	207 - 269	30 - 49				
	140*	25*	3*	203	11*	203
Cotton	74 - 112	13				
Potatoes	230	22				
Soybeans[a]	105 - 143	12 - 20				
	288	24				
	134	13	6	203	7	203
Wheat	56 - 91	17				
	140	25*				
	81*	15*	2*	203	5	203
Grain Sorghum	280	45				
Oats	168	27				
Alfalfa[a]	224 - 538	22 - 34				
	504	39				
Bromegrass	130 - 224	39 - 56				
	186	33				
Coastal Bermuda Grass	392 - 672	34 - 45				
Kentucky Blue Grass	202 - 269	45				
	224	27				
Quackgrass	235 - 280	30 - 46				
Reed Canary Grass	336 - 448	40 - 45				
	457	63	49	203	45	203
Ryegrass	202 - 280	62 - 84				
Sweet Clover[a]	177	18				
Tall Fescue	151 - 325	29				
	151	33				
Orchardgrass	336	49				
Hardwood Forest	94	9	25	203	6	203

* Grain

[a] Also takes N from atmosphere.

** Converted from original in lb/ac. yr. (1 lb/ac. yr = 1.12 kg/ha yr)

Soil Considerations

Soil properties are an important factor in identifying and selecting sites for an economical land treatment system. The important physical and hydraulic properties of soil, deciding the choice of the land treatment system, are given in Table 4 (5). An incorrect choice of the site, as well as treatment method, could lead to the phenomenon of soil clogging, which could cause serious pollution problems in the surrounding areas.

Table 4. Soil Considerations in Land Treatment of Sewage (5)

Depth of soil profile, ft	
1 - 2	Suitable for OF (a)
2 - 5	Suitable for SR and OF
5 - 10	Suitable for all processes
Texture and structure	
Fine texture, poor structure	Suitable for OF
Fine texture, well-structured	Suitable for SR and possibly OF
Coarse texture, well-structured	Suitable for SR and RI
Infiltration rate, in./h	
0.2 - 6	Suitable for SR
0.2	Suitable for RI
0.2	Suitable for OF
Subsurface permeability	
Exceeds or equals infiltraiton rate	Infiltration rate limiting
Less than infiltration rate	May limit application rate

a. Suitable soil depth must be available for shaping of overland flow slopes. Slow rate process using a grass crop may also be suitable.

Toxicity Considerations

The sources of potentially toxic elements to sewages are residential, urban and industrial areas. Table 5 provides a useful guide for the application of contaminated sewage based on five important heavy metals (7).

Table 5. Maximum Amounts of Heavy Metals that can be Safely Applied to Land (7)

Metal	Soil Cation Exchange Capacity (meq*/100 g soil)		
	0.5	5 - 15	more than 15
	Max.	metal addition,	lb/acre
Zinc	200	500	1000
Copper	125	250	500
Nickel	125	250	500
Cadmium	5	10	20
Lead	500	1000	2000

* Milli-equivalents

Public Health Considerations

The risks and countermeasures in the land treatment of sewage have been well recorded. As regarded the risks, the incidence of shigellosis, salmonellosis, typhoid fever and infectious hepatitis have been observed. Several viral hazards have also been associated. In addition to this, heavy metals, biocides and other carcinogens present in sewage have been found to be hazardous to public health.

An effective solution to reduce these risks is to carry out pretreatment of sewage prior to its land application, provide deep soil layers or deep drip channels, or use plastic sheets to cover the surfaces. Further, a careful selection of site reduces the odor nuisance and threats due to microorganism transport as well as the contamination of nearby groundwater resources.

MANAGEMENT STRATEGY FOR LAND TREATMENT

Land treatment should not be looked at as a mere treatment device. It is in fact much more than the other treatment processes, since in this case an organized exploitation of nutrients, soil and water is made to produce utilizable bio-mass i.e. vegetation. This is in general a common feature of most of the recycling methods described earlier. Naturally a consideration in totality is necessary for an effective utilization of such processes.

From strictly technological view point, we can design land treatment systems of different types, but the overriding question is what quality of sewage should be applied to the land. The various thresholds imposed by the vegetation, soil, toxicity and public health considerations discussed earlier do not permit the land treatment system to be implemented in isolation, but supplemented by adequate pretreatment system.

The range of 'pretreatment' is quite large, and studies have been made with application of raw sewage treated at a secondary level. In the latter, land treatment is merely looked at as a tertiary treatment device since most of the nutrients, necessary for the production of bio-mass, are removed at the pretreatment stage. Application of raw sewage on land, though successful in some cases, could lead to problems of clogging and ponding at site, bad odours, sickening of soil and vegetation, reduction in the economic returns of the crops and high probability of epidemics and public hazard. On the other hand, use of land as a tertiary treatment device is not so effective as the recycling potentials of land, i.e., production of biomass and soil enrichment are not exploited due to nutrient deficiency. Primary treatment consisting of screening, degritting and rapid sedimentation (short detention times) appears to be the most practicable pretreatment in such instances. If the sewage is contaminated due to industrial wastes, precipitation of toxic elements should be carried out at the sedimentation basins.

DISCUSSION AND RECOMMENDATIONS

Land treatment of sewage as a recycling option is truly an interdisciplinary area of research involving biologists, chemists, agricultural sciences, hydrologists, public health experts, and civil engineers etc. This heterogenicety has led to several independent studies on different aspects of land treatment, but organized research on the 'total aspects' and 'total evaluation' are not many in the literature. Despite the voluminous literature on land treatment, therefore, several information gaps (sometimes overlaps), misinterpretations, poor understanding of the process have resulted which realize into debatable prescriptions, making the decision analysis quite difficult. A more organized and scientific collection of data is therefore necessary through careful design of experiments and sustained monitoring.

Most of the data reported so far is from the Western countries and its applicability is certainly limited when land treatment systems are to be designed in this region. It is therefore urged that the educational and research institutions in this region take up projects for an indepth evaluation of land treatment systems.

Another important aspect could be that of data dissemination or diffusion. One positive step towards this problem has been already taken by ENSIC, at AIT, by preparing a state of art review on 'Land Treatment of

Municipal Wastewater (3)'. A similar document on 'Land Application on Sewage Sludge' has also been published by ENSIC at AIT (4). A lot more however, needs to be done, especially on the preparation of easy-to-use design charts and tables, published in the regional languages.

ACKNOWLEDGEMENTS

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VIABLE LOW COST SANITATION OPTIONS

Dr Krisno Nimpuno

Institute for Housing Studies-BIE

Rotterdam - Holland

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VIABLE LOW COST SANITATION OPTIONS

Dr. Krisno Nimpuno

Institute for Housing Stuides-BIE
Rotterdam - Holland

Conventional sewerage is a very costly and complicated sanitation solution. Even in many European and American cities, where for a long time sewage pipes have connected all neighbourhoods to a central sewage plant, there are often great difficulties in keeping the system functioning without harm to the environment; the use of modern detergents by the public can given great problems; the mixing of industrial waste water with sewage poisons the sludge of the sewage plants, so that it becomes too dangerous to be used as fertilizer; sometimes the distance to the sewage plant becomes so great that the pipes start to function as unintended biogas plants, and finally the sludge is often so pathogenic and volatile that it has to be kept to drain and mature for periods well up to one year. Likewise is the effluent often so rich in organic and pathogenic material that discharge into surface water bodies becomes inadvisable. The notorious Lake Eerie turned black, lost all forms of life and it became a threat to men, because of such discharge. In this whole process the balance of nature is seriously disrupted: on the one hand valuable minerals and organic materials are constantly extracted from the land, which becomes depleted. On the other hand large quantities of unstable organic material are dumped into lakes and rivers so that the watercycle is disrupted, and is robbed of all its oxygen.

To restore the natural balance of the land and water cycles, very costly measures are necessary. For cities, which do not have sewerage systems yet, these disadvantages have to be considered in addition to the high costs of building the sewerage network and treatment plants. The very high consumption of water that this system requires, has to be added to that and it may be up to fifty percent of the total water consumption of the city.

The search for alternatives has partly been motivated by these considerations, especially since an evolutionary approach often is an economic necessity. Very few third world cities would have the resources to build a complete sewerage system for the entire population in one construction project.

The few attempts to this end in Developing Countries have not been encouraging. In Ghana such a system was installed, but even in the areas where the sewage pipes had been built many of the house owners have refused to be connected. If this is difficult for new housing projects, even worse is to build such a network of underground pipes through existing, often unplanned, residential areas, an engineer's nightmare, which often requires the destruction of many of the dwellings it intends to serve.

Low Cost Sanitation has therefore become a subject that requires a variety of solutions, which have to improve the housing conditions without destroying them. It is often necessary to find individual solutions for some houses first, because in many cases resources are lacking to provide sanitation for an entire neighbourhood. It also may mean to find a less than perfect solution first, which in later stages can be improved. Waterless solutions or systems which use little water are an advantage, because water is becoming such a scarce resource in all urban areas.

From the point of view of suitability in existing low income housing areas, some special criteria are necessary in addition to those requirements necessary for low cost sanitation in general. As argued elsewhere,* these criteria should include health, environmental and economic aspects.

SPECIAL CONSIDERATIONS FOR DEVELOPING COUNTRIES

In Developing Countries some special requirements are needed over and above the general criteria of the WHO. The general population has limited technical knowledge and it is not realistic to expect a complicated toilet system to function without much maintenance and service. It should also be clear that the cost factors decide the applicability of the systems. It is, therefore, useful to add a few points to the general criteria when applied in Developing Countries.

Operation

The daily operation should require minimal educational and technical instructions which can be taught to all ages:

- A simple, safe toilet routine should suffice for the daily operation of the system.

Costs

The system should economically be within reach of the people:

- The construction costs should not exceed 10% of the total house investment.

Construction

It is equally important that the maintenance requirements are low and that the construction will require mainly local materials and can be executed by semi-skilled labour:

- The facilities should mainly be made of local materials and require minimal maintenance.

Water

The scarcity of water and the high costs of foul water treatment are strong arguments to avoid the use of water as a transport medium:

- The use of water to dilute and transport the excreta should, if possible, be avoided

* See Nimpuno, SEWAGE DISPOSAL FOR DEVELOPING COUNTRIES - A REVIEW OF OPTIONS: Gothenburg, 1976

Urban Adaptability

Sanitation systems are not only needed in future residential areas, but as the great majority of the urban dwellers in the Developing Countries do not have direct access to satisfactory excreta disposal systems, it is at least as important to require that disposal systems are identified for existing housing areas.

- Application should also be possible in existing high density areas.

CRITERIA FOR EXCRETA DISPOSAL SYSTEMS IN DEVELOPING COUNTRIES

The five special criteria for Developing Countries should replace the WHO criteria which just state that a simple and inexpensive construction is needed.

For existing low income settlements without adequate sanitation facilities it is of great importance that small scale, even individual household installations can be chosen, that in time the individual provisions can be linked up to form a network and that the systems gradually can be upgraded. These requirements can be added to the criteria mentioned earlier.

When the list is then put together, the criteria for developing countries are as follows:

1 The surface soil should not be contaminated.

2 There should be no contamination of ground water that may enter springs or wells.

3 There should be no contamination of surface water.

4 Excreta should not be accessible to flies or animals.

5 There should be no handling of fresh excreta, or when this is indispensable, it should be kept to a strict minimum.

6 There should be freedom from odours or unsightly conditions.

7 The daily operation of the system should only require a simple and safe toilet routine.

8 The construction costs should not exceed 10% of the total investment in housing.

9 The facilities should mainly be made of local materials and require minimal maintenance.

10 The use of water to dilute and transport excreta should, if possible, be avoided.

11 Application in existing high density areas should be possible.

For existing neighbourhoods should be added:

12 The system should be suitable for a small scale application, covering a few households only.

13 It should allow gradual integration into a neighbourhood network.

14 The system is to allow gradual development to reach a high environmental and health standard.

During the last decade many alternatives to the conventional sewerage system have been proposed, tested and developed. Several solutions looked initially very exciting, but did not find any wider application. Others have showed that there are low cost solutions which are practical and acceptable for a variety of conditions.

This choice of options should be offering a solution to the most common conditions and it is reviewed in this paper. It is useful to look at a few of the solutions proposed during the past decade that did not find any wider application.

Modern bucket latrine failures

Several of these proposals originated from the industrialized countries and proved to be far from low cost when applied in developing countries. Most of these are modern variations of the bucket latrine: systems to conserve waste for some time without too many adverse environmental effects and allow later treatment elsewhere. The chemical toilet, the freeze toilet and the packaging toilet belong to this group. With chemicals, low temperature or sealing, the waste does not break down for some time, and can be kept, transported and handled without much inconvenience. The solutions are quite expensive and only postpone the problem, because the pathogens in the waste stay alive and the organic material is not being mineralised. The material has to be transported to a treatment plant and rendered harmless there. This is often too costly to achieve and since such toilets are expensive in operation as well, these systems are not appropriate solutions.

On site treatment failures

Other systems included treatment but did not work well in developing countries or were too expensive in use. The mouldering toilets or composting toilets and the incinerating toilets belong to this group. The incinerating toilets are expensive to purchase and to use. Operating on oil, gas or electric power, the incinerators destroy all pathogens and mineralise all organic matter, but pollute the air and are very costly.

Mouldering toilets or composting toilets which slowly break down the waste at ambient temperature are very difficult to operate in humid areas, are very bulky and failed in several African pilot programmes. These toilets are based on a very slow natural aerobic composting process that is quite sensitive to changes in temperature and humidity. Several attempts to improve the performance of mouldering toilets resulted in complicated and expensive installations which still would require more maintenance and care than seems justified in low income settlements.

For hot dry countries, however, such composting toilets can function well, as has been demonstrated in the traditional "long drop" toilets of Yemen and Morocco. Here urine runs off separately and evaporates, while the solid material is mouldering in a closed vault for many years.

Viable options

The seventies have brought much interest in the subject of Low Cost Sanitation and many research and implementation programmes have served to identify viable low cost options. The differences in culture, climate and economic development of different countries require a variety of solutions and now a few viable low cost systems have proved to be effective and appropriate.

Among the waterborne options one can mention the aqua privy, the improved cesspool, the pour flush latrine and possibly the biogas system. All these systems use very little water: 2-5 litres of water each time the toilet is used, while these systems all give on site treatment.

The septic tank - a three compartment system - requires more flushing water than that, while the oxidation pond offers a low cost treatment system for small neighbourhoods and institutions, and is a form of sewerage system. These five options are so well known that no further elaboration is needed.

Waterless systems which have been applied successfully are improved pit latrines and the Vietnamese toilet: a double vault anaerobic composting toilet.

An option that has not been applied on any large scale is high temperature aerobic composting yielding animal or fish feed.

The systems mentioned here are all applicable as low cost, small scale solutions, but from the users point of view these are more demanding than conventional sewerage systems, which offer the flush and forget comfort, and where the treatment takes place far away and is done by professionals. With on site treatment systems, the user has to involve himself in the maintenance and management tasks in sanitation; sludge has to be pumped out, vaults and tanks must be emptied and other maintenance operations are required. This requires motivation, training and supervision and is therefore more demanding than the flush and forget approach.

Some excellent systems fail if tried on a large scale, because of such difficulties. Low cost sanitation systems, therefore, will be successful only if the users are prepared to be trained and are willing to take an active interest in the proper maintenance of the system.

A very disciplined and highly organized country as Vietnam can apply a system which requires careful use and maintenance of the anaerobic composting toilet. At a lesser organized level, either a simpler toilet system has to be chosen or professional management has to take over the maintenance tasks.

The Low Cost Sanitation options mentioned here will be discussed in detail on various papers in the workshops, and all required technical information will be available from these speakers. The double pour flush will be discussed by Mr A K Roy of the World Bank project and by Professor Bhatt. The cesspool and upflow filter will be discussed by Dr. Chongrak and myself. The Improved Pit Latrine will be presented by several African speakers as well as by Mr R. Carroll of BRE.

Dr. Le will give details of the Vietnamese anaerobic composting toilet - Dr Ksemsan and Mrs Mbere will share some of their experience of the aqua privy with us. From Brazil and Hawaii we will hear some details on aeration ponds.

Mr Rajput and several other Indian speakers will take up the Biogas system, which above all is of relevance in conjunction with animal waste.

The conventional three compartment septic tank is certainly known to all and will not need any further introduction.

DESCRIPTION OF SYSTEMS

The Aqua Privy

The Aqua Privy has gained new interest with the recent improvements. The Aqua Privy is a single water borne sanitation system which can be used for family size units as well as for large public facilities. It consists of a single waterfilled tank, where excreta decomposes under anaerobic conditions into gasses, which are vented out of the tank and sludge which settles in the tank and which has to be removed periodically. The Aqua Privy can be built either with or without flushing arrangements.

Waste water comes into the tank through the drop pipe causing an equal volume of effluent to leave the tank through an overflow into a soakage or into a sewer line. The water in the tank is covered with a layer of scum which hinders oxygen from the air to dissolve into the water but allows gas from the tank to bubble through. This biological membrane plays an important role in the effective decomposition of the excreta in the tank, and should not be ruptured by incoming or outflowing material. The drop pipe and the outlet should therefore be well submerged under the membrane.

The effluent is not as well purified as the effluent from a septic tank and it still contains lighter, suspended solids and some pathogens. It can however be infiltrated into the ground or even be used for subsurface irrigation.

In a recent R & D project in Botswana, several improvements of the Aqua Privy were tested to increase its convenience for the users. Instead of a squatting plate a pedestal of ceramic material was used, with a circular pan, causing a spiraling flow of the flush water, thus increasing its flushing effect. An inlet for the disposal of laundry water, dish water and shower water was introduced as well.

The Aqua Privy has proved to be an effective low cost sanitation system and in a number of countries it functions well in housing estates as well as in public buildings. The size of the tank can be adapted to the number of people using the systems. For the refugee camps in Thailand a new type of aqua privy was developed locally. A prefabricated plastic tank of ca. 4 cubic metres with 4 squatting plates on top has been installed as a neighbourhood unit in the latest camps. Overloading as well as overflowing soakage pits have been plaguing the first units.

It is possible to interconnect several Aqua Privies with a small bore sewer for additional treatment. Since the effluent already has lost most of its organic load a very simple treatment system, such as an oxidation pond suffices to assure a satisfactory result.

The sludge has to be removed periodically from the tank and has to be stored for some time before it is suitable as fertilizer. The Aqua Privy is suitable for refugee camps and offers a good standard of sanitation. The system is also an economical solution for permanent settlements, the maintenance is simple and the installation and operational costs are low.

The Cesspool

The cesspool design as it was launched as the low cost solution for urban areas in Thailand in the early seventies, consists of two interconnected tanks. The first tank is for settling solids, while the partly purified effluent flows into a second tank, a soakage.

The first tank has a ventpipe, since most of the biogas is produced here, and an inlet for the waste is a squatting plate with a waterseal. Both tanks are made of concrete rings; the first one has a tight bottom, the second one has no floor. This design requires regular removal of the sludge, but the system still percolates a considerable quantity of unstabilized organic matter and pathogens into the ground water. It is however very easily constructed and requires little maintenance.

The system works reasonably well in areas with a high ground water level, which keeps the second tank filled with fluids. As a result a secondary treatment takes place before the effluent soaks away. If there is a low ground water level, however, the overflowing fluids from the first tank soak away into the ground before any secondary treatment takes place. The pollution effect will then be considerable.

Very few houses in Bangkok lack a toilet facility. The sanitation campaigns of the last two decades have resulted in a very high acceptance of individual facilities: well over 90% of the slum households have one kind of toilet system or another.

Two important factors have played a role in the rapid acceptance of toilets in the Bangkok slums. The availability of an effective waterseal prevents the occurrence of unpleasant odours and the vicinity of a toilet is therefore not provoking negative reactions.

The second factor contributing to the general acceptance relates to the simple construction methods developed for the system. The whole construction is readily available in prefabricated parts from a multitude of suppliers at a very low price. The system is so cheap in its implementation that many households build a second toilet instead of emptying the original one. A complete unit is available from any building material supplier for as little as US$40.

In summary, easy and economic supply of the installations and the elimination of unpleasant sights and odours are the key factors behind the high implementation ratio of toilet systems in Thailand.

A second look at the system however discloses a different picture. The actual installations that one finds in the slums are somewhat different from the original cesspool design.

Instead of two tanks, there is only one - it consists of a set of rings without a bottom plate and has a squatting plate with a water seal, but without a ventpipe on top. The tank sometimes hardly enters into the soil, but rises through the surrounding water up to the floor of the house. The user still enjoys the same advantages as in the case of the correct double pit cesspool; cheap and easy installation and an effective waterseal keeping out all unpleasant odours.

The treatment process however has changed radically. Fluids leach directly without treatment into the surrounding surface water. There is no secondary treatment of effluents and the percolation of fresh faecal matter into the water body is quite possible. There are many operational problems with this type of toilet, but from the users point of view it is satisfactory: it is cheap to construct and pleasant to use. The operational difficulties are not immediately apparent. The leaching effect constitutes a long term health hazard and causes severe pollution. The direct soakage reduces the mineralisation process of the settling solids. The lack of a ventpipe results in a build-up of biogas in the tank and causes blockages.

The adverse environmental conditions in the slums are partly related to this malpractice of building simplified cesspools. In order to improve the performance of the cesspools much development work has been done in recent years. The addition of an upflow filter as a secondary stage after the cesspool is a radical improvement.

The upflow filter is an effluent purification tank connected with the overflow of the cesspool. It can be built as an improvement to the regular cesspool as well as for the simplified one.

The effluent is released at the bottom of the upflow filter and flows through a gravel bed to the top of the filter tank and is then discharged through an outlet pipe. The purification is the result of microbiological action of bacteria attached to the surface of the gravel.

The final effluent may be safe enough to be discharged in storm water drains. The first field tests of the upflow filter have been quite successful, although clogging problems have occurred. Intermittent loading, and flushing with stormwater should however be adequate to cope with this problem. The upflow filter can be constructed with the same prefabricated concrete rings as the cesspool system and is therefore a cheap improvement of the existing cesspools.

<u>The Vietnamese Toilet</u>

The Vietnamese Toilet is a family unit consisting of two above ground tanks for dry anaerobic composting. Each toilet yields about 1 cubic metre of biofertilizer per annum. The Vietnamese Toilet is a composting toilet, but differently from other systems, the composting process takes place without aeration or turning over of the material. Composting systems are usually very sensitive to temperature, humidity, acidity and C/N ratio.

The Vietnamese avoided most of these problems by separating urine from faeces and by constructing the system for anaerobic composting. The separate treatment of urine greatly reduces the acidity, humidity and lowers the nitrogen content of the waste pile. To achieve a suitable C/N ratio it is sufficient to throw some ashes on the fresh excreta, which also eliminates odours and prevents the presence of flies. Urine is led away to a separate container with either water or soil and ashes. The urine is, after a few days, used as garden fertilizer.

The toilet is very simple to construct and to operate, and the Vietnamese claim to have applied the system for practically the entire rural population. The system is surprisingly free from odours, insects and other disagreeable by-effects. It is the only toilet system that functions well in swampy and flood prone areas. For refugee settlements it should be possible to construct larger units. The Vietnamese system has been tested in Mozambique and Canada and it should be a very suitable solution for many other countries. It has so far not been used in public facilities, but only as a family size unit. In Vietnam the toilet is generally applied in peri-urban and rural areas.

It seems that the system lends itself for further development so that even public buildings and urban housing can be served by this excellent sanitation system.

The Improved Pit Latrine

The basic concept of the pit latrine is very simple. The human waste is deposited in a deep pit which is gradually filled and then sealed and left undisturbed for a long time to ensure the mineralisation of the organic matter.

The pit latrine is the most widespread and simplest of the rural sanitation systems. In favourable circumstances pits will have a long lifetime and can be effective at a very low cost. But pit latrines have developed a bad name because of the problems caused by inadequate construction. A poorly constructed pit can collapse, be flooded, be smelly and plagued with insect infestations.

The infiltration of fluids from the pit into the ground water may pollute it over a wide area and may contaminate nearby wells. It is essential that a pit latrine is well drained; if fluids accumulate in the pit anaerobic conditions develop, producing very disturbing biogas. Pit latrines should therefore be built in stable permeable soil with a low water table. In rocky or very clayish soils the pit will function as an open cess pit, which obviously should be avoided.

A reliable and functional construction is necessary to avoid unpleasant events such as collapsing or flooding pits. Surface water should be prevented from entering the pit and undermining its stability. The construction should be so stable that collapse will not occur.

It is therefore in most soils necessary to have a strong lining of the upper part of the pit. Insect proofing of the latrine is another measure which should be considered.

Among the recent improvements of the pit latrine, we can mention projects in Botswana, Zimbabwe and South Africa which used a ventilated pit, with a 15 cm. diameter ventpipe. The pipe is topped with mosquito netting (wire mesh) and allows daylight to enter into the pit to attract flies. It was found that flies get trapped and die at the top part of the ventpipe. The toilet room itself was often placed on undisturbed ground next to the pit with a diagonal asbestos or PVC chute into the pit. This offset positioning of the pit reduces the risk of collapse.

Another interesting detail in pit latrine design was introduced in the pit slabs in the Mozambican sanitation programme. The slabs are round and concave. Made of reinforced concrete, these have proved to be strong enough for transport handling and for the maximum loads required.

Another variation is the VIP (Wright, Ghana) which combines the advantage of the vertical drop with the stability of a partly offset pit. The use of a waterseal, in the pour flush latrine, also allows offset positioning of the pit while it has the additional advantage of preventing odours from entering the toilet room. In the Khao I Dang refugee camp in Thailand, long trenches of 3-4 metres depth were used under long rows of toilet cubicles, crude timber ventpipes at the back of the cubicles reduced the odours, while lime was thrown into the pit after each use. The capacity of the latrines proved to be great, but flooding and collapsing of pits plagued the system.

These quite large pits of 3-5 cubic metres or more can serve for periods exceeding ten years and are during that time almost maintenance free. After the pits have been filled, the contents will have to be left undisturbed for about a year before they are well-mineralised and safe to handle. Emptying a pit after a shorter period of time is both very unpleasant and risky.

A double pit design has been developed by the Building Research Establishment of Watford, UK (Carroll) using shallow (1.5 cubic metre pits) as a family unit with a three year emptying cycle. The arrangement should be practical in areas where the ground water table can reach up to 1.30 metres under the soil surface. This Permanent Improved Pit latrine (PIP) being tested in Botswana can be planned as a permanent installation. The size of the pit and the dimensions of the slab are critical factors in the construction costs of pit latrines. The limited size of the PIP pit gives also the advantage of a much cheaper installation. The requirement of a one year retention period is easily fulfilled and emptying is therefore safe.

The PIP is therefore a promising design which has considerable advantages over the conventional large pits.

<u>The Double Pour Flush</u>

The Double (Vault) Pour Flush system has been developed in India and is now applied there as well as in Nepal and Bangladesh on a wide scale by the World Bank projects.

It combines features of the Vietnamese and the cesspool systems, is easy to operate and cheap and simple to build. It is however less suitable for areas with a very high ground water level because it leaches. The Double Pour Flush consists of a squatting plate with a water seal alternatingly connected to two tanks. When a tank fills up gradually the fluids seep out through the perforated bottom leaving the solid material in the vault. When the tank is full, the connector is switched to the second tank while the dry material in the first one is left undisturbed to mineralise. The retention time is as long as one year, which guarantees an adequate pathogen destruction. The stabilised compost is removed and used as fertilizer when the second tank has filled up. The emptied first tank is now ready for use again. As with the cesspool, this toilet is simple and pleasant to use. Two litres of water are enough to flush the system and the squatting plates are easy to clean. Double vault systems have the advantage that the faecal matter is retained for a long time to ensure mineralisation and pathogen destruction. Urine and flushing water are allowed to seep away, while only solid material is accumulated which constitutes merely 20% of the total volume of excreta received. The composting of the dry material is similar to that of the Vietnamese toilet, which is known for its effectiveness.

The effluent leaching away certainly still contains elements of faecal matter and thus pathogens. On well drained grounds where the vaults are above ground water level this is acceptable. It concerns small quantities which do not exceed the absorption capacity of soil. In high ground water areas, however, the tanks fill up with water and become leaching pools, similar to the cesspool. It is not a suitable system for such areas. The double vault pour flush allows cleansing water to enter into the tank. It also has the advantage that it requires no handling of unstabilised material. The compost is, by the time it is removed, inoffensive and safe; emptying and transport is therefore not experienced as repulsive.

Aerobic Composting

Different from the options mentioned above, Aerobic Composting of Human Waste has not found any wide scale application so far. It offers however, exciting possibilities for recycling. The organic matter in human waste is still rich in protein and is suitable as animal feed for fish and pigs. In South East Asia this has been utilised for centuries: in Vietnam and Indonesia fish ponds are fed with fresh human waste, while China, Bali and the Philippines have used it as pig feed.

This practice is far from safe since intestinal parasites and other pathogens can reinfest man after surviving in these animals. Effective pathogen destruction can be achieved by aerobic composting, which produces sufficient temperatures (50 - 60°C) to pasturise the compost. The compost is a neutral and inoffensive stable soil, which is easy and safe to handle. It is still valuable as a nutrient for animals or as a soil fertilizer. The great drawback of composting is the need for handling the fresh night soil; a risky and disagreeable task. It requires a regular turning of the compost pile to assure good aeration and a sufficient pathogen destruction. The development of box composters has solved many of these disadvantages.

A mixture of human waste with straw, paper or hyacinth fed into the insulated, aerated composting box can be left undisturbed until the compost has been stabilised. The compost has a considerable value as fish, pig and chicken feed and can be an income-generating product. The technology of aerobic composting is simple and not costly. The constraints lie in the organisational and cultural fields. It would only become attractive if it can be organised at the community level. It is then that sufficient quantities are available and that paid workers can operate the system. A safe bucket collection system combined with a well organised composting unit may become an attractive neighbourhood level solution.

IMPLEMENTATION

Sanitation is a collective concern, which requires the active understanding and cooperation of all community members. Since it is a taboo ridden subject, it also is difficult to achieve such cooperation. Cultural and organisational constraints are more important than the technology; the technical options are there, but application requires much determination and effort. Educational factors play a very important role because only if a basic understanding of the needs for sanitation has been achieved, the people can be mobilised for its implementation. The implementation programmes will be different for each area, adjusting to the local traditions and culture. At the same time, it changes habits and beliefs and becomes therefore an element of cultural change.

This complexity of factors may be one of the reasons why sanitation so far has failed to reach most low income groups.

Technicians are not the best agents of change, while other professionals feel unsure of the technical requirements of sanitation and environmental health.

Sanitation for part of the population, however, does not make any sense, and the implementation of affordable and acceptable solutions for low income groups is therefore an important question for us all.

HUMAN WASTE UTILIZATION FOR BIOGAS PRODUCTION

C. Polprasert
V.S. Rajput
C. Pacharaprakiti
S. Suthivawut

Asian Institute of Technology
G.P.O. Box 2754
Bangkok 10501, Thailand

Hygienic disposal of human waste is a serious problem in most developing countries, especially in the rural areas where the level of education and concern for health are at a minimum. There are various ways to treat and dispose of human excreta. However, with the recent energy crisis, the concept of waste recycling rather than waste treatment alone has received wide attention. One of the waste recycling technologies currently being promoted is anaerobic digestion of human excreta for the production of biogas. Biogas largely consists of methane (CH_4) about 65%, carbon dioxide (CO_2) about 30%, and trace concentrations of other gases. CH_4 is the desirable gas because of its high calorific value (890-1,070 BTU/ft^3) and can be used primarily in household cooking, lighting, and heating.

It has been reported that there are approximately 80,000 biogas plants in China, 36,000 in India, 27,000 in Korea, 7,000 in Taiwan, less numbers in the Philippines, Thailand, Indonesia and Japan (1). The majority of these biogas plants are fairly small (1-6 m^3) and owned by individual farmers, though larger community-scale plants (30 m^3) on plantations and associated with schools and co-operatives exist. There is variation in what thought to be the minimum number of animals required, or gas used, by a single household, though reports indicate that in practice consumption may be as low as 0.2 m^3 per capita for daily cooking and some biogas digesters could operate on one cow and the family nightsoil. The monthly production of biogas from one person's excreta (or nightsoil) was estimated to be about 1.0 m^3, depending on dietary habits; whereas the monthly gas consumption for cooking was 5 to 6 m^3 per person, assuming efficient burner operation (2). Thus, to produce sufficient biogas, the human nightsoil to be fed to a biogas digester should be supplemented with animal manure or vegetable matters. This paper presents long-term performance results of four pilot-scale biogas digesters fed with a mixture of nightsoil, water hyacinth (Eichhornia crassipes), and rice straw. Data of some microbiological investigations are included.

PRINCIPLE OF BIOGAS PRODUCTION

The anaerobic process in which the biogas is formed involves the decomposition of organic and inorganic matter in the absence of molecular oxygen, and consists of two phases of digestion. In the first phase, saprophytic bacteria attack or hydrolyse complex organic compounds present in the nightsoil and other waste materials such fats, proteins, and carbohydrates; these compounds are converted to simple organic substances suitable for acid-forming bacteria to metabolise and produce volatile acids (mainly acetic acids). In the second phase, the activity of methane-forming bacteria is predominant in which the volatile acids produced are utilized with the formation of CH_4, CO_2 and other gases. A diagram of anaerobic digestion of organic compounds is shown in Figure 1.

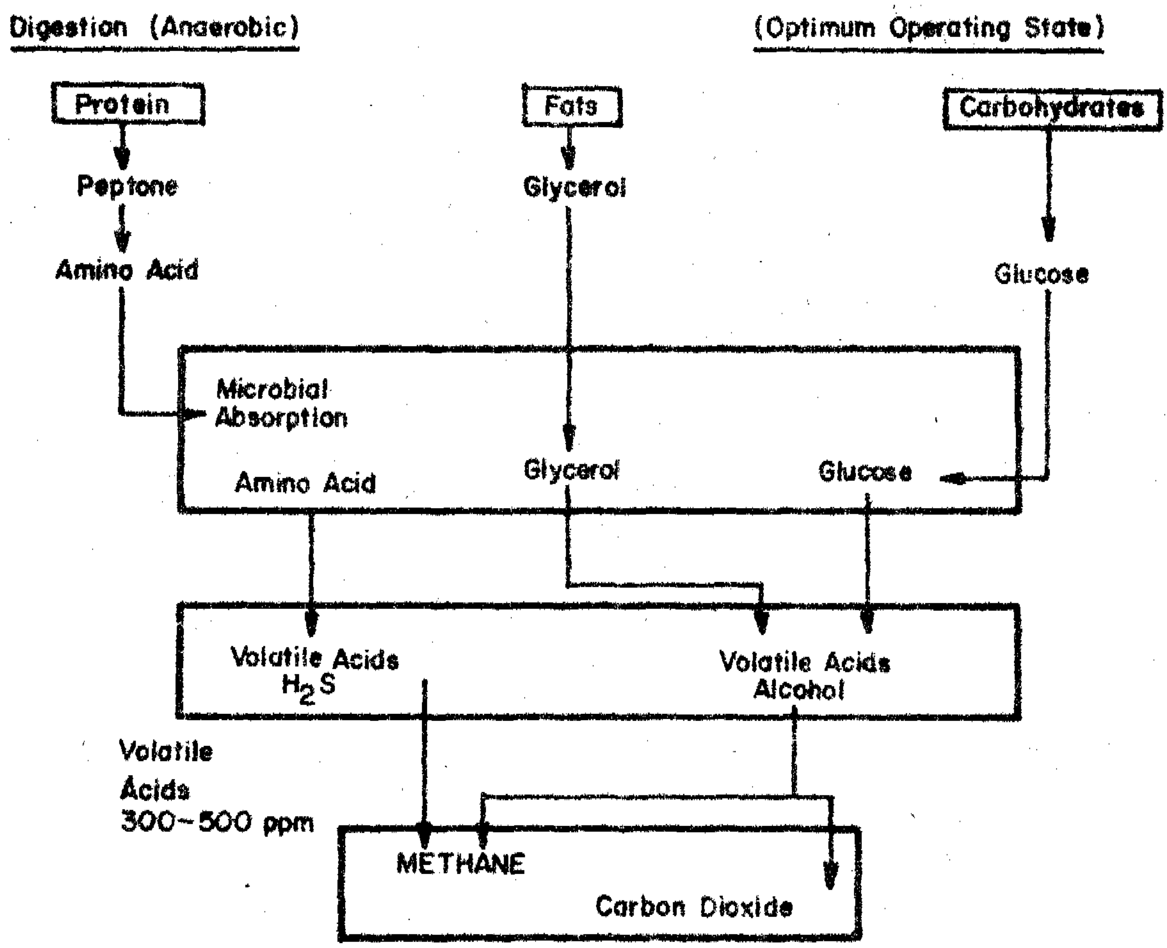

Figure 1: Anaerobic Digestion of Organic Compounds

To maintain an anaerobic system that will stabilize organic compounds and produce biogas efficiently, the acid-forming and methane-forming bacteria must be in a state of dynamic equilibrium. Some of the important factors influencing efficiency of the biogas process are as follows.

Ambient Temperature

The difference between ambient temperature and digester temperature is in the order of 1°- 2° C, as there is not much heat generated during anaerobic decomposition. The methane bacteria of various kinds are present within the mesophilic and thermophilic ranges. The higher the temperature the better the anaerobic digestion (more gas produced), up to a limit of 55 °C. The digester can be heated by external sources, but it may be cheaper to bury the digester underground.

Loading

This term can be expressed in terms of organic loading (kg BOD or COD/m^3/-d), and hydraulic loading or detention time. A too-high organic loading will normally result in excessive volatile acids concentrations in the digester (sour condition) with a consequent decrease in pH, an adverse effect to methane-forming bacteria. A too-low organic loading to the digester will not provide sufficient quantity of gas for household uses. An optimum loading to the digester has been reported to be about 2 kg COD/m^3-d for pig and poultry manure wastes.

The hydraulic loading or detention time has an equally significant effect to digester performance. An optimum detention time for a digester (normally 30-60 days) is dependent on the types of incoming raw materials and environmental conditions inside the digesters. Too short a detention time will not allow sufficient time for the bacteria to metabolize the wastes, while too long a detention time could result in accumulation of digested materials.

pH

Low or acidic pH retards the growth of methane bacteria. This condition could occur when there is too high acidification of the fermenting mass, due to over-loading or some environmental factors that will inhibit methane-bacteria growth, the gas generation will suffer. Too high pH can also cause adverse effects to the methane bacteria. Dilution or low loading have been found to make pH less critical in this case.

Ammonia Toxicity

Ammonia nitrogen increases with long detention time and could inhibit gas production when its concentration reaches a critical level. Again, dilution or low loading makes ammonia toxicity less critical.

3. Gas Storage Chamber : This is the free space in the top portion of the digestion chamber, the volume of which is subjected to changes due to gas pressure developed inside the chamber. The developed pressure will push the digester slurry up through the three openings, namely the inlet, the outlet, and the water pressure tank connecting pipe.

4. Outlet : The outlet is made of 100 mm diameter PVC pipe fitted to the digestion chamber at the level 150 mm above the digester bottom. A drainage pipe, made of 100 mm diameter PVC and incorporated to the outlet, is closed with a valve except when draining off the digester slurry.

5. Water Pressure Tank : The water pressure tank, a hollow square of concrete (700 x 700 x 500 mm : width x length x depth), is connected to the digestion chamber by a 120 mm diameter steel pipe inserted into the slurry about 1000 mm above the digester bottom. The slurry enters the water pressure tank when there is pressure developed in the digestion chamber and will stay there as long as the pressure in the gas storage chamber is higher than the atmospheric pressure. The level of slurry in the water pressure tank is used as a pressure head to force the gas in the storage chamber to flow through the gas vent to the gas facilities. Because the pressure head of slurry in the water pressure tank is equal to those in the inlet and outlet, the locations of these inlet and outlet should be high enough to avoid unnecessary spill of the slurry. The water pressure tank is necessary for storing the excessive slurry pushed up by the biogas pressure; otherwise, the sizes of the inlet and outlet have to be enlarged.

6. Gas Vent : The gas vent, made of 20 mm diameter PVC pipe is equipped with a valve for controlling the gas flow rate. There is a manometer connected to the gas line for pressure measurement. The excessive gas produced is stored in a separate gas storage tank as shown in Figure 2.

7. Mixing Device ; A mixing device is consisted of a central steel pipe with a handle at its top and four 5 mm thick steel disks (300 x 300 mm : width x length) attached as shown in Figure 2. Mixing is accomplished by rotary and vertical translatory motions of the central steel pipe. The disks agitate the slurry to provide better contact between the organic matter and the bacteria, and this operation prevents accumulation of the digested residues in the digestion chamber.

Four 3.5 m^3-digesters of this type were constructed for the experiment. The total construction cost of each digester, based on the local market price in Bangkok during August 1981, was 4,900 baht (or US$ 215).

Raw Materials

The raw materials used as influent to the biogas digesters were a mixture of nightsoil, water hyacinth, and rice straw. The nightsoil was obtained from a jail in Patumthani provice, the water hyacinth and rice straw were available in abundance nearby; some characteristics of these raw materials are shown in Table 1. The water hyacinth and rice straw were shredded into small pieces, about 1-2 cm long, prior to mixing with the nightsoil. The influent mixture was prepared in such a proportion as to produce a carbon/nitrogen (C/N) ratio of approximately 25/1, suitable for microbial metabolism, and its moisture content adjusted to be about 9-10%.

Table 1. Characteristics of Raw-Materials Used for Biogas Production

Raw Materials	Carbon % by Weight (C)	Nitrogen % by Weight (N)	Phosphorus % by Weight (P)	Moisture Content % by Weight	Volatile Solids g/kg	C/N Ratio
Water hyacinth	38.2-47.1	1.2-2.4	0.3-0.8	12.0-93.0	688-848	18/1-30/1
Nightsoil	45.2-51.0	3.4-4.8	0.5-1.0	81.0-86.0	814-918	10/1-13/1
Rice straw	44.0-49.0	0.5-0.9	0.09-0.2	10.0-12.0	792-882	48/1-86/1

Digester Operation

Each biogas digester was started up, with a batch process of 50 days, by being loaded with 200 l of anaerobically digested sludge from a wastewater treatment plant in Bangkok, and 2.8 ^{3} of the influent mixture. Subsequently, the digesters were operated on a semi-continuous basis with feeding undertaken once/day, while mixing was conducted twice/day, before and after feeding. The hydraulic detention time of the digesters was kept between 50-70 days to ensure adequate degradation of the raw materials. The quantity of slurry withdrawn from the digesters was made equal to that of the influent fed to maintain the above operating conditions. All four digesters were operated in a similar way. The organic loadings of the four digesters varied from 0.6 to 3.5 kg volatile solids/m^3/day, depending on the raw material mixture characteristics.

Digesters No. 1 and 2 were initially loaded on 17 and 26 June 1980, respectively. However, these digesters did not function until December, mainly due to leakages. Digesters No. 4 and 3 were initially loaded on 26th December 1980 and 10th January 1981, respectively. Digesters No. 1 and 2 started functioning from the first week of December 1980 and Digesters No. 3 and 4 from 20 January and February 1981, respectively. Continuous loading of digesters No. 1 and 2 was started from December and continuous loading of digesters N. 3 and 4 from the first week of March 1981.

The measurement of biogas production was conducted regularly, as frequently as possible, while the other parameters, pH, temperature, total solids, volatile solids, nitrogen, phosphorus and COD of the influent mixture and digester slurry were analysed periodically.

Public Health Aspects

The attenuation of enteric organisms (bacteria, viruses and helminths) during the anaerobic digestion process was studied. Samples of biogas digester influent and effluent were collected monthly and analysed for standard plate count bacteria, total coliforms, faecal coliforms, bacteriophage, and for the ova of helminths.

RESULTS

Digesters Performance

The percent COD reduction for the four biogas digesters ranged from about 80 to over 90, depending on the influent concentration. Because the bulk form of the influent was volatile solids (vs), the mean percent reduction for volatile solids in all digesters was also more than 80, while the mean reduction of total solids ranged from 76 to 89 percent. There were about 44-45 and 40-53 percent reductions of N and P, respectively, in these biogas digesters. The slurry pH were found to be between 7.8, the most desired range for anaerobic bacteria. A summary of the biogas digester performance based on the chemical characteristics of inffuent and effluent are presented in Table 2. These data indicate that all four digesters operated satisfactorily.

A comparison between ambient temperature and the temperature within biogas digester number 1, made every 3 hours for a 48 hour period, indicated relatively slight changes in digester temperature from 28.4 °C to 30.0 °C. Ambient temperatures were higher than the digester temperature during the day but were lower during the night. More routine semi-diurnal measurements of the temperature of biogas slurry from the four digesters also indicated a relatively low and uniform temperature of ranges of 1 to 4 °C.

To maintain an anaerobic system that will stabilize organic compounds and produce biogas efficiently, the acid-forming and methane-forming bacteria must be in a state of dynamic equilibrium. Some of the important factors influencing efficiency of the biogas process are as follows.

Ambient Temperature

The difference between ambient temperature and digester temperature is in the order of 1°- 2° C, as there is not much heat generated during anaerobic decomposition. The methane bacteria of various kinds are present within the mesophilic and thermophilic ranges. The higher the temperature the better the anaerobic digestion (more gas produced), up to a limit of 55 °C. The digester can be heated by external sources, but it may be cheaper to bury the digester underground.

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The hydraulic loading or detention time has an equally significant effect to digester performance. An optimum detention time for a digester (normally 30-60 days) is dependent on the types of incoming raw materials and environmental conditions inside the digesters. Too short a detention time will not allow sufficient time for the bacteria to metabolize the wastes, while too long a detention time could result in accumulation of digested materials.

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Ammonia Toxicity

Ammonia nitrogen increases with long detention time and could inhibit gas production when its concentration reaches a critical level. Again, dilution or low loading makes ammonia toxicity less critical.

Viscosity of the Slurry

Viscosity can cause stratification of the slurry which then reduce the bacterial activity to a minimum. Moreover, the gases produced would be accumulated in the slurry and some of them such as H_2S have an inhibiting effect on the bacteria. Stirring, dilution and low loading can help solve this problem.

Stirring

In general, stirring has advantages to the biogas digester as the bacteria will be uniformly dispersed and will contact better with the incoming wastes, stratification is prevented, all result in better gas yield. Stirring can be done by gas mixing and plunger. However, the benefits of stirring to small-scale digesters are less than those for large-scale digesters.

MATERIALS AND METHODS

Design of Biogas Digester

There are two major types of biogas digesters employed worldwide, namely, the movable cover or the Indian type and the fixed cover or the Chinese type. Although a considerable number of these biogas digesters have been installed, there have been numerous problems such as the high capital cost of construction and installation, temperature fluctuation, blocking of the inlet and outlet chambers, and no provision for mixing the contents of the digester. These factors, either individually or in combination, could lead to failure in CH_4 production and eventually to the abandoning of the biogas digester. Previous work was undertaken to develop and modify the existing types of digester, and the size of the pilot scale digester (or the low-cost biogas digester) constructed was 60 litres (3). In this study, the digester is similar to the low-cost biogas digester except with a few modifications. The digester size is 3.5 m^3 (Figure 2). The main components of this biogas digester are described below and the construction details are presented elsewhere (4).

1. Inlet : The raw materials (influent) are fed through this inlet into the digestion chamber. The inlet is made of 100 mm diameter PVC pipe fitted to the digestion chamber 100 mm above the digester bottom to allow for maximum contact between the organic matter in the influent and the anaerobic bacteria.

2. Digestion Chamber : The digestion chamber is made of a ferrocement cylinder with an inner diameter of 1500 mm and a height of 2000 mm. This chamber, where digestion of the organic matter occurs, is connected with the inlet, outlet and the water pressure tank connecting pipe. The chamber is placed 1300 mm underground to avoid excessive temperature

fluctuation, and the exposed portion is painted black to absorb the solar heat during daytime.

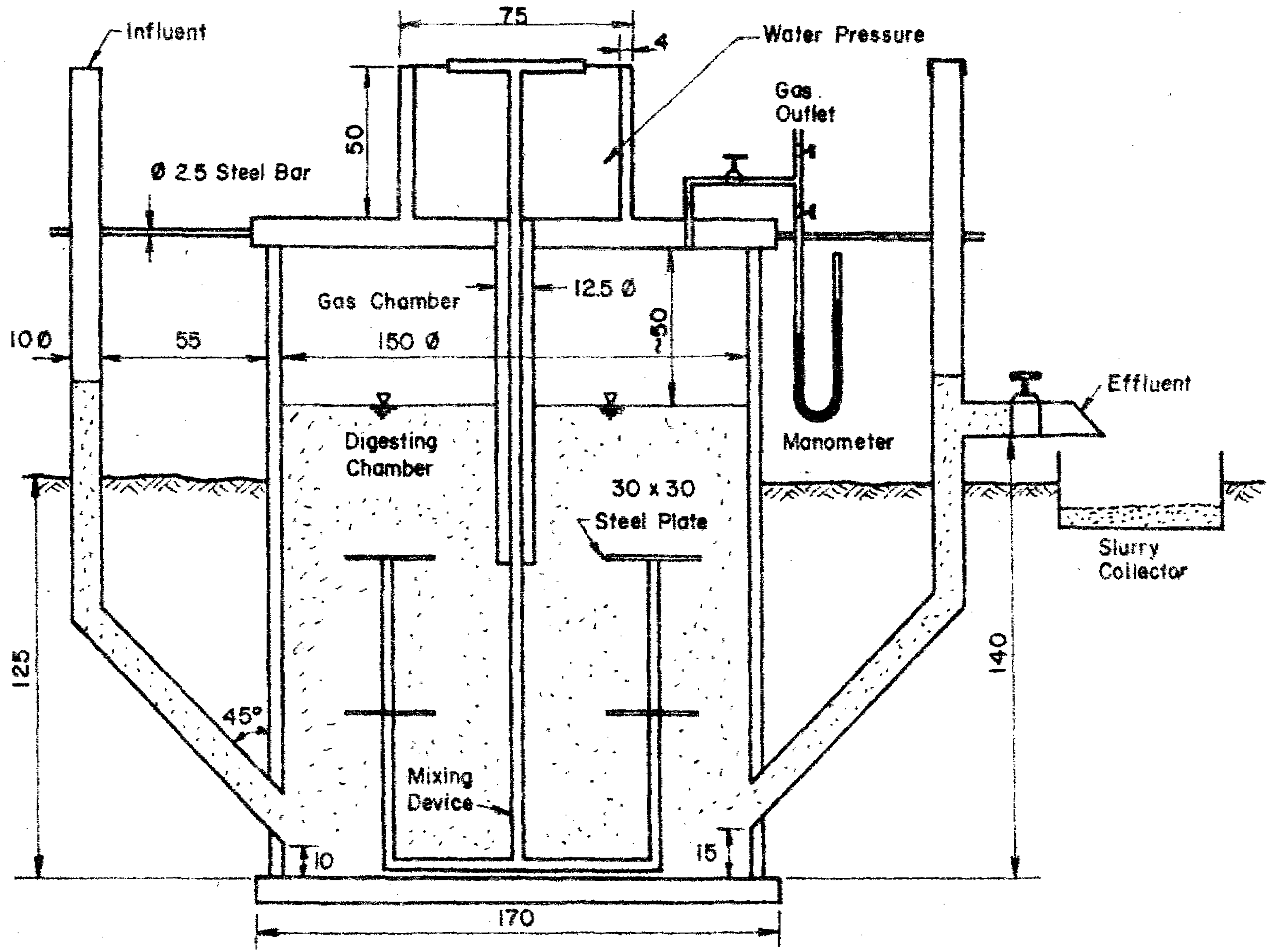

Figure 2 : Detail of Ferrocement Biogas Digester
(Dimensions in Centimetres. Scale 1:20)

3. Gas Storage Chamber : This is the free space in the top portion of the digestion chamber, the volume of which is subjected to changes due to gas pressure developed inside the chamber. The developed pressure will push the digester slurry up through the three openings, namely the inlet, the outlet, and the water pressure tank connecting pipe.

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Rice straw	44.0-49.0	0.5-0.9	0.09-0.2	10.0-12.0	792-882	48/1-86/1

Digester Operation

Each biogas digester was started up, with a batch process of 50 days, by being loaded with 200 l of anaerobically digested sludge from a waste-water treatment plant in Bangkok, and 2.8 ^{3} of the influent mixture. Subsequently, the digesters were operated on a semi-continuous basis with feeding undertaken once/day, while mixing was conducted twice/day, before and after feeding. The hydraulic detention time of the digesters was kept between 50-70 days to ensure adequate degradation of the raw materials. The quantity of slurry withdrawn from the digesters was made equal to that of the influent fed to maintain the above operating conditions. All four digesters were operated in a similar way. The organic loadings of the four digesters varied from 0.6 to 3.5 kg volatile solids/m^3/day, depending on the raw material mixture characteristics.

Digesters No. 1 and 2 were initially loaded on 17 and 26 June 1980, respectively. However, these digesters did not function until December, mainly due to leakages. Digesters No. 4 and 3 were initially loaded on 26th December 1980 and 10th January 1981, respectively. Digesters No. 1 and 2 started functioning from the first week of December 1980 and Digesters No. 3 and 4 from 20 January and February 1981, respectively. Continuous loading of digesters No. 1 and 2 was started from December and continuous loading of digesters N. 3 and 4 from the first week of March 1981.

The measurement of biogas production was conducted regularly, as frequently as possible, while the other parameters, pH, temperature, total solids, volatile solids, nitrogen, phosphorus and COD of the influent mixture and digester slurry were analysed periodically.

Public Health Aspects

The attenuation of enteric organisms (bacteria, viruses and helminths) during the anaerobic digestion process was studied. Samples of biogas digester influent and effluent were collected monthly and analysed for standard plate count bacteria, total coliforms, faecal coliforms, bacteriophage, and for the ova of helminths.

RESULTS

Digesters Performance

The percent COD reduction for the four biogas digesters ranged from about 80 to over 90, depending on the influent concentration. Because the bulk form of the influent was volatile solids (vs), the mean percent reduction for volatile solids in all digesters was also more than 80, while the mean reduction of total solids ranged from 76 to 89 percent. There were about 44-45 and 40-53 percent reductions of N and P, respectively, in these biogas digesters. The slurry pH were found to be between 7.8, the most desired range for anaerobic bacteria. A summary of the biogas digester performance based on the chemical characteristics of inffuent and effluent are presented in Table 2. These data indicate that all four digesters operated satisfactorily.

A comparison between ambient temperature and the temperature within biogas digester number 1, made every 3 hours for a 48 hour period, indicated relatively slight changes in digester temperature from 28.4 °C to 30.0 °C. Ambient temperatures were higher than the digester temperature during the day but were lower during the night. More routine semi-diurnal measurements of the temperature of biogas slurry from the four digesters also indicated a relatively low and uniform temperature of ranges of 1 to 4 °C.

Table 2. Summary of the Chemical Characteristics of the Influent and Effluents of the Four Biogas Digesters

Parameters	Influent Range (mg/l)	Digester No. 1 Effluent		Digester No. 2 Effluent		Digester No. 3 Effluent		Digester No. 4 Effluent	
		Range (mg/l)	Reduction (%)	Range (mg/l)	Reduction, (%)	Range (mg/l)	Reduction, (%)	Range (mg/l)	Reduction (%)
COD	26,225–88,784	1,725–12,642	85–93	1,660–14,014	84–93	2,856–8,477	89–90	5,656–1,808	93
Total Solids	39,167–55,500	3,875–12,900	72–93	3,934–12,326	73–91	5,237–19,850	58–91	10,400–3,700	75–83
Volatile Solids	29,167–44,500	1,250–6,980	80–95	1,625–6,213	82–94	2,100–11,000	70–95	1,900–5,800	81–96
Total Nitrogen	760–1,611	391–863	31–57	310–731	28–61	598–863	15–61	382–746	30–74
Total Phosphorus	143–197	70–95	36–59	71–99	38–58	79–102	31–61	65–81	45–66
pH	7.0–7.9	7.1–7.6		7.1–7.6		7.1–7.4		7.1–7.5	

Detailed data of biogas production on a daily basis are presented in Figure 3. There was some fluctuation in the daily volume of biogas produced, due mainly to irregularities in organic loading because of problems involved in the collection and transportation of nightsoil. However, initially there was leakage of gas at the joint between the ferrocement cylinder and the top cover, but this was remedied by applying epoxy tar. The biogas production rate and its methane content are present in Table 3. The mean biogas production rates in the four digesters were similar and approximately 0.2 m^3/kg volatile solids/day whilst the gas had a methane content of 60%.

After about 2 months of operation, there was scum accumulation in the upper part of the slurry inside the digesters which caused difficulty adding raw materials and mixing the digester contents. This problem was overcome by releasing the pressure inside the digester, by vigorously mixing the slurry, and by withdrawing parts of the slurry which were refed into the digester and remixed with the contents. A second problem was the development of excessive pressure inside the digesters due to the biogas production, which could have caused gas leakage, especially at the joints or connecting parts of the ferrocement structure. This problem was overcome by diverting excess gas for storage in the separate gas storage tank as shown in Figure 4. However, in practice the gas produced would be continuously used for cooking, heating and lighting, and the need for a separate gas storage tank would not be essential. Apart from the above two problems, the ferrocement digesters were found to function efficiently and satisfactorily.

Public Health Investigation

Parasitic ova removal in the biogas digesters was effective. It was found that only one slurry sample had Ascaris ova, while in the rest ova were absent or identified as dead. Because parasitic ova have a relatively high specific gravity and large size, most of them would settle down to the digester bottom with the residue; if retained for a long period of time, anaerobic conditions in the digester could cause the ova to die-off also. However, the digester slurry were found to still contain high concentrations of bacteria and bacteriophages (Table 4) which could be due to several reasons: heterogenous character of the slurry, inadequate mixing of the slurry and short-circuiting of fluid flow in the digesters.

Complete data on the digester performance and public health studies can be found in the project report (5).

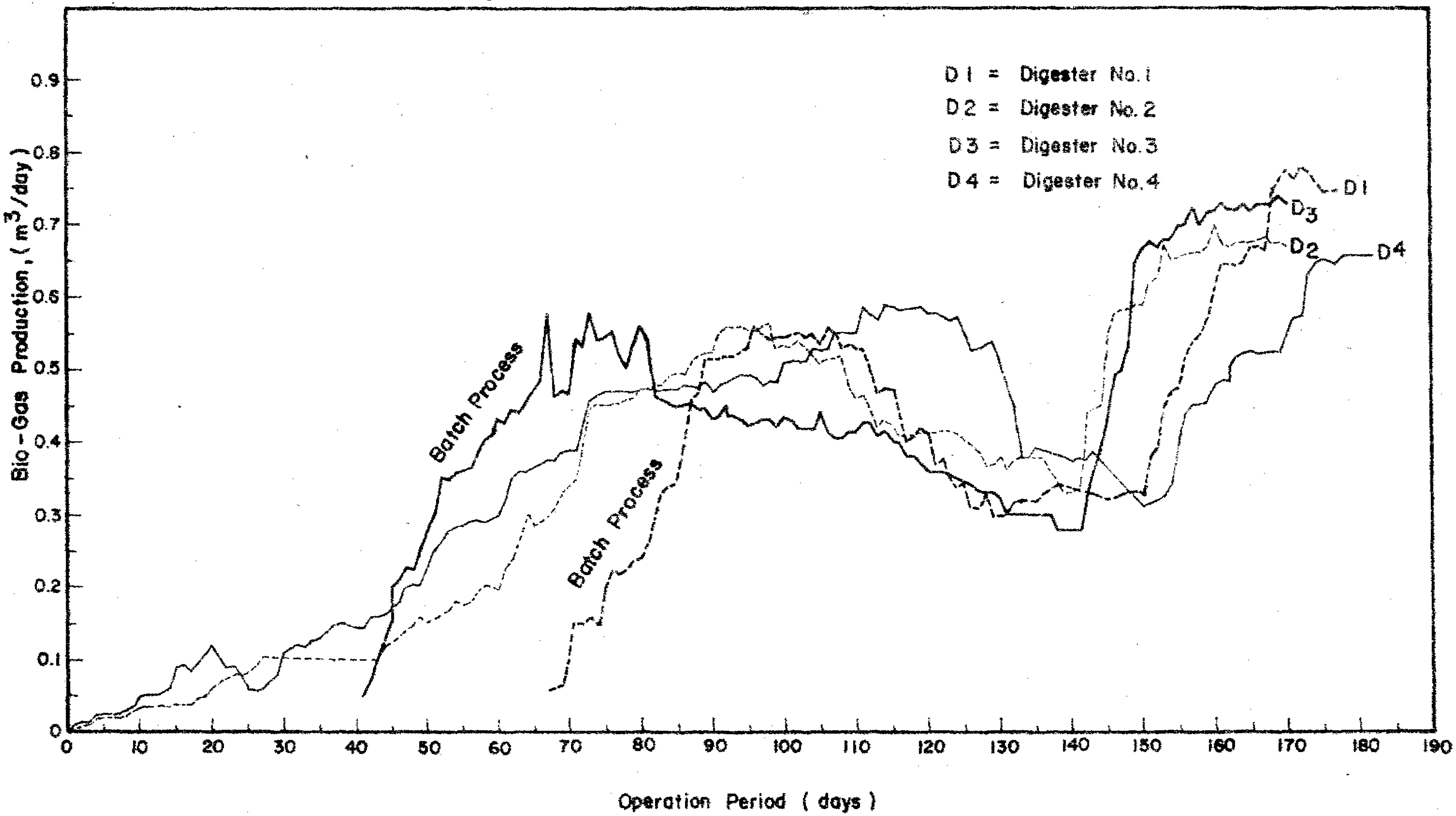
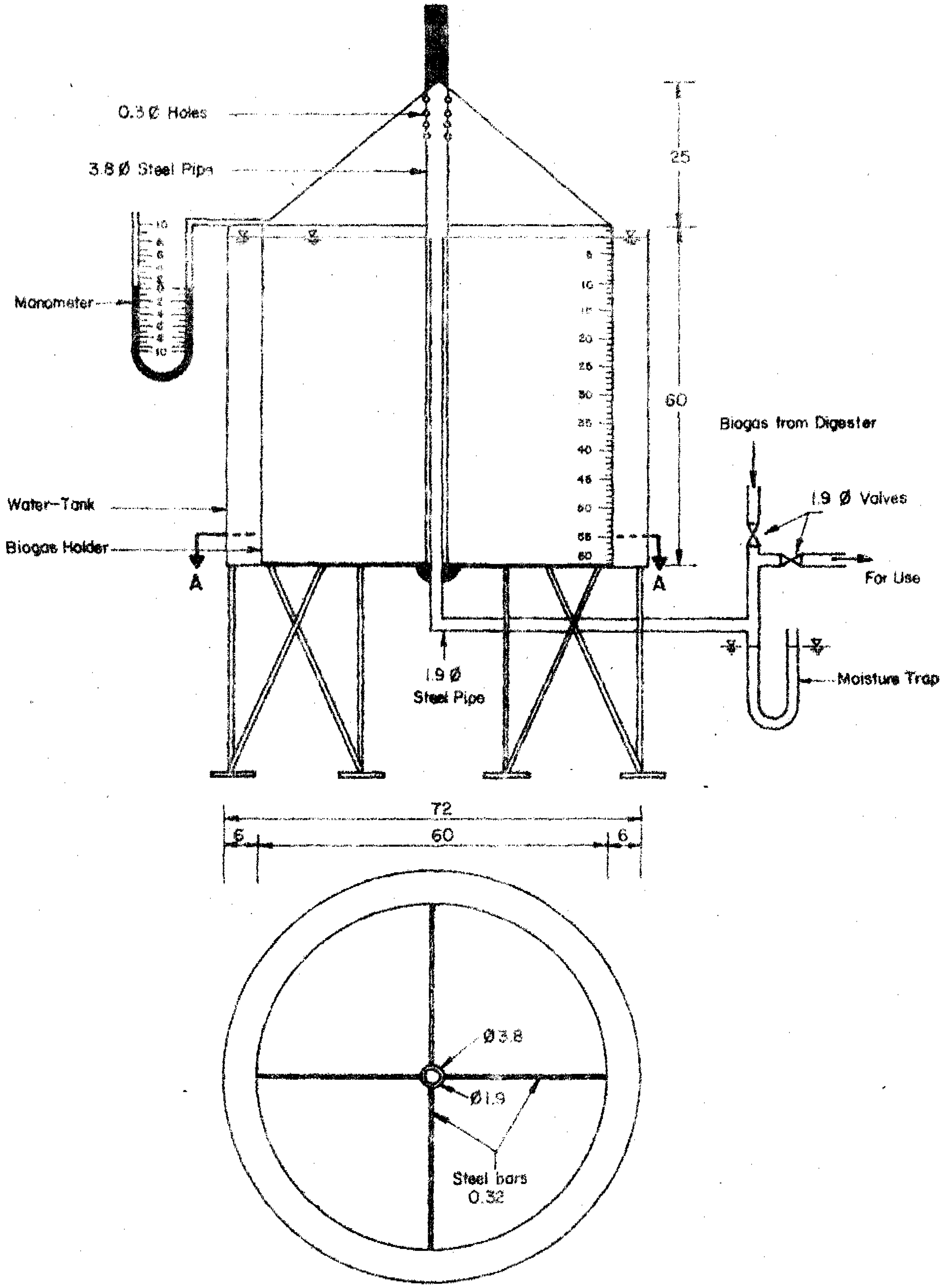


Figure 3 Biogas Production Rate from Four Anaerobic Digesters

Table 3. The Biogas Production Rate (m^3 of Gas/kg Volatile Solids/day) and the Percentage Methane Content Content of the Gas from the Four Digesters

Month	Digester Number							
	1		2		3		4	
	Biogas Production Rate m^3/kg VS/day	Methane Content (%)	Biogas Production Rate m^3/kg VS/day	Methane Content (%)	Biogas Production Rate m^3/kg VS/day	Methane Content (%)	Biogas Production Rate m^3/kg VS/day	Methane Content (%)
Dec 80	0.057	48.3	0.09	49.0				
Jan 81	0.096	60.5	0.15	61.7		39.0		
Feb 81	0.121	64.0	0.125	62.5		65.5		54.8
Mar 81	0.270	63.10	0.270	63.7	0.225	61.3	0.350	61.25
Apr 81	0.400	60.0	0.350	62.0	0.350	63.0	0.280	61.0
May 81	0.163	60.5	0.173	61.8	0.179	64.0	0.162	60.3
Jun 81	0.180	64.0	0.182	65.0	0.180	62.0	0.156	61.0
Mean	0.184	59.3	0.191	60.8	0.207	59.13	0.199	59.67



Section A-A

Figure 4: Detail of Gas Storage Tank
(Dimensions in cm. Scale 1:10)

Table 4. Bacteria and Bacteriophage in Biogas Influent (Nightsoil) and Biogas Slurry.

Date	Tests	Biogas influent	Biogas slurry digester 1	Biogas slurry digester 2	Biogas slurry digester 3	Biogas slurry digester 4
11 Dec 80	Standard	7.8×10^{8}	3.3×10^{6}	6.2×10^{6}	-	-
26 Jan 81	plate count/	1.2×10^{8}	7.8×10^{6}	9.0×10^{6}	-	-
23 Feb 81	1 ml, 1 g	5.0×10^{7}	6.0×10^{7}	4.0×10^{7}	-	-
30 Mar 81		7.8×10^{8}	7.1×10^{7}	4.7×10^{7}	3.8×10^{7}	-
20 May 81		6.8×10^{8}	3.1×10^{7}	5.2×10^{7}	2.2×10^{8}	3.2×10^{8}
17 Jun 81		8.9×10^{8}	5.5x107	6.3z10^{7}	4.7×10^{8}	4.6×10^{7}
11 Dec 80	Standard total	5.4×10^{7}	1.3×10^{6}	1.6×10^{6}	-	-
26 Jan 81	coliform MPN	1.3×10^{7}	9.2×10^{5}	1.6×10^{6}	-	-
23 Feb 81	index/100 ml,	3.5×10^{7}	1.7×10^{6}	3.5×10^{7}	-	-
30 Mar 81	100 g	3.5×10^{7}	8.5×10^{5}	2.4×10^{6}	1.4×10^{6}	-
20 May 81		5.4×10^{7}	7.0×10^{5}	3.5×10^{6}	1.8×10^{7}	1.8×10^{7}
17 Jun 81		3.5×10^{7}	5.4×10^{6}	3.5×10^{6}	1.6×10^{7}	9.5×10^{5}
11 Dec 80	Standard	3.5×10^{7}	3.5×10^{5}	1.4×10^{5}	-	-
26 Jan 81	fecal coli-	1.7×10^{6}	3.5×10^{5}	1.1×10^{5}	-	-
23 Feb 81	form MPN	3.5×10^{7}	1.7×10^{6}	2.4×10^{7}	-	-
30 Mar 81	index/100 ml,	3.5×10^{7}	3.5×10^{5}	2.4×10^{6}	1.4×10^{6}	-
20 May 81	100 g	1.7×10^{7}	1.7×10^{5}	2.7×10^{5}	1.8×10^{7}	7.9×10^{6}
17 Jun 81		1.7×10^{6}	1.3×10^{6}	7.9×10^{5}	1.6×10^{7}	3.3×10^{5}
11 Dec 80	E. coli	9.2×10^{6}	7.9×10^{5}	3.3×10^{5}	-	-
26 Jan 81	Bacterio-	5.4×10^{8}	2.8×10^{5}	2.1×10^{5}	-	-
23 Feb 81	phage MPN	2.2×10^{6}	2.8×10^{5}	1.3×10^{6}	-	-
30 Mar 81	index/100 ml,	9.2×10^{6}	6.8×10^{4}	7.0×10^{5}	2.6×10^{5}	-
20 May 81	100 g	3.3×10^{6}	3.5×10^{5}	3.5×10^{5}	3.5×10^{5}	4.6×10^{5}
17 Jun 81		5.4×10^{6}	7.0×10^{5}	1.1×10^{6}	1.3×10^{6}	4.9×10^{5}

DISCUSSION

The anaerobic process in the biogas digesters involves the biochemical reactions of anaerobic bacteria in breaking down the complex organic compounds into simple compounds. The major end-products of this process are methane (CH_4) and carbon dioxide (CO_2) plus trace concentrations of other gases which result from the bioconversion of the organic matters. In this respect, there are reductions of the BOD (or COD) and volatile solids of the influent, but in most cases, the digester slurry still contains high concentrations of substrate and nutrients suitable for further reuses. Because the anaerobic bacteria, especially the methane formers, are sensitive to environmental changes, the proper operating conditions have to be provided for the digestion process. In this study, although there were some operational problems due to excessive scum accumulation inside the digesters periodically, the vigorous mixing of the digester contents helped to maintain the gas production satisfactorily. Other operating conditions were normal and the treatment results obtained were comparable to those reported in the literature. It should be noted that the percentage reductions of nitrogen and phosphorus of 44-45 and 40-53%, respectively, in the digester were obtained form the difference in nutrient content of influent and effluent. Since the digesters were not desludged during the project, much of the nutrients accumulated in scum inside the digester. The similarity in the data for N and P suggest that little N was lost by volatilization.

SUMMARY

The results of this study showed that human nightsoil mixed with water hyacinth and rice straw at a proportion to yield a C/N ratio of 25/1 could be used to produce biogas. The biogas digesters, constructed of ferrocement and used in the experiment, were relatively low-cost, easy to operate, and allowed for digester mixing. However, the digester slurry still contained high densities of microorganisms which could pose some public health problems if disposed of unhygienically into the environment. These slurry could be further reused or treated prior to disposal.

ACKNOWLEDGEMENT

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THE PROBLEMS OF CONSTRUCTION, OPERATION AND MAINTENANCE IN BUNDUNG LOW COST SANITATION PROJECT

Mrs. Nurhasanah

Directorate of Building Research
Bandung, Indonesia

OBJECTIVES

The development objectives of the Low-Cost Sanitation Project are:

a. To improve the health conditions and-well-being of the urban low-income population through the prevention, or decrease in the incidence, of water-borne diseases, which are primarily caused by defective sanitation and the consequent pollution of essential drinking water resources.

b. To strengthen the Government's long-term capability to plan for the development of the urban sanitation sector.

BACKGROUND

Indonesia's present urban population of approximately 32 million (including peri-urban settlements) is expected to increase to 70-80 million by the year 2,000. Of the present population, only 30% have access to satisfactory excreta disposal facilities. The expansion of these services is to a great extent taken up by the growth in urban population.

So far the Government of Indonesia has given priority to the expansion of urban water supply systems, and planned to pursue vigorously its policy of providing piped water supply at basic need levels to 60% of the urban population by 1985.

Over the past years, sewerage and sanitation studies have been conducted for a number of large cities. These, without exception, point at the large investments required for fully-fledged centralized sewer systems.

However, the increased investments in safe water supplies will fall short of yielding their full benefit if they are not complemented by adequate excreta and solid waste disposal systems. Given the large backlog in satisfactory urban excreta management, and the unfeasible high costs of conventional urban sewer systems, intermediate systems need to be developed and introduced. They will considerably improve the present situation and at the same time can be constructed within the present budgetary and economic constraints.

Substantial efforts in this direction have been undertaken under the Kampung Improvement Projects.

This paper describes low-cost sanitation in three kampungs in Bandung as part of the Bandung Urban Development Project (BUDP), with special attention to the problems of construction, operation and maintenance. Its relevance to the seminar lies in the attempt to achieve what the seminar brochure says cannot be done, i.e. solve low-income groups' sanitation by conventional means.

BUDP is a US$ 70 million urban development project being executed by the Indonesian Government with financial assistance from the Asian Development Bank. The project arises from a major study carried out in 1978 by an international consortium of consultants. It is based on the first stage implementation program identified in the study and includes the following sectors:

- kampung improvement (KIP)
- drainage
- sewerage
- solid waste management
- serviced housing plots with core houses.

This paper is concerned with the upgrading of facilities under KIP.

Nearly 80% of Bandung's 1.5 million inhabitants live in kampungs. KIP is directed at three of the worst kampungs, housing some 120,000 people, which exhibit all the classic features of such areas: very high density (up to 500 persons per hectare), frequent flooding, polluted water supply, inadequate sanitation, poor pedestrian and vehicular access, and lack of social facilities.

There is a wide range of disposal systems in use at present: private flush toilets, non-flush toilets, communal toilets, and drop-latrines built over rivers/canals. Apart from one small area, there is no comprehensive sewer network.

Combined open drains carry most sewage to the nearest water course; flushing is generally inadequate and these channels are often blocked with solid waste. Flooding is a regular occurrence. The resultant sanitary and hygienic conditions are unsatisfactory.

The basic KIP package comprises an extensive network of new or improved footpaths. Each length of the network is incorporated to local drainage, piped water supply and minor sewers; and linked, as appropriated, to main networks. In addition, communal ablution units (MCKs) are provided as well as land for community facilities. The BUDP Solid Waste sector will provide a comprehensive domestic refuse collection and disposal system.

KIP SEWERAGE INPUT

A basic network of minor sewers, each 230 meters per hectare, is being inserted along with the improved path network. These are linked to secondary/trunk sewers provided by the BUDP Sewerage sector. The system is designed to allow for eventual connections to all houses.

House connection chambers are provided every 10-15 metres. Individual house-owners are responsible for the construction of connections to the chambers according to acceptable specifications.

MCKs are being provided for those houses which cannot have access to individual facilities. These incorporate a toilet, a bathing cubicle and a clothes washing area. There is a range of designs to suit different locations. These are allocated to a group of households who are responsible for cleaning and payment.

ISSUES

The paper examines the program under implementation with respect to the following points:

<u>Cost</u>:

- an analysis of capital costs on a gross and per hectare or capita basis and a comparison with other KIP component costs.
- the proposed cost recovery system and its implications for affordability, particularly by 10 lowest-income groups.
- cost implications for the extension of the project to other kampung areas.

<u>Construction</u>:

The relatively sophisticated level of technology being used demands a comparably sophisticated construction and supervision capability.

- the use of small local contractors and typical construction problems.

- the effectiveness of contract supervision and the contractor/project relationship.

- maintenance problems.

Management:

- description of the proposed integrated management organisation.

- short-term management/operation implications pending launching of Bandung Water & Sewerage Authority.

Land Values:

The cost-recovery system is based on the anticipated increase in land values.

- the impact of main sewerage delivery on land values and the resulting effect on the dynamics of the housing market, with particular reference to the rental sector.

Social Dimension:

- analysis of social response with particular reference to lowest-income groups.

- prospects for those unable/unwilling to obtain individual sewers connections.

- assessment of the match between the technology of the system and the community's percention needs and development priorities.

AFFORDABLE SANITATION - THE DOUBLE PIT LATRINE

R F Carroll, CEng, MIMechE

Building Research Establishment, UK

International Seminar:

Human waste management for low income settlements

16-22 January 1983, Bangkok, Thailand.

AFFORDABLE SANITATION - THE DOUBLE PIT LATRINE

by R F Carroll, CEng MIMechE, UK Building Research Establishment

INTRODUCTION

The BRE Permanent Improved Pit (PIP)[1][2] latrine concept was developed in an attempt to bring together the best in simple and minimum cost sanitation technology for situations where only pit type latrines are affordable. The result was an effective latrine and on-site treatment system that satisfies the basic criteria of providing a means of collecting and retaining human excreta until rendered harmless and inoffensive before discharge to the environment. To extend the PIP principle of utilising twin pits or chambers and allowing a two-year retention period for stored excreta to eliminate health hazards through human contact, two alternative designs have been produced for situations where:

(i) there is a high water table or persistent flooding,

(ii) a small amount of water can be used for flushing a low volume waterseal.

These two latrine designs are respectively the Raised Improved Pit (RIP) and the Double Improved Pourflush (DIP). They are intended to complement the PIP design in giving alternatives to meet most situations likely in developing countries.

The designs, figures 1 to 4, are intended to illustrate concepts. A variety of construction materials could be appropriate and must be selected to suit availability in a particular situation; the choice must also be linked to suitability and durability.

DOUBLE PIT LATRINES - IMPROVED AND PERMANENT

The first major development of PIP type double pit latrines was in Botswana, where over 2000 were built in 1979-80 and where they were called the Revised Earth Closet (REC)[3]. The cost at that time was marginally less than the large ROEC single pits and considerably cheaper than the Botswana type B aqua privy[4].

The PIP concept is basically that twin chambered pits are used, only around 1.5 m^3 effective volume of each chamber, and are intended to be emptied by suction hose or manually with long handled shovels. The material to be emptied would have been retained in a chamber for at least two years after sealing off to ensure advanced decomposition and removal of organisms harmful to humans. The material should be friable and humus-like if retained above the water table.

If emptying takes place in wet conditions, eg where the pits are flooded, then the chamber contents could be like a running slurry and suction emptying would be necessary. However, as long as the retention period of two years has been observed then the material should have little offensive odour and should be harmless to health.

The designed capacity of each chamber is intended to last a family of five or six persons for around three years before sealing off and bringing the other chamber into service. Two more years are allowed to elapse before emptying the first chamber.

Ventilation pipes are provided to both chambers, discharging above roof level. This drawing-off of gas and air from the chambers, produced mainly by wind blowing across the open end of the ventilation pipe, induces an inflow of air through the latrine inlet hole. This prevents gases entering the superstructure from the pit via the inlet hole, thus reducing unpleasant odours.

The PIP concept is primarily intended as a basic dry pit latrine, although it will function even if periodically flooded. Emptying dry material lends itself to manual emptying and if suction is to be used then a high air flow machine is necessary, drawing through a 100 mm diameter hose. Traditional cesspit emptyers will only draw material such as thin slurries, since the hose needs to be completely filled with liquid; often a 75 mm hose is used, which for domestic latrine emptying is susceptible to blockage by domestic rubbish sometimes deposited in latrines.

VARIATIONS OF THE DOUBLE PIT CONCEPT

For areas with high ground water all the year round or which are subject to flooding, a double pit has been designed to allow the decomposing excreta to be retained above ground level. This has been called the Raised Improved Pit (RIP) latrine.

The RIP has a sand filter 1 m deep immediately below the waste matter. Liquids of decomposition, urine and water that have been put into the latrine will seep downwards and sideways. The sand filter will reduce the pollution problem by filtering out most harmful organisms that might otherwise contaminate the ground water.

In many developing countries water is used for personal cleansing after defecation and there is often a desire to incorporate a waterseal in the latrine as a gastight seal. A twin chamber, pourflush type latrine design has been produced and has been called the Double Improved Pourflush (DIP) latrine. Flushing is by hand using a container of water around 1½ litres. The waterseal should be around 12 to 18 mm.

To assist percolation of liquids, the twin chambers in the ground are surrounded by a sand bed to increase the percolation area of the pit sides. Some cleaning of the sand filter could take place during the retention period, where naturally occurring bacteria would tend to break down the solid particles and slime that may block the interstices between the particles in sand and soil.

It is important that the percolation capacity of the surrounding ground is suitable if quantities of water are to be introduced to pit type latrines.

PERMANENT IMPROVED PIT LATRINE (PIP) - Figure 1

This design is the original BRE concept of the double, emptyable and ventilated pit latrine. It is suitable for suction emptying or manual emptying with long handled shovels. Main features are:

(i) No water necessary. If water is used for personal cleansing the amount should be kept to a minimum.

(ii) Small double pits or chambers, each 1.5 m^3 effective or storage volume.

(iii) Pit tops and superstructure supported.

(iv) Pits ventilated, to reduce odour and insect nuisance.

(v) Mechanised or manual emptying.

(vi) Two year retention period.

(vii) Three year emptying cycle.

(viii) Pit contents decomposed, harmless, inoffensive and useful as a fertiliser.

(ix) The retention period is also a rest period, allowing bacteria in the ground to break down organic matter tending to block soil interstices and affecting the absorption of liquids into the ground.

The construction sequence:

(a) Initial shallow excavation, 350 mm deep, with level bottom.

(b) Concrete liner (ring beam), 500 mm deep x 100 mm thick, cast in shutters on undisturbed ground.

(c) Pits excavated within liner and partition wall constructed up to the underside of the liner.

(d) Precaste concrete floor panels and access covers assembled.

(e) Superstructure erected on floor panels.

(f) Separate ventilation pipe with insect screen to each pit.

RAISED IMPROVED PIT LATRINE (RIP) - Figure 2

This design is a variation of the original PIP latrine, incorporating the same principles. It is intended for situations where the groundwater is high or the site is subject to flooding.

Excreta is retained in the chamber above ground level and in this way the resultant decomposed soil-like material should be free of excessive water on emptying, thus keeping the bulk to a minimum and helping to prevent odour.

Filtering out of harmful organisms should be achieved by the shingle and sand layers, thus reducing the risk of pollution of groundwater.

The rest period of at least two years (retention period for material before emptying chambers) should encourage a self-cleaning effect of the sand and ground interstices. Naturally occurring bacteria can break down organic particles and slime that tend to block originally porous media.

Exterior walls can be of brick or concrete block. The partition wall should be rendered at least on one side to make it impervious and so prevent any migration of pathogens between chambers through the partition wall.

DOUBLE IMPROVED POURFLUSH LATRINE (DIP) - Figures 3 and 4

Another variant of the PIP and incorporating a pourflush waterseal. There is therefore a requirement for water in small amounts to flush the waterseal traps after use. Around 1½ to 2 litres of water should be sufficient to clear the trap, remaking the shallow waterseal of from 12 to 18 mm.

The chambers have honeycomb brick or blockwork end walls to allow percolation of liquids to the ground. By surrounding the perimeter walls with a sand bed, increased percolation should result. This would be unnecessary if the latrine is constructed in porous sandy soil with good percolation.

Similar to both the PIP and RIP latrines, the rest period for the ground and sand barrier may help to prevent clogging by organic matter, utilising naturally occurring bacteria.

Figure 4 illustrates a version of the DIP that has the toilet pan inside the house and the chambers of 'pits' outside. Twin squatting plates are shown, but could be a single plate (toilet pan) with outlet pipe taking the flow to a 'diverter' arrangement. The flow is directed to one or other of the receiving chambers.

SUMMARY AND CONCLUSIONS

Several thousand emptyable double pit latrines have been installed on site and services plots in Botswana and Lesotho. Plotholders generally have accepted the technology because they are used to the traditional idea of a pit latrine and they accept the advantages to be gained from the new designs.

An effectively ventilated pit that is properly maintained produces hardly any odour and consequently minimal fly nuisance. Fly breeding in the pit is contained when an effective insect screen is fitted to the outlet of the ventilation pipe, thus preventing the escape of flies and reducing the spread of diseases of faecal origin.

Longer term aspects, such as possible pollution of groundwater and structural stability of the installation, need to be studied. Already in some types of ground in Botswana it has been found necessary to continue the pit lining to the bottom, to prevent erosion of the soil walls due to the seasonal rise and fall of groundwater. If suction emptying is adopted particular attention to soil suitability will be important in deciding on the extent of necessary lining to prevent erosion.

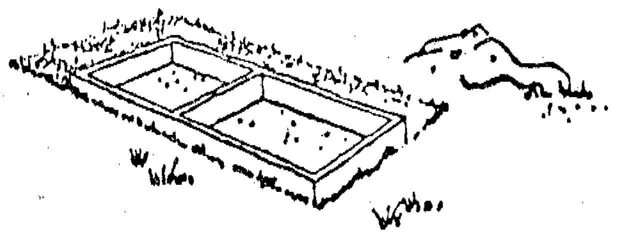
There is widespread interest in the possibility of efficient mechanised emptying of pit latrines. This interest is mainly where large traditional single pits exist and are full, so that their useful life can be extended.

BRE has current research into likely systems for pumping out pits and chambers, principally to service the types of double pit now being developed. A prototype suction tanker is being built for extensive field trials in Botswana, that should be capable of drawing dry sludge as well as the range of wet sludges found in pits, aqua privies and septic tanks.

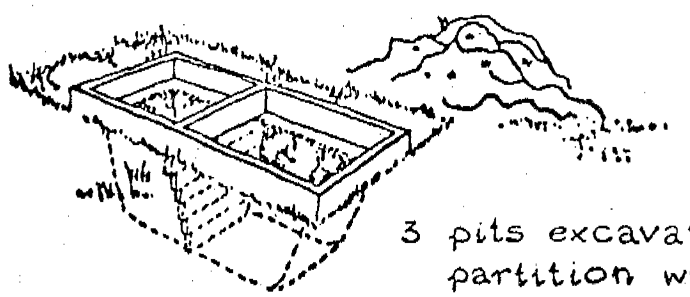
Economies can still be made in latrine construction costs by experimenting with available materials, improving detail design and by using more self-help labour.

PIP

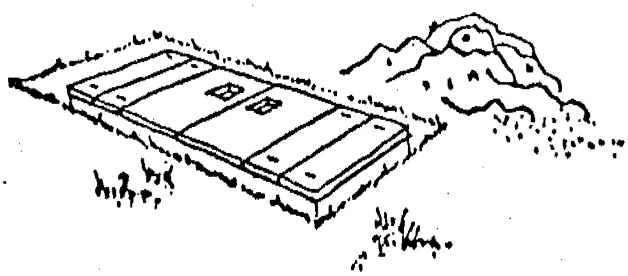
1 shallow excavation - level base



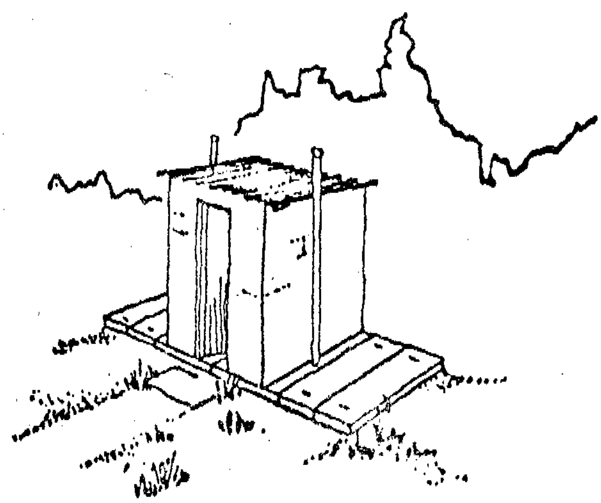
2 concrete liner cast in shutters on undisturbed ground



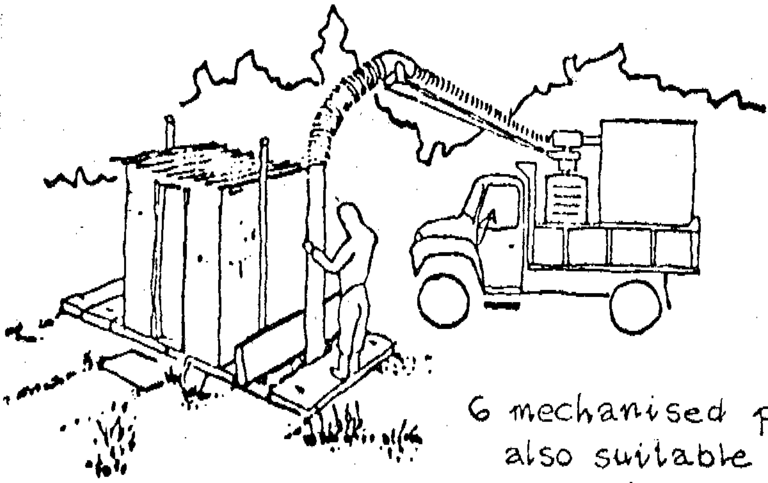
3 pits excavated within liner; partition wall constructed



4 precast concrete floor panels and access covers assembled



5 superstructure on floor panels; separate vent to each pit compartment



6 mechanised pit emptying; also suitable for manual emptying

Figure 1

In Africa field testing is required for the RIP and DIP versions of permanent doublt pits, although pourflush double pits are already in service in other parts of the world. It is hoped to build demonstration examples of the Raised Improved Pit in Malawi so that not only can its acceptability and construction costs be ascertained, but also the need for and the effectiveness of the sand filter be studied.

ACKNOWLEDGEMENTS

The writer would like to acknowledge the advice of Mr W John Lewis, Ministry of Lands, Valuation and Water, Malawi, for his advice on pollution hazards of latrine systems and the filter effects of a sand bed for the RIP latrine.

Also acknowledged are the helpful discussions held with Dr Peter Morgan, Blair Research Laboratory, Zimbabwe, concerning fly breeding and vent screening in pit latrines.

The work described in this paper has been carried out as part of the research programme of the Building Research Establishment of the Department of the Environment.

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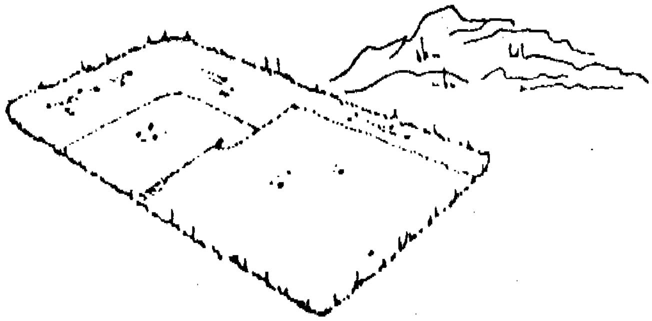
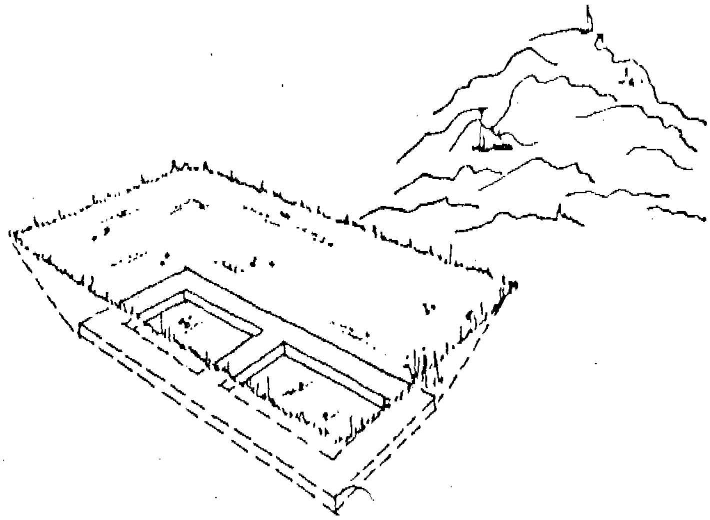
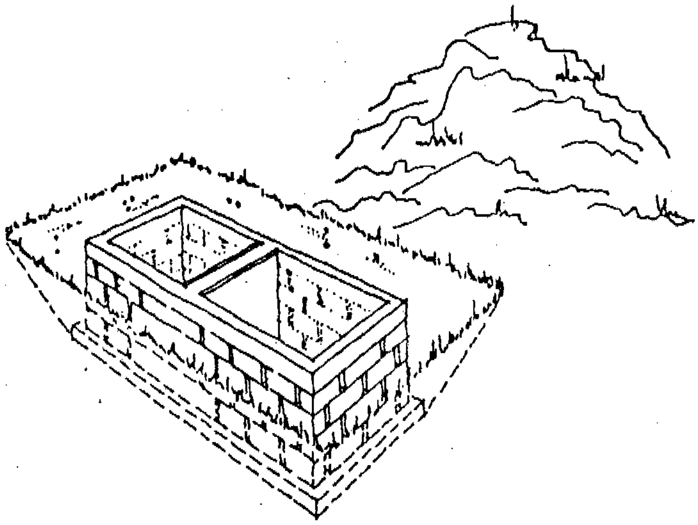
RIP



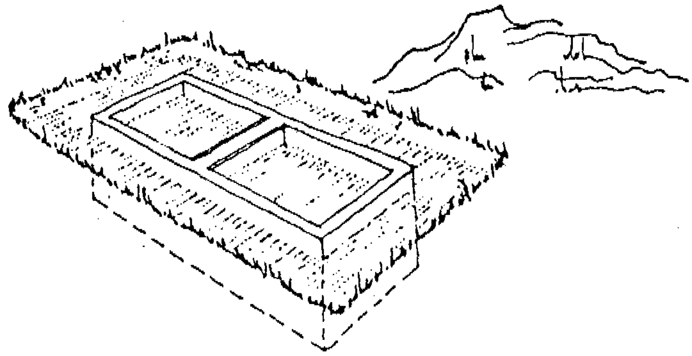
1 excavation to depth of footings



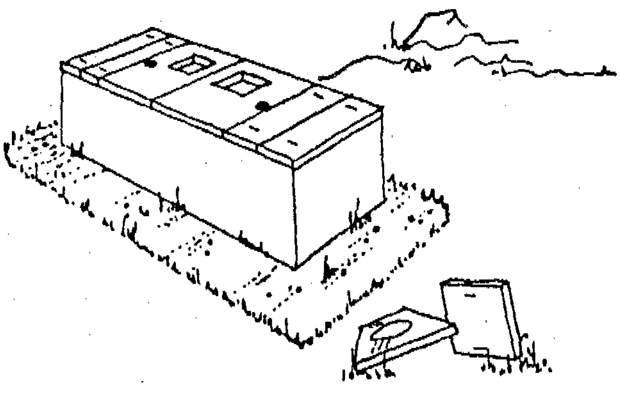
2 strip foundations for walls



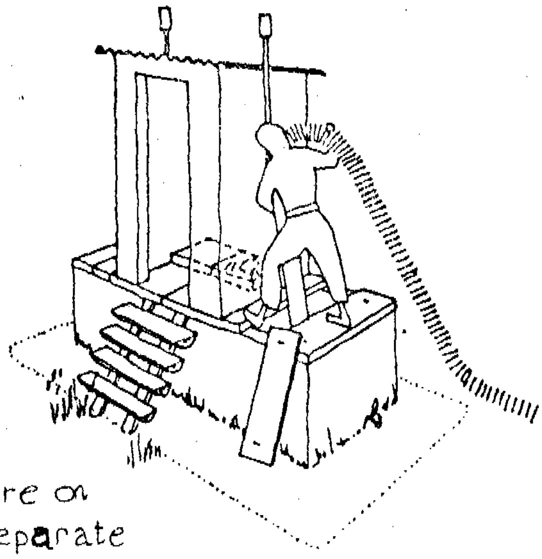
3 honeycomb brick or block walls



4 shingle/sand bed ; backfilled excavation



5 walls taken up to floor level ; precast floor units and access covers assembled



6 superstructure on floor units ; separate vent to each chamber ; mechanised or manual emptying

Figure 2

DIP 1

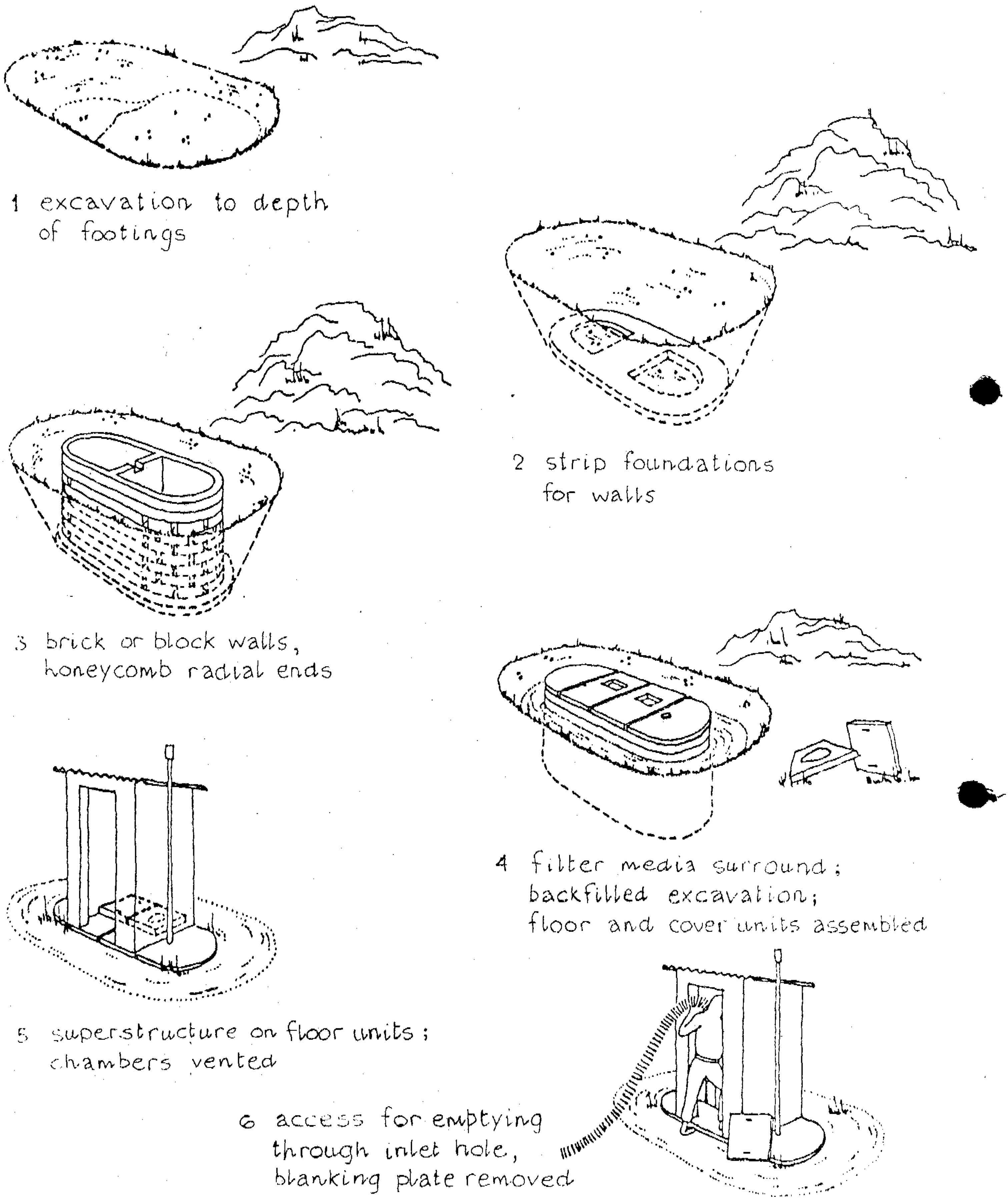


Figure 3

DIP 2

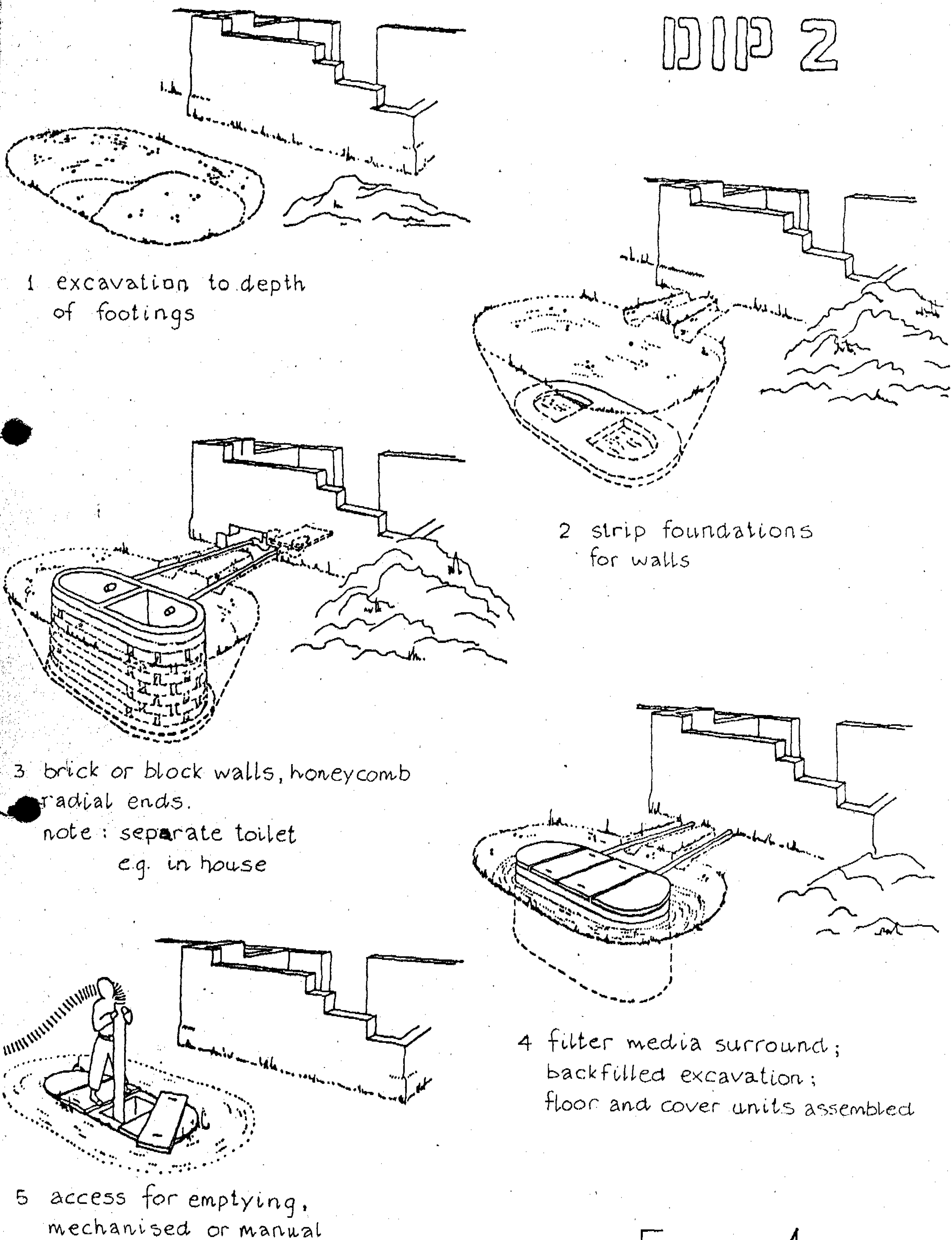


Figure 4

AFFORDABLE SANITATION FOR DEVELOPING COUNTRIES

R F Carroll, CEng, MIMechE
Building Research Establishment, UK

BRE Overseas Division Course:
Building research for developing countries 6-10 September 1982

AFFORDABLE SANITATION FOR DEVELOPING COUNTRIES

by R F Carroll CEng MIMechE

INTRODUCTION

The BRE Permanent Improved Pit (PIP) latrine concept was developed in an attempt to bring together the best in simple and minimum cost sanitation technology for situations where only pit type latrines are affordable. The result was an effective latrine and on-site treatment system that satisfies the basic criteria of providing a means of collecting and retaining human excreta until rendered harmless and inoffensive before discharge to the environment. To extend the PIP principle of utilising twin pits or chambers and allowing a two-year retention period for stored excreta to eliminate health hazards through human contact, two alternative designs have been produced for situations where:

(i) there is a high water table or persistent flooding,

(ii) a small amount of water can be used for flushing a low volume waterseal.

These two latrine designs are respectively the Raised Improved Pit (RIP) and the Double Improved Pourflush (DIP). They are intended to complement the PIP design in giving alternatives to meet most situations likely in developing countries.

The designs, figures 1 to 6, are intended to illustrate concepts. A variety of construction materials could be appropriate and must be selected to suit availability in a particular situation; the choice must also be linked to suitability and durability.

DOUBLE PIT LATRINES - IMPROVED AND PERMANENT

The first major development of PIP type double pit latrines was in Botswana, where over 2000 were built in 1979-80 and where they were called the Revised Earth Closet (REC). The cost at that time was marginally less than the large ROEC single pits and considerably cheaper than the Botswana type B aqua privy.

The PIP concept is basically that twin chambered pits are used, only around 1.5 m^3 effective volume of each chamber, and are intended to be emptied by suction hose or manually with long handled shovels. The material to be emptied would have been retained in a chamber for at least two years after sealing off to ensure advanced decomposition and removal of organisms harmful to humans. The material should be friable and humus-like if retained above the water table.

If emptying takes place in wet conditions, eg where the pits are flooded, then the chamber contents could be like a running slurry and suction emptying would be necessary. However, as long as the retention period of two years has been observed then the material should have little offensive odour and should be harmless to health.

The designed capacity of each chamber is intended to last a family of five or six persons for around three years before sealing off and bringing the other chamber into service. Two more years are allowed to elapse before emptying the first chamber.

Ventilation pipes are provided to both chambers, discharging above roof level. This drawing-off of gas and air from the chambers, produced mainly by wind blowing across the open end of the ventilation pipe, induces an inflow of air through the latrine inlet hole. This prevents gases entering the superstructure from the pit via the inlet hole, thus reducing unpleasant odours.

The PIP concept is primarily intended as a basic dry pit latrine, although it will function even if periodically flooded. Emptying dry material lends itself to manual emptying and if suction is to be used then a high air flow machine is necessary, drawing through a 150 mm diameter hose. Traditional cesspit emptyers will only draw material such as thin slurries, since the hose needs to be completely filled with liquid; often a 75 mm hose is used, which for domestic latrine emptying is susceptible to blockage by domestic rubbish sometimes deposited in latrines.

VARIATIONS OF THE DOUBLE PIT CONCEPT

For areas with high ground water all the year round or which are subject to flooding, a double pit has been designed to allow the decomposing excreta to be retained above ground level. This has been called the Raised Improved Pit (RIP) latrine.

The RIP has a sand filter 1 m deep immediately below the waste matter. Liquids of decomposition, urine and water that have been put into the latrine will seep downwards and sideways. The sand filter will reduce the pollution problem by filtering out most harmful organisms that might otherwise contaminate the ground water.

In many developing countries water is used for personal cleansing after defecation and there is often a desire to incorporate a waterseal in the latrine as a gas-tight seal. A twin chamber, pourflush type latrine design has been produced and has been called the Double Improved Pourflush (DIP) latrine. Flushing is by hand using a container of water around 1½ litres. The waterseal should be around 12 to 18 mm.

To assist percolation of liquids, the twin chambers in the ground are surrounded by a sand bed to increase the percolation area of the pit sides. Some cleaning of the sand filter could take place during the retention period, where naturally occurring bacteria would tend to break down the solid particles and slime that may block the interstices between the particles in sand and soil.

It is important that the percolation capacity of the surrounding ground is suitable if quantities of water are to be introduced to pit type latrines.

PERMANENT IMPROVED PIT LATRINE (PIP) - Figures 1 and 2

This design is the original BRE concept of the double, emptyable and ventilated pit latrine. It is suitable for suction emptying or manual emptying with long handled shovels. Main features are:

(i) No water necessary. If water is used for personal cleansing the amount should be kept to a minimum.

(ii) Small double pits or chambers, each 1.5 m^3 effective or storage volume.

(iii) Pit tops and superstructure supported.

(iv) Pits ventilated, to reduce odour and insect nuisance.

(v) Mechanised or manual emptying.

(vi) Two year retention period.

(vii) Three year emptying cycle.

(viii) Pit contents decomposed, harmless, inoffensive and useful as a fertiliser.

(ix) The retention period is also a rest period, allowing bacteria in the ground to break down organic matter tending to block soil interstices and affecting the absorption of liquids into the ground.

The construction sequence:

(a) Initial shallow excavation, 350 mm deep, with level bottom.

(b) Concrete liner (ring beam), 500 mm deep x 100 mm thick, cast in shutters on undisturbed ground.

(c) Pits excavated within liner and partition wall constructed up to the underside of the liner.

(d) Precaste concrete floor panels and access covers assembled.

(e) Superstructure erected on floor panels.

(f) Separate ventilation pipe with insect screen to each pit.

RAISED IMPROVED PIT LATRINE (RIP) - Figures 3 and 4

This design is a variation of the original PIP latrine, incorporating the same principles. It is intended for situations where the groundwater is high or the site is subject to flooding.

Excreta is retained in the chamber above ground level and in this way the resultant decomposed soil-like material should be free of excessive water on emptying, thus keeping the bulk to a minimum and helping to prevent odour.

Filtering out of harmful organisms should be achieved by the shingle and sand layers, thus reducing the risk of pollution of groundwater.

The rest period of at least two years (retention period for material before emptying chambers) should encourage a self-cleaning effect of the sand and ground interstices. Naturally occurring bacteria can break down organic particles and slime that tend to block originally porous media.

Exterior walls can be of brick or concrete block. The partition wall should be rendered at least on one side to make it impervious and so prevent any migration of pathogens between chambers through the partition wall.

DOUBLE IMPROVED POURFLUSH LATRINE (DIP) - Figures 5, 6 and 7

Another variant of the PIP and incorporating a pourflush waterseal. There is therefore a requirement for water in small amounts to flush the waterseal traps after use. Around 1½ to 2 litres of water should be sufficient to clear the trap, remaking the shallow waterseal of from 12 to 18 mm.

The chambers have honeycomb brick or blockwork end walls to allow percolation of liquids to the ground. By surrounding the perimeter walls with a sand bed, increased percolation should result. This would be unnecessary if the latrine is constructed in porous sandy soil with good percolation.

Similar to both the PIP and RIP latrines, the rest period for the ground and sand barrier may help to prevent clogging by organic matter, utilising naturally occurring bacteria.

Figure 7 illustrates a version of the DIP that has the toilet pan inside the house and the chambers or 'pits' outside. Twin squatting plates are shown, but could be a single plate (toilet pan) with outlet pipe taking the flow to a 'diverter' arrangement. The flow is directed to one or other of the receiving chambers.

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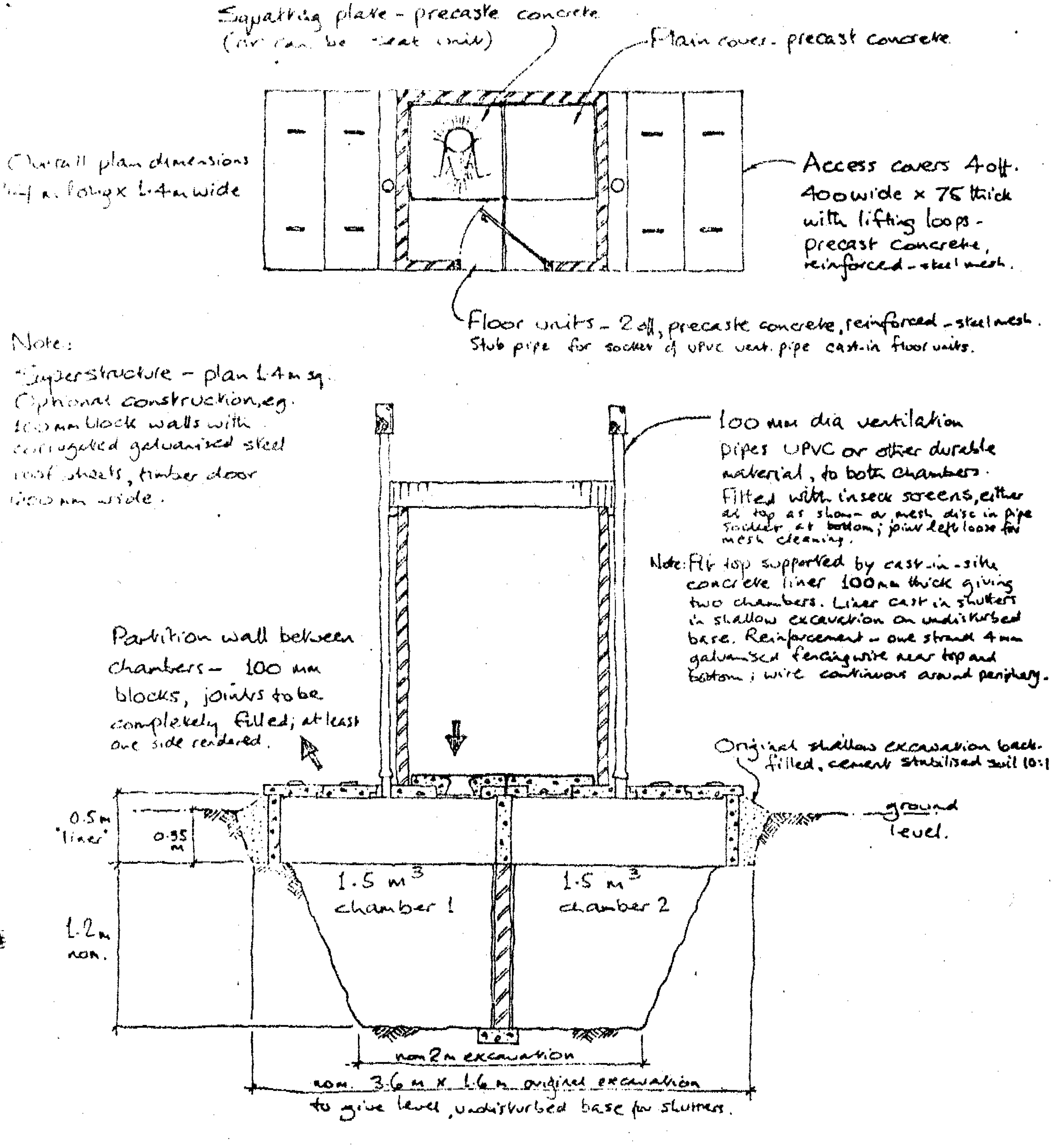
ACKNOWLEDGMENTS

Acknowledgments to Mr John Lewis, Loughborough University of Technology, for his advice on filters to reduce the risk of bacterial pollution of groundwater from pit latrines.

Acknowledgments also to Mr Brian Muckley ARIBA, for providing the artists illustrations, figures 2,4,6 and 7, depicting the sequence of construction of the various latrines in this paper.

PIP



Note: chambers emptied thro' access covers. Material to have at least two years retention before removal. Chambers used alternately for three-year periods (estimated for family of 5/6 persons.)

"Permanent Improved Pit Latrine" (PIP)

Building Research Establishment, UK.

28. 8. 80

Scale 1/40 approx.

Dimensions in mm & m

Figure 1

PIP

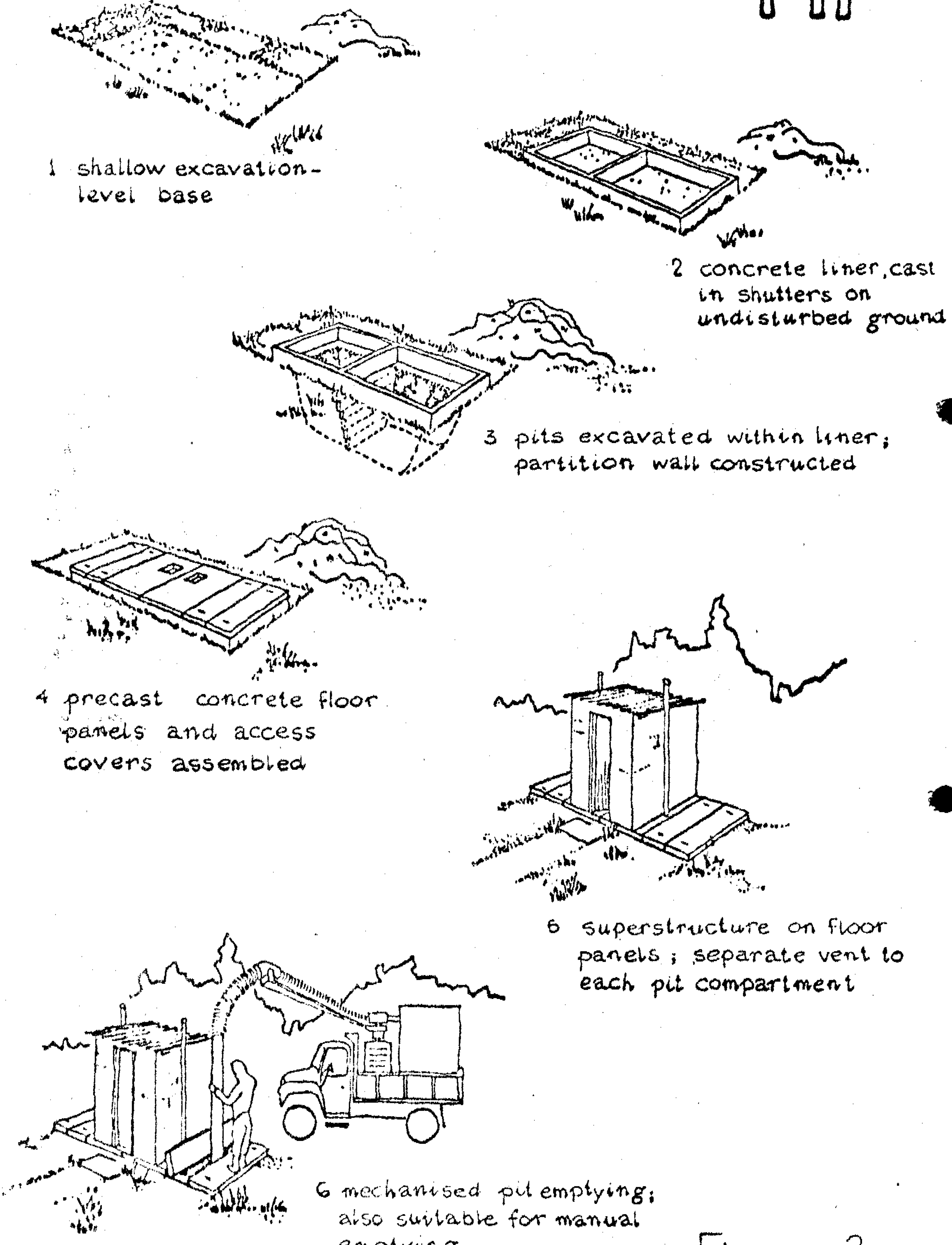
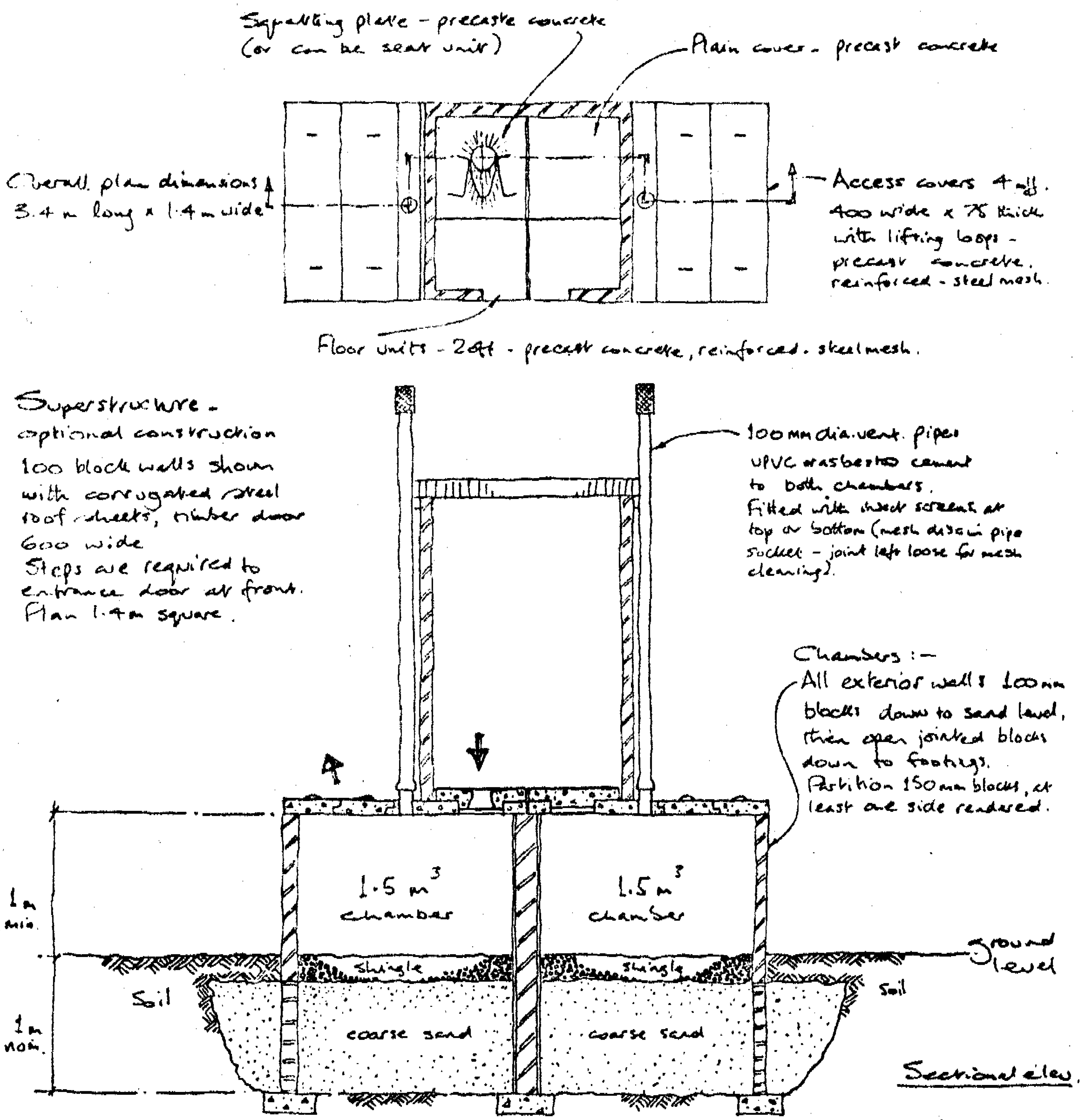

1 shallow excavation-
level base
2 concrete liner, cast
in shutters on
undisturbed ground
3 pits excavated within liner;
partition wall constructed
4 precast concrete floor
panels and access
covers assembled
6 superstructure on floor
panels; separate vent to
each pit compartment
6 mechanised pit emptying;
also suitable for manual
emptying

Figure 2

RIP



"Filter bed" - 200 shingle over 800 clean coarse sand, (3 mm sieve down).

Note: Chambers emptied thro' access covers. Material to have at least two years retention before removal. Chambers used alternately for three year periods (estimated for family of 5/6 persons).

"Raised Improved Pit Latrine" (RIP)

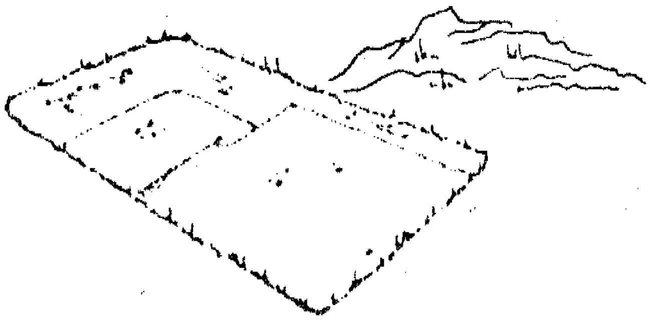
Building Research Establishment, UK

RL 6. 6. 80 (1)
28. 8. 80 (2)

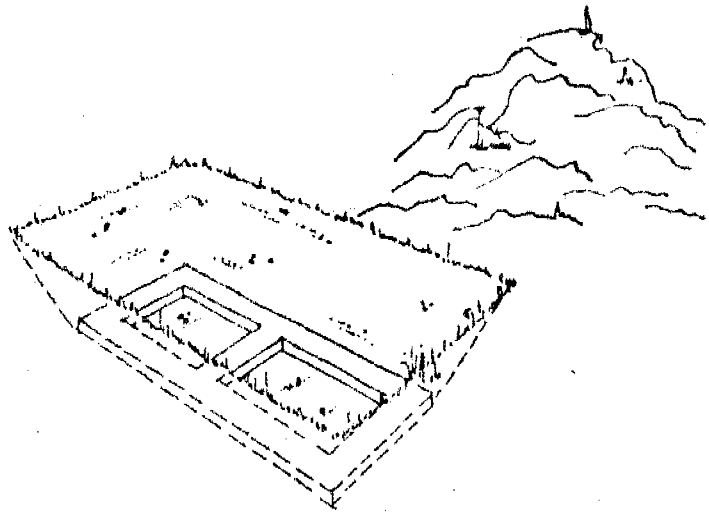
Scale 1/40 approx.
Dimensions in mm & m

Figure 3

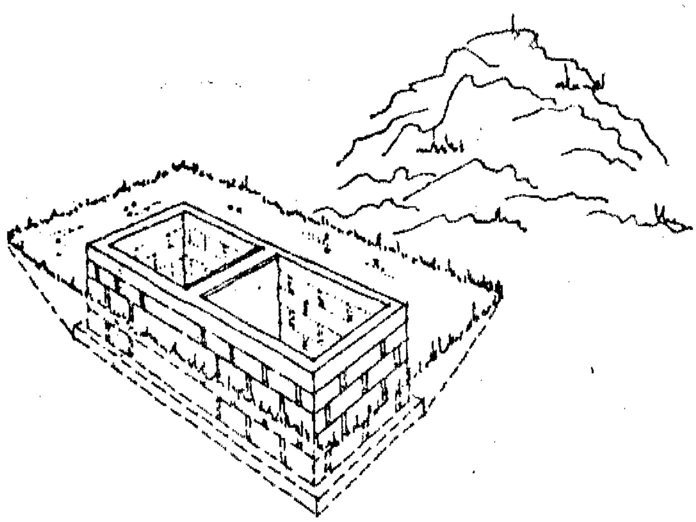
RIP



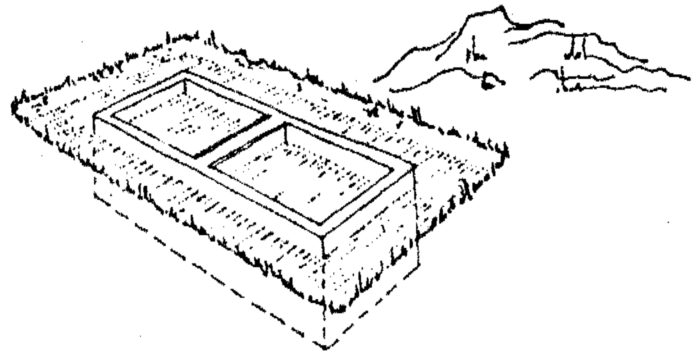
1 excavation to depth of footings



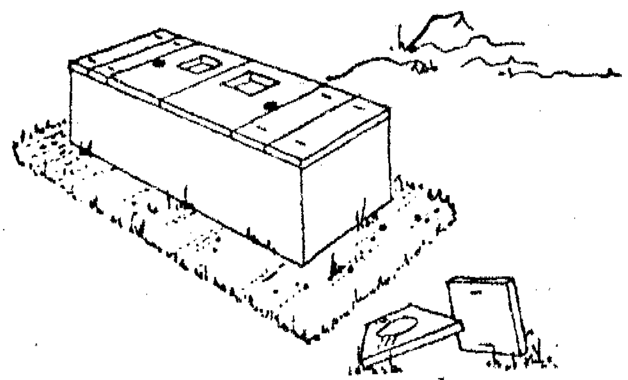
2 strip foundations for walls



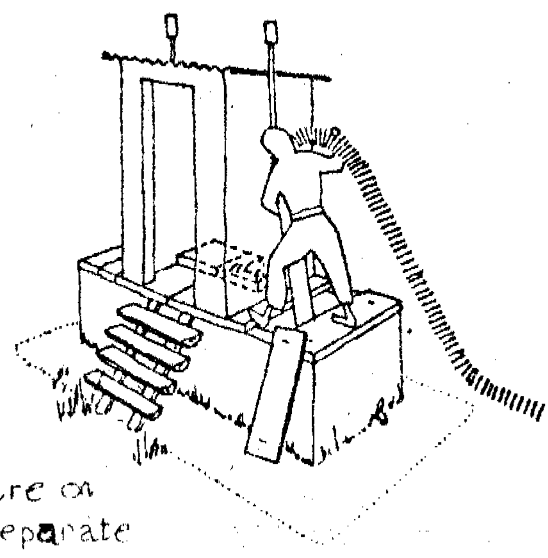
3 honeycomb brick or block walls



4 shingle/sand bed ;
backfilled excavation

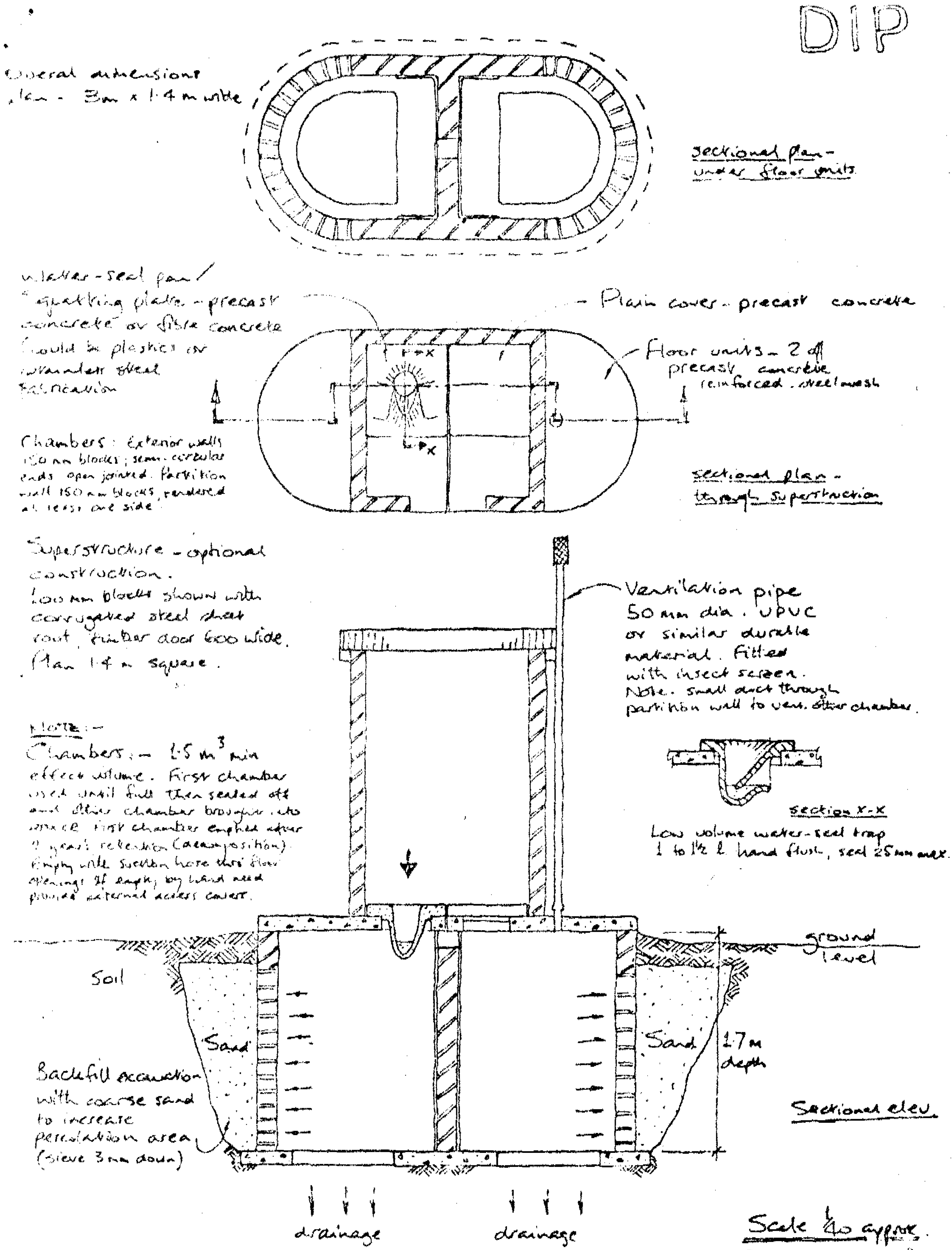


5 walls taken up to floor level ;
precast floor units and access
covers assembled



6 superstructure on
floor units ; separate
vent to each chamber ;
mechanised or manual emptying

Figure 4



Scale 1/40 approx.
Dimensions in mm & m

"Double Improved Pourflush Pit Latrine" (DIP)
(in ground with good permeability and above water table)
Building Research Establishment UK

6.6.80

Figure 5

DIP 1

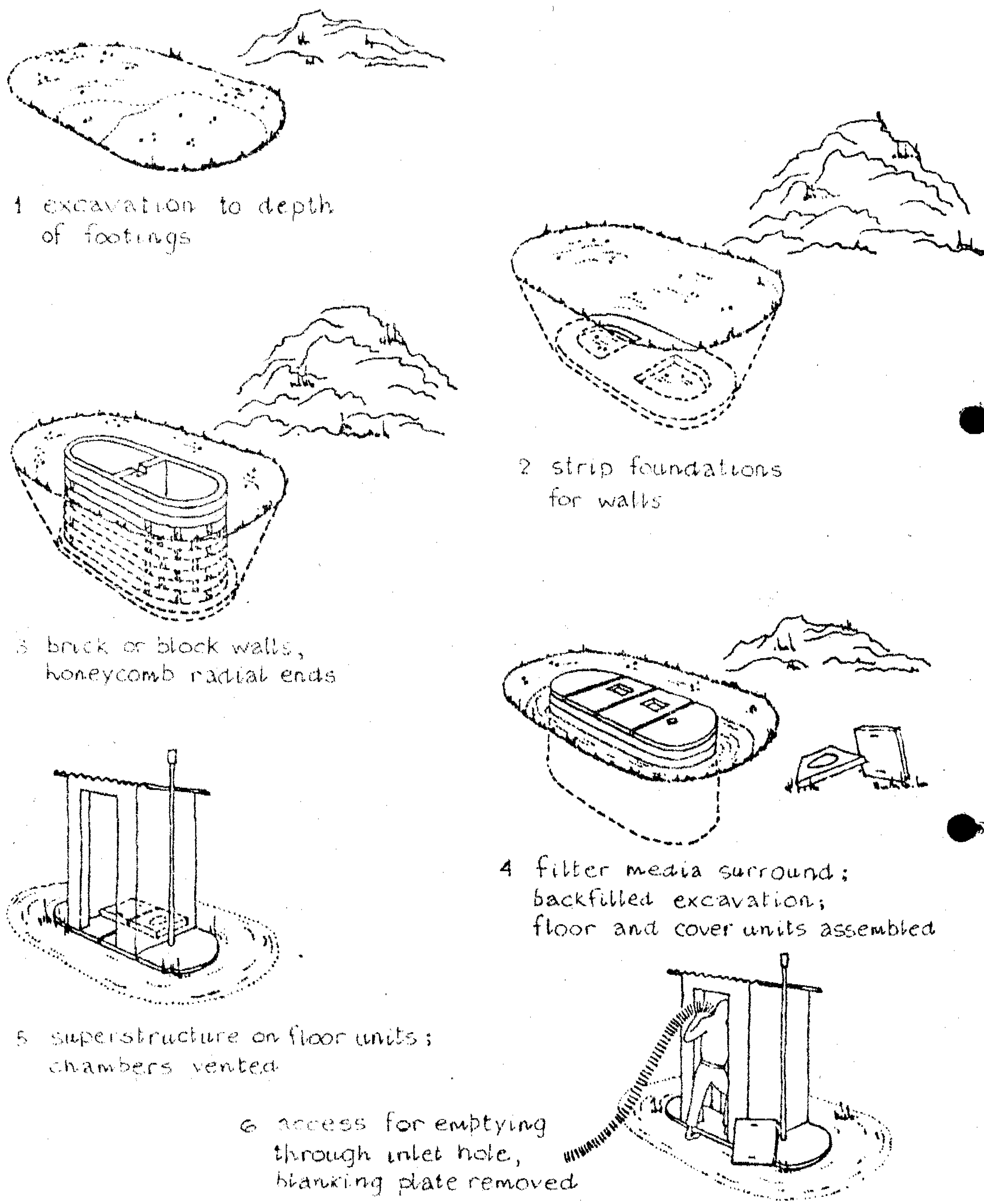


Figure 6

DIP 2

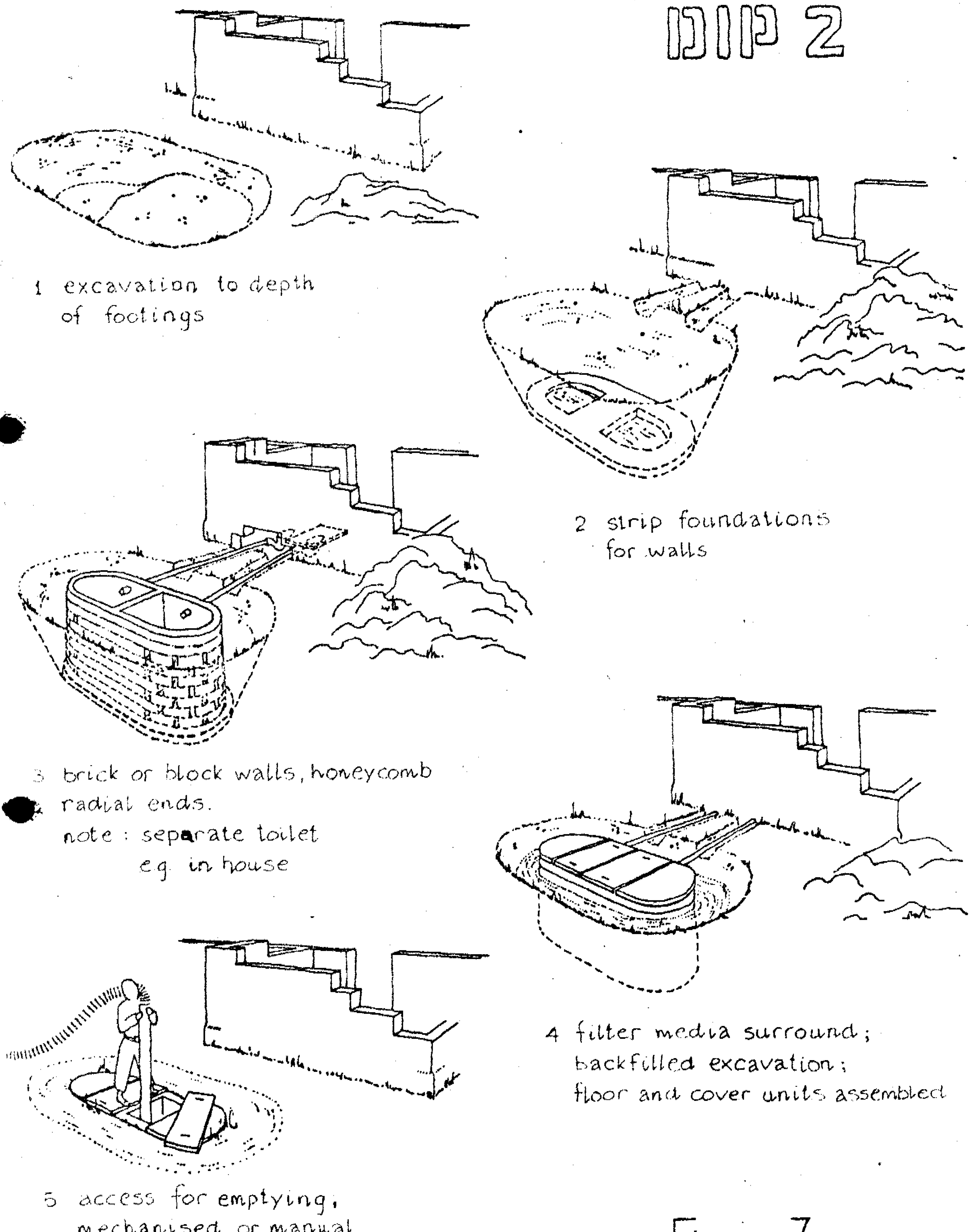


Figure 7

SOCIAL ENGINEERING AND APPROPRIATE TECHNOLOGY

An experienment from Baldia Soakpit Pilot
Project Karachi.

By

QURATUL AIN BAKHTEARI
Community Organizer
KATCHI ABADI IMPROVEMENT PROGRAMME UNICEF.

1. My present write up is based on my personal experience which I came across while working as a community organizer for three years now, in a UNICEF sponsored project for Katchi Abadi (Slum) improvement, in Baldia Town, Karachi.

Baldia Town:

It is located towards the North of Karachi. The industrial areas, which is very close to Baldia, provides employment for many of its people. According to the census of 1971, the population of Baldia was 79,529. But now it is not less than 200,000 covering a total area of 430 hecters, having 24,200 plots.

The people and their living condition:

The population is economically and socially Hetrogeneous. People from all over the country live in small pockets or Mohallas (neighbourhoods) which are extremely homogenous, because people belonging to same villages live within their own ethic group.

Majority of the houses are semi-pucca, that is the Walls are made of C.C. blocks with no plaster, and tin or asbestos sheet about 5% are hutments, and 5% have good quality R.C.C. structure most of the people are unskilled labours e.g. potters and apprentice for mason and carpenters. Quite a few are working as loaders at the fish harbour. But a good percentage of trained mechanics and technical people, who work in the industries near Baldia, Unemployment seems not tobe a major problem. Although they are low paid workers.

Water is supplied by a net work of stand pipes installed by the K.M.C. (Karachi Metropolitan Corporation) for 5 hours a day.

Sanitation the most common latrines are served by the conservancy, system. About 70% - 80% of the houses in Baldia has bucket latrines. The residents place a gallon oil drum or a battery case, in a rectangular channel in which faces is collected. Another common practice is that the latrine has a plinth slabes towards a hole, in the outside wall through which faeces are removed and urine and cleaning water runs off to the road way or open ground outside the plot.

The containers or channels are emptied by self-employed sweepers. Who collect the excreta in bigger tin, then the house owner throws water into the channel, to clean it. The water usually runs through the outside face of the boundry wall, and stays there.

When containers of the sweepers are full, he takes them to one of the three main disposal points, or dumps the contents into a nearer drains or vacant land. The condition of these laterines get worse. When the sweepers do not come for 2 days, excreta and waste water flow on the streets. Sometimes a small pool of stagnant sullage and excreta, are found out side the plot near the latrine. The occupants of the houses with out latrines, and also some children from house holds with latrines defecate, in open spaces and streets.

According to K.M.C. health reports on developing countries, more than one in 9 babies born in the slum areas of there countries die before reaching one year of age. Those who survive suffer from frequent diseases and ill health.

The main causes of this high mortality and morbidity rate are unsanitary methods, of human waste disposal and a low level of health consciousness.

Baldia Town being one of the oldest and largest Katchi Abadi (Slum) concentration of Karachi, faces these problems.

Since the sufferers were mostly children, this made UNICEF interested in the sanitation programme of Katchi Abadies. Since 1979 I am working at the grassroot level as community organizer. My work is mainly to organize people to improve their sanitary conditions by upgrading their existing sanitation system that is the soakpits latrines. The first mohalla (neighbourhood) where we started our programme was in Turk Colony in Baldia.

Turk Colony the people and Community:

This community is right in the middle of Baldia Town, It is a compact homogenous community, who call themselves Turk Sepoys, because their ancestors orginally came from Turkey as soldier of Muslim Army who conqured India. The area was totally inhabited by Turk Community in 1958, when Baldia was a large piece of vacant land, on the out skirts of Karachi. In 1960 after the fire in the city inwhich a large number of huts were burned, the government got them settled in the present area. About 250 small plots were alloted to them. The area now covered by this community is 70,000 sq. feet. with more than 500 plots accommodating more then 600 families.

The people of Turk Colony came in 1947 from veraval a village in Junagharh State (India). The community is like one big family, because of inter-marriages, one finds every family related to the other. Their language is Gujrati, but can speak Urdu too.

The total population of this colony is about 4000 to 6000 people. The family pattern is generally joint family system. Illiteracy rate is high, and eighty percent of the women cannot read or write, the area lacked any medical and educational facilities from the government or any other institution, most of the people are skilled and unskilled labours e.g. masion, carpenters, petty shop-keepers, hawkers, paddlers. The average income is Rs.400 to Rs.1,000 per month. Few who work in middle eastern countries sends home a good amount some of the women are also involved in income generating activities within on outside their area. Water is supplied by 12 stand pipes in lanes of the colony. These taps receive water every second day for 2 hours. There is a extreme shortage of water.

Sanitary condition is the same as in whole of Baldia, about 80% of the people have bucket laterines, and 20% have a traditional style soakpita latrines. This shows that people do have sanitary knowledge, although the number is few with soak-pits latrines. But as these soakpits are poor in construction, and lack proper technology, thus they do not function properly, and get filled up within a very short period, the other aspect was that these pits are made outside the houses on the streets, which creats an obsticle in future development of the area as well as the pits gets damaged by heavy vehicles. Seeing the failure of the locally make soakpit laterines, most of the people do not make an attempt to construct one for themselves.

The Social Organization of Turk Colony:

The people of Turk Colony has a local social organization. This organization was created to check the antisocial elements and to solve family problems of the community, it is call ed Veraval Turk Jamat, it has a office in Turk Colony. Th organization consist of elderly people of the community, who were elected about more than 5 years, ago, although the election is supposed to be held every year, since then there has been no election. The Jamat has a strong social control over its community. The community gives Rs.2/= (about 25 cents) per month as member ship fee. The other way of income of this Jamat is, that they rent out crokery, cutlery, tents and other requirements of wedding ceremoneys, and other items on social and religious occasions of their community.

The major community services the Jamat provides are as follows:-

1) Distributing charity to the widows and orphans.
2) Running a sewing centre for the girls.
3) A night tution centre for the boys.
4) Giving assistance in the marriage of destitutes.
5) Holding functions and arranging visits for the outside visitors and for their spritual leaders.

6) The most common and the major function of the Jamat as told by the people and the Jamat's members, was and still is, is arbitration. Fights and qurrals often occurs within groups and families. The Jamat settles all sorts of problems from divorce and family problem, to anti-social problems of the community. So none of the cases go to police or courts. Jamat's decision is final. In case of disobedience the person or family is socially insolated, and nobody visits the person or family, in times of happenies or sorrow even in death, the Jamat and the members do not give any assistance.

Social Engineering and Appropriate Technology:

In 1979 when we came incontact with s me of the younger people of Turk Colony and discussed the sanitary condition of their area. It was revealed that they themselves were very much fed up, with the dirt deseise in their area the soakpits they made were of poor quality and would not last long. After holding many meetings and exchange of ideas for solutions for a proper sanitation programme. It was found that due to following reasons people do not have a proper latrine.

1) Generally people are not aware of the relation ship between human waste and deseise.
2) The efforts the few made to construct soakpits, failed to solve the problem, due to lack of knowledge for appropriate technology.
3) People are too poor in some area, to have a soakpit.
4) The availability of the sweepers who are employed by the household, for cleaning of their bucket latrines.

5) Lack of understanding and awareness in the local community's social organization for the solution and management of sanitation.

6) Dependency upon local authorities for a sewerage system.

7) Depending upon God to take care of the ill health and desieses.

In the view of the above finding UNICEF took up the design of long life soakpits latrines prepared by wast and water in developing countries (Wedc) group from the University of Technology Loughbrough, England. Since the pit latrine was to last longer and was technically more durable, the cost was higher then what the community, could afford. The other problem was that the pit has to be constructed inside the houses, the design of the soakpits was such that minimum amount of water was required, and if the family is of mine members, the pit would last for 10 to 15 years, depending upon the proper utilization of the latrine. For these reasons following approach was used by UNICEF in colaboration with Karachi University, Deptt: of Social Work and Pakistan Jaycees (Junior Chamber of Commerce.).

1) There will be a Baldia Soakpit Pilot project which will have a Civil Engineer for the technical side of the soakpits.

2) For the social aspects there will be a community organizer, who will organize the community and creat health councíousness by motivation, education, training and demonstration and then transfering the successful sanitation models in other areas, through local community organizations.

All these details of the project were discussed with the people of Turk Colony and after months of motivation, meetings and demonstration of the designs the group of these young men who belong to a cricket team in Turk Colony was organized, for construction of soakpits in side their houses. Once this small group of young people were convinced and motivated, UNICEF provided an engineer to plan and help the project, in the technical aspects.of the construction of pit latrines.

Designs and illustrations were printed and distributed by this group, and efforts were made to list the poorest and the most filthy condition of the latrines. A survey was conducted on chi'ds mortality and morbidity rate, and on the existing sanitary conditions of the area.

The cost of the soakpits was drawn out which came to about Rs.1700/=(US.170 Dollars) per pit, this was too much for the people to bear and for any organization to provide. So people were asked to share in the cost by providing the labour. This was though and time taking job, for many reasons, which we will discuss in the end. To start with and to break the bearer this group of cricketers started digging their own pits, and started organizing to produce the construction material for soakpits themselves, in order to bring down the cost. Within a months time more then ten pits were constructed by the mason, who belong to this group of Turk Community, he was trained and assisted by the engineer of the project. All the labour was done by the people while material assistance came from UNICEF

(US.170) Rs.1000/=
this not only brought down the cost from 1700 rupees/(US.100 dollars) but also helped this group organize better, and probided an apportunity for others to see the new and improved design and to observe and learn construction of the pit laterine, and also to see the benefit and the marked cleanlines of the homes as well as the lanes.

All these points had a very positive impact on the Soakpit construction and acceptance of the pit latrines,. Within a short period of less then six months 90 soakpit laterines were constructed, in which labour and management was provided by the people, while the material for the poorest came from UNICEF, rest of the well off house holds made their own laterines by their own resources, with the technical assistance from the project.

This groups of people of the Turk Colony organized very strongly and made remarkable contribution to the sanitation programme of their area as well as in the motivation of their mother Jamat that is Turk Jamat, who did not participate at all, and did not approve the participation of these younger people also, because they organized themselves in a Turk Welfare Society and started their own news paper, in which they gave all the details of soakpit construction and asked the Turk Jamat to widened its approach and take sanitation up as one of its functions. The efforts the Turk Society made in motivation demonstration and participation in the construction of the soakpit laterines are asfollows:-

1) Holding meetings and motivating people, by making home visit, and distributing designs and methods in the construction of soakpits.

2) Purchasing of material at the whole sale rate.

3) Storing the material.

4) They brought ? sets of digging tools for the people wanted to dig their own pit themselves.

5) Producing construction material themselves e.g. blocks and lids, covers of the pit.

6) Doing free labour for the destitute and the widows.

7) Listing of the houses and marking them for the follow up, in sanitation training programme.

8) The society also provided a place for the office of the project, in which all the labour for the carpentory of table and chair was done by the people.

9) They invited the may or of Karachi and showed him that how they have cleaned their area and asked for more water taps in their colony.

10) Apart from sanitation the society under took the following responsibilities of their community. Helping and assisting the K.M.C.(Karachi Municipale Corporation) and the local Councilor in the developmental plans of their areas, for e.g.lease construction of roads, open drains, electricity.

11) They manage to get more water taps and street light.

12) A resrvior water tank was constructed.

The obsticale they faced was of lack of confidence and trust in the people. Following were the ways through which the people expressed their mistrust, and created problems in motivation and construction.

1) That why should we put in our labour this should be also

provided by the project, may be the society or the project is holding back the money for the labour.

2) That these people have some personal interest or they will aske for votes or want to convert us in to Christians or they will take away our land after the soakpit is made.

3) What will happen if the pits gets full, we do not want to have all the dirt in side our houses.

4) Sanitation will not help in improving our health it is God's will even if we have laterines, still it is God's will to keep us healthy, laterine or no laterine, so why bother. These and many other small inquiries were made, some time-s by the people themselves and sometimes by inciting the issue by Jamat's members who though and believe that the sanitation is not people responsibility.

The Jamat said that they cannot do all this construction work its members being old and weak physically, they wanted to carry on with their traditional role, that one gets by being an elderly member of a society. Their believe that all the problems will be solve by giving charity to the poor, and leaving the rest to God's will. But at the same time they did not approve the popularity and success of this young group of Turk Society.

Impact of Sanitation:

After the construction of Soakpits the women and children had to be trained and educated on the utilization of the laterine.

Since sanitation, hygine and health is basically concerned with women and children, and I had to visit every family

personall , this brought me in close contact with women. All the women who now had soakpit laterines formed in groups and regular group meeting were held, in these meetings they were taught how to store waste water from bath room and the left over water from washing clothes. Demonstration was made how to flush with minimum water. Leaflets and hand books were printed on better child care,ehygine and sanitation . But when these reading material was given to the women, they could not read at all, and it was at this point their men and women realized the need for the education of women and children.
As the community of Turk Colony was thinking about the draw backs of lack of literacy in their women and girls, I used this opportunity, at once by discussing and investigating the problem in more detail, soon I came up with the following reasons of high illiteracy rate in women and children.

1) The government schools do not have enough place, to accomodated all the children.
2) Parents do not send their daughters and small children to school, because the schools are too far from home.
3) Education for girls is consider useless, as they will be married and have children and home to look after.
4) The parents who wants to educate their daughters, do not want to send them to school, but would prefer, to send to a neighbours home for religious education.
5) Most of the children work, and cannot follow the school timings.

6) Schooling is too expensive for most of the parents, so if they can afford they would prefer to send their boys to schools, rather then sending their daughter.

7) The mother's keeps the eldest daughter to help her in the house work and look after the babies.

8) Some parents were against girls education, because they belive that once she knows to read and write, she will write letter to her boy friends, which will bring disgrace to the family.

9) Most of the children and especially girls and working boys, and those who are small, but is old enough for school, do not go to school, because of expenses involve for books, uniform, shoes lack of attention, timing and distance of school.

From the above findings, we searched for a traditional educational system present in the community, besides government primary schools. We found the followings:-

1) Large number of children goes to the homes of their neighbours for religious education only, here they pay a fee of Rs.5/- per month (US.50 cents) for two hours a day.

2) Few women and girls who are educated up to high school, teachrs small children and girls in their homes and gives primary education as well as religious education and charges Rs.5/- (US 50 cents) to Rs.15/- (US 1.50 Dollars) per month.

3) Since this traditional pattern of education, do not have fixed timing, and the girls are sent here more easily, because usually this educated girl or lady is wel known and respected by the community, it does not give the impression of a formal school that is outside their community and control. In women's meeting we discussed a educational programme for women and children which will be based on the same traditional educational system present in the community. This idea was very much accepted by both men and women of the community

So in August, 1981I I alongwith the women of the community prepared a programme to look for, girls, and women who have high school education and by November,1981 we had ten such girls and a women who were given training in primary education, by a student of social work Deptt: Karachi University, who has a degree in education also.

One women was given training in adult literacy to teach women read and write. Funds for the teaching material was collected from the mothers and women of the group, and by end of Nov. 1981 these ten teacher were teaching to more then 300 children in their own homes, for two hours a day, for a fee from 50 ps. (US 5 cent) to Rs.15/- (US 1.50 Dollars) per month. The children were taught by charts slates, which the parents of the children provided.

Women started a sewing and craft centre and literacy to classes, up to now more then 100 women have learned to read and write. And most of these women assist me voluntory in motivation in the new neighbourhoods to start sanitation programme.

In July,1982 UNICEF started supporting this home school programme too, and by this support we have now trained, 50 girls, out of these 43 are giving primary education combine with hygine and sanitation lessons, to more than 900 children out of these more than 600 are girls, who have never been to any school. In each home school there is a mother group, these mothers meet once a month, for training and lectures on health and sanitation.

Through these home schools our soakpit programme has expended in 14 neighbourhoods of Baldia, having more than 5000 families. The clean lines inside their homes because of pit lateTine made them realize that things can be done, if they participate in improving the conditions themselves, soon at every door came a dust bin the little children for whom it was normal to defecate on the street, or infront of the their homes, became into trouble by the women and older children. I myself s[illegible] women fighting over a child, who has defecated on the street, a practise ~~giving or~~ going on for nearly 30 years. The rest of the women wanted, the mother to clean it atonce. This successful community's traditional social organizational model, is presently being transferred in another community in Baldia. The community is Cambellpur Colony, and this time the people are rural migrants, who have alongwith them, brought their own social organization too.

<u>Demonstration and transfering of Turk Colony's sanitation model to Camblepur Colony:</u>

Soakpits as said earlier was not a new or an alian idea, but it was already present in the community, it was only due to lack of technology and social organization for management that people could not construct a long life pit latrines with stronger design. It proved to be a very successful approach to up grade the existing traditional sanitation system. Turk Colony is now serving as a demonstration of a low cost sanitation and management for other neighbourhoods of Baldia Town. The Community of Camblepur Colony in Baldia who has a similar sanitation system as a Turk Colony but they are rural migrants from Punjab, and is presently under the process of transfering of the sanitation programme of Soakpits from Turk Colony to their Colony.

The process for this expansion depends on the demonstration teaching and training of Turk Welfare Society. It is started when people of Camblepur Colony requested us, to start a same soakpit programme in their area. We arranged a formal meeting with the Turk Welfare Society and the people of Camblepur Society. In this meeting people of Turk Colony presented their experience, and approach for the Soakpit construction. The people of Turk Colony explain, how they motivated and organized their community, and how they managed to bring down the cost of construction. Slides on the work of Turk Colony were shown to them, and all the questions and enquiries by Camblepur were this time answered and satisfied, by the people of Turk Colony.

The next step was field demonstration of soakpits in Turk Colony, all the people of Cambulpur Colony interested in the sanitation programme were invited by the people of Turk Colony to see and observe the design and working of the new soakpits, and the cleaness in their area. After this demonstration the people of Camblepur requested our project Engineer to come to their area, a help them construct their soakpits, they also requested the mason of Turk Colony who is also the president of Turk Welfare Society, to train them in the construction of the soakpits, which the Turk Welfare society's masion immediately agreed.

The people of Camblepur Colony has constructed more than 30 soakpits within two months they have their own masion trained by the mason of Turk Colony, and the whole management, and construction is exactly the same, as it was in Turk Colony. The reasons that construction of soakpits started faster then Turk Colony were as follow:-

1) Camblepur Colony had a Community organization from before, known as Tanzeem-e-naw Camblepur. Since they came from rural area of Pakistan, it is their tradition to have a local village organization in their village. It was this organization they took up the soakpits construction and management.
2) Any technical or other problems that come up they did not have to wait for the project staff but they went to Turk Colony

and get immediate assistance from them.

3) It is easier and more acceptable to learn from the people belonging to the neighbouring area who has more or less same socio-economic status. The Community's response towards the outside educated and professional people, is that they are to be respected but not to put into practice to what they say they feel that it is easier for the educated and trained outsiders to do what they are saying but they themselves cannot do it. But once if the improvemental approach comes from the, people of their own area, then they feel sure that they can also do it.

Conclusion and recommendation:-

The miseries, problems and struggle for survival, makes the people of Katchi Abadies more united, and informorly organized. Their very survival in such adverse conditions is a prove, that they do have some organization within them, of which sometimes even they are not conscious. Our work with them was basically to study this traditional survival or organizational models the very existence of these Katchi abadies whow that there has to be some system in these apprently disorganized Abadies. We see that soakpit served as a success full entry point in the area, for the following reasons.

1) Because an intensive observational study of the social economic environmental and organizational structure was first carried out.
2) Soakpits and home schools being the existing traditional sanitation and educational system was introduced and accepted because it has been practiced by the people for a very long time,

even their ancesters used soakpits long before they come to Baldia, this system served as an entry point, rather then bring and imposing a refined and expensive technology, which would have been difficult to maintain, due to lack of water even if provided by any authority, same is with Home School education.

3) An immediate solution to their problem once the people were organized to take up the programme, immediate assistance rather then to delay the process due to bureucretic Chennels, which in return break the tempo of community motivation and accelerates the mistrust already present in them.

4. Meetings were held to establish trust, confidence and communication at their level, while following the traditional community's communicational system.

5) Not to expect quick results, but to move at the people's pace, the officers of the programme were not official or formal, but that of team work with the people.

6) We did not enter the area with any establishment, as, office staff furniture carpets, chokidars(care takers), peons, clerks such an official establishment, immediately creates a berrier between the people and the programme, and most of the time is spent in organizing the office, then to know and be in the community. It is also

observed that provision of a elaborate office, makes the already reluctant field officers who avoid the field work to sit in the office more.

7) Since sanitation, health education are those social services which are received and maintained by women, and because we had organized women worker at the implymentation level, this helped the local community women to be organized in involving activly in the programmes. because it is traditionally not expected to deal with women, we first discussed with their men and by their consist approached their women.

8) We noticed that there was a social organization present in Turk Colony from before, which was preforming the traditional role only, while they could have helped improve the environmental conditions of their area too, as they had a strong social control on the community, but it did not realize the need to change its out look and to up grade its functions, according to the changing needs of the time, untill the Turk Society was created during the process of soakpit construction.

"Human Waste Disposal Systems for Low Income Settlements in SRI LANKA"

H. PINIDIYA

National Water Supply and Drainage Board Ratmalana,

SRI LANKA

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ABSTRACT

The main Objective of this study is to identify the present sanitation conditions of the low income group of the Community in the Midland areas of the island and also to propose improved Sanitary Excreta Disposal Systems to the individual households. This will prevent various types of health hazards being spread throughout the island and protect the health which will result in improving the lives of the people.

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INTRODUCTION

The prevailing epidemic of the bowel diseases in Sri Lanka apparently reflects the inadequate sanitary facilities available especially to the lower income group of the Community and also the necessity of providing Sanitary Excreta Disposal Facilities.

It is estimated that 80% of the urban and 50% of the rural households have the fortune of utilising some mode of sanitation facilities while the rest are confined to none. Pipe Sewerage Facilities are not common features in Sri Lanka and are only available in Colombo, the capital of the country. The Government of Sri Lanka is making every endeavour to provide improved sanitation facilities to the Community with the assistance of the United Nations Development Programme (UNDP), United Nations International Childrens Education Fund (UNICEF) and the World Health Organisation (WHO). Greater emphasis is being made under these programmes initially, to convert all bucket latrines to either water sealed or pit latrines. Also whenever and wherever adequate water supplies are available sanitary excreta disposal systems will be encouraged among people through incentives provided by the Sri Lankan Government.

In the last decade it has become evident that all international and bilateral development programmes launched in providing better sanitation facilities in Sri Lanka have not achieved the results originally forecast. Therefore, such comparative failures have a serious impact when they are related to the Public Health Sector. The adoption of inappropriate and highly sophisticated technology has been the main reason for the lack of success of these programmes. Today, it is an accepted fact that proposed technical solutions for development projects, besides being technically feasible, should conform to the technological infra-structure, economic, sociological/cultural traditions.

This survey was carried out to explore the possibility of promoting the existing sanitation facilties among the low income group of the Community and it was based on Midland areas such as Anuradhapura, Matale and Polonnaruwa. The inability to carry out this survey in the coastal areas was due to no availability of requisite data and information. Therefore, the proposed Exreta Disposal System is planned to suit the geological conditions and the sociological standards of the Community in the aforesaid areas.

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THE EXISTING SANITATION FACILITIES

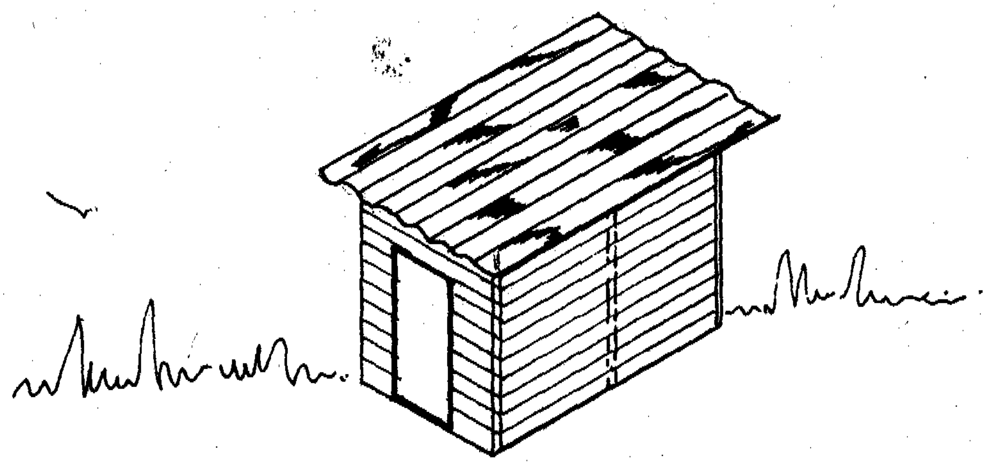
The overall sanitation conditions of a village depends mainly on the sanitation conditions of individual households rather than that of the public buildings and industries. Major attention is being given to excreta disposal, whereas disposal of sullage and solid waste is given a lower priority.

Low cost, on-site latrine systems have been adopted normally in the rural areas of the country for fundemental different types which are used for excreta disposal.

- No latrine - Defecation in the scrub
- Improvised pit latrines without water seal (with improvised squatting plate).
- Direct pit latrines with and without water seal
- water sealed latrines with offset pit
- bucket type latrines
- V.I.P. (Ventilated Improvised Pit) latrines

Although in the urban areas of the country a large number of cistern flushed modern (water sealed) toilets are used by the middle class popoulation, the poorer defecate in the scrub as its a must in their lives.

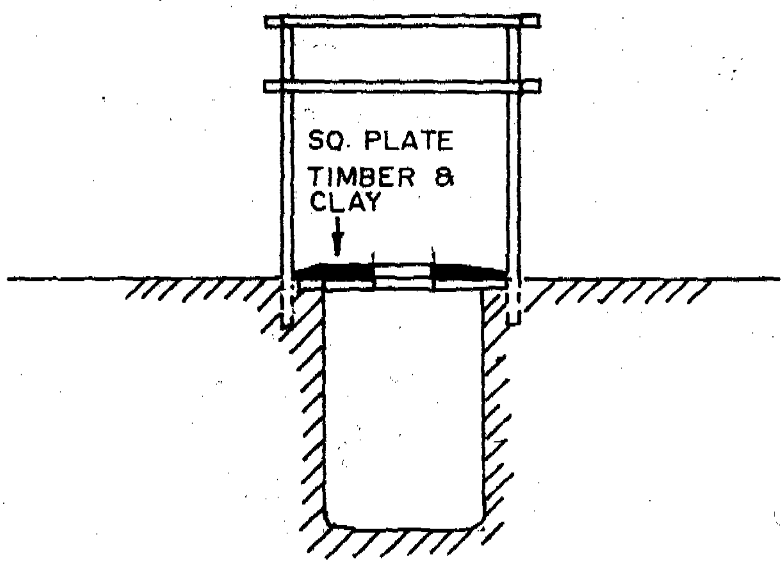
The improvised pit latrine consists of a squatting plate placed directly above a pit (Fig. Nos. 1 & 2). The phrase "Improvised" is used because the squatting plate is made out of different materials such as clay or wood rather than concrete or bricks with cement rendering.



WOODEN SUPERSTRUCTURE FOR USE WITH IMPROVISED OR DIRECT PIT LATRINE

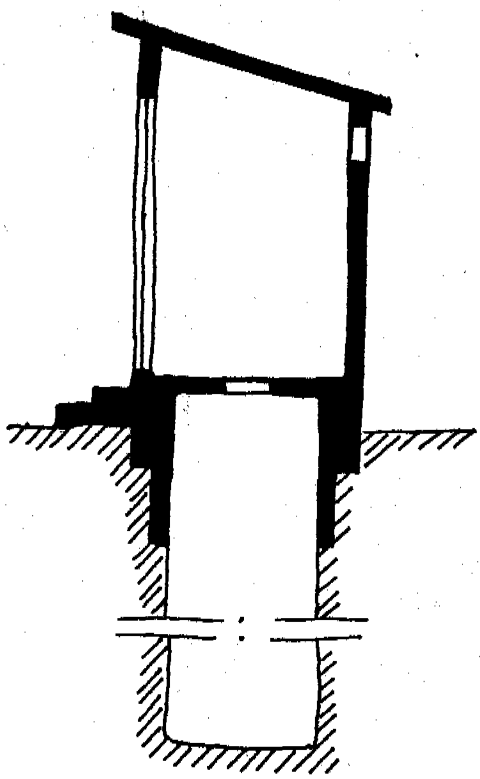
FIG: 1

6



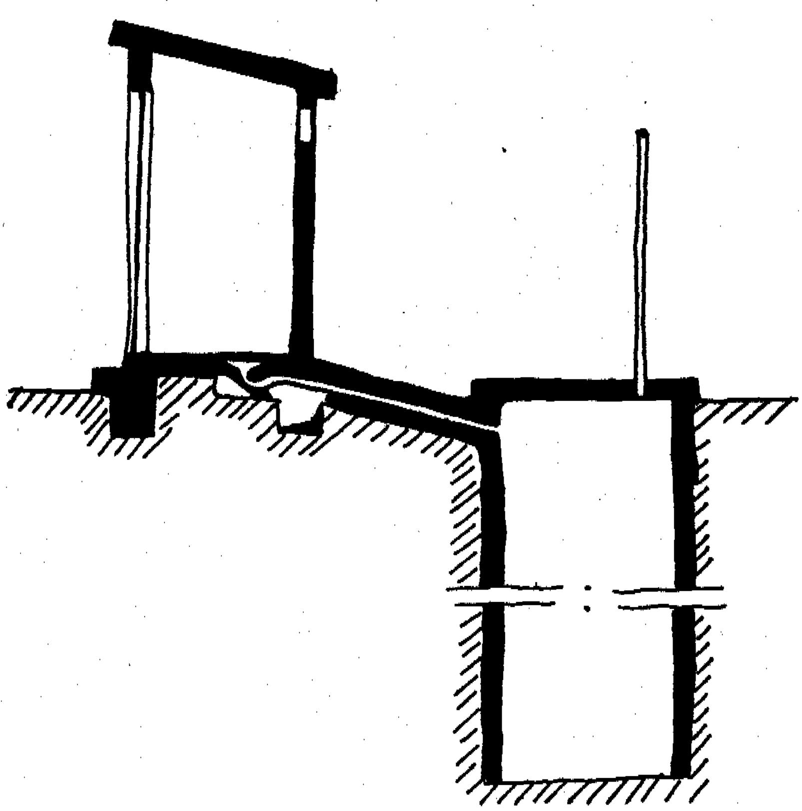
IMPROVISED DIRECT PIT LATRINE

FIG. 2



DIRECT PIT LATRINE WITHOUT WATER SEAL

FIG. 3



WATER SEALED OFFSET PIT LATRINE

FIG. 4

Although the improvised pit latrine is cheaper and has a high potential for user participation in construction, the major disadvantage is that people tend to wash outside the latrine in order to save the squatting plate from decaying. This practice will increase the risk of polluting the vicinity of the latrine with pathogens, and for that reason this type of latrine is not considered to be satisfactory from a sanitary point of view.

The principle of the direct pit latrine is similar to that of the improvised latrine, except that the squatting plate is made of concrete. Such plates are preferred as it is possible to wash inside and prevent pollution by washing outside (Fig. No.3).

The offset pit latrine consists of a latrine compartment with a water sealed squatting plate completely offset from the pit (Fig. No.4).

As an exception cistern flushed water sealed toilets are used in the rural areas where the survey was conducted.

The design of different types of latrines does not vary considerably from an area or village to another. However for each rural community the prevailing types of latrines differ depending on the parameters as described below.

1. Water Supply
2. Location of Village
3. Size of Village
4. Topography
5. Soil Conditions
6. Standard of Living

1. Water Supply

Pour Flush System is very rarely used in the water scarce areas and in certain places where the latrines have been built with water sealed pans fixed to the squatting plates, where the owner has removed or destroyed the pan converting the pour flush latrine into a direct pit latrine.

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During the dry season when there is an accute shortage of water, many people stop using their latrines and defecate in the scrub close to streams or rivers where water is available.

Thus the standard of sanitation depends very much on the presence of a good and adequate water supply. If this is made available or improved it will almost automaticslly result in an improvement of the sanitation conditions in general.

2. Location of Village

In remote areas where there is plenty of scrub jungle no latrines are available as people do not seem to consider lack of sanitation facilities as a problem. On the other hand where scrub land and convenient places are less, the need for a latrine has become necessary.

3. Size of Village

Any implication of the sanitation conditions does not reflect this factor.

4. Topography

Topographical conditions are independent with sanitation systems.

5. Soil Conditions

Normally the direct pits are unlined and in the dry zone of the island only very few users complain about collapsing of the pits during the wet periods. But in certain areas it has completely opposite results with the pit latrines, because of sandy soils.

6. Standard of Living

In uderdeveloped villages, the lack of sanitation is evidently greater than in the developed villages and most latrines are of the improvised pit type. Very often a latrine is situated as far away from the house as possible and invariably at the boundary of the land. Attached type of latrines are rare in the rural areas and if found are always of the water seal type.

PRESENT PROGRAMMES

Sanitation activites and health education are the responsibility of the Ministry of Health and Sanitation Programmes are implemented through Public Health Inspectors (PHI) of the Department of Health.

Since 1955 there is a scheme of rural latrine construction where a subsidy is provided to house-holders to construct water sealed latrines. The financial provision for this programme was increased to Rs.4 Million in 1981 and this facilitated an increase in the subsidy that was granted from Rs.25/- to Rs.250/- which also resulted in construction of latrines being increased from 12,000 to 15,000. This financial provision was subsequently reduced and construction of latrines was also reduced to 8,000. Since latrine construction is undertaken by the household concerned, the major constraint in implementation of the sanitation programme, however seems to have limited production. Therefore, it is necessary to initiate a more realistic scheme if total sanitation is to be achieved in the coming years.

At present number of Sanitation Projects are under way in Sri Lanka and the Danish International Development Agency sponsored [redacted] Rural Water Supply and Sanitation Programme in Matale and Polonnaruwa areas is one of the outstanding Projects among these. The cost of the complete Project amounts to Rs.225 Million Rupees and the estimated total cost for sanitation improvements will in 1981 prices amount to:

	Million Rs.
General Sanitation	25.61
Institutional Sanitation (Schools)	1.77
Supervision and Overheads	6.65
TOTAL COST	34.03

In order to get the maximum benefits from the proposed programme in improved water supplies and sanitation, an intensive health education programme is being carried out in the relevant communities. The cost for training health instructors and carrying out the programme over a 3 year period has been estimated to Rs.6.52 million.

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PROPOSED EXCRETA REMOVAL SYSTEMS FOR INDIVIDAUL HOUSEHOLDS

Based on the economical and sociological standards of the people in the considered areas a number of excreta disposal systems are proposed. The proposal envisages the provision of adequate sanitary excreta disposal facilities to the people with lower income. Excreta Disposal Systems suitable for adoption are:

(A) Direct pit latrine without water seal
(B) Direct pit latrine with water seal
(C) PourFlush latrine with offset pit
(D) Pour Flush latrine with septic tank and soakaway systems.

The direct pit latrine without water seal is included as the lowest standard of excreta removal systems to be used in the study area whereas the septic tank system is included as the highest possible standard.

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(A) Direct pit latrine without Water Seal

This system can be easily adopted specially in the water scarce areas (Fig. 5).

Design Criteria

(a) The pit - Generally the cross section of the pit is about $1m^2$ and depth approximately 3 - 6m. The walls of the pit may be fully lined, semilined or unlined depending on the stability of the soil. In sandy soil or when ground water table is high the pit would be lined to prevent collapsing preferably with wood, concrete or burned brick. In any case the lining should not prevent seapage of fluids in to the ground.

Generally the top most 1m could be lined to avoid any type of collapsing involved.

The pit should be constructed as deep as possible to ensure a longer life time. However the volume (v) of the pit can be calculated from equation.

$$V = 1.33 \times C \times P \times N \ m^3$$ Ref. 5

Where C - the pit design capacity m^3/cap/year

P - the No. of people using the latrine

N - the No. of years the pit is to be used

The factor 1.33 is introduced as the pit is filled with earth or emptied when it is ¾ full. The value C varies from 0.04 to 0.06 m^3/cap/year depending on whether the pit is wet or dry and what kind of materials are used for cleansing in Sri Lanka. Where only water is used for anal cleansing in latrines, the valuve of C could be considered as 0.05 m^3/cap/year.

For pits more than 4 meters deep, the volume is calculated as: $V = 1 + C \times N \times P \ m^3$

The factor 1 is added to allow for filling of the upper most meter with earth.

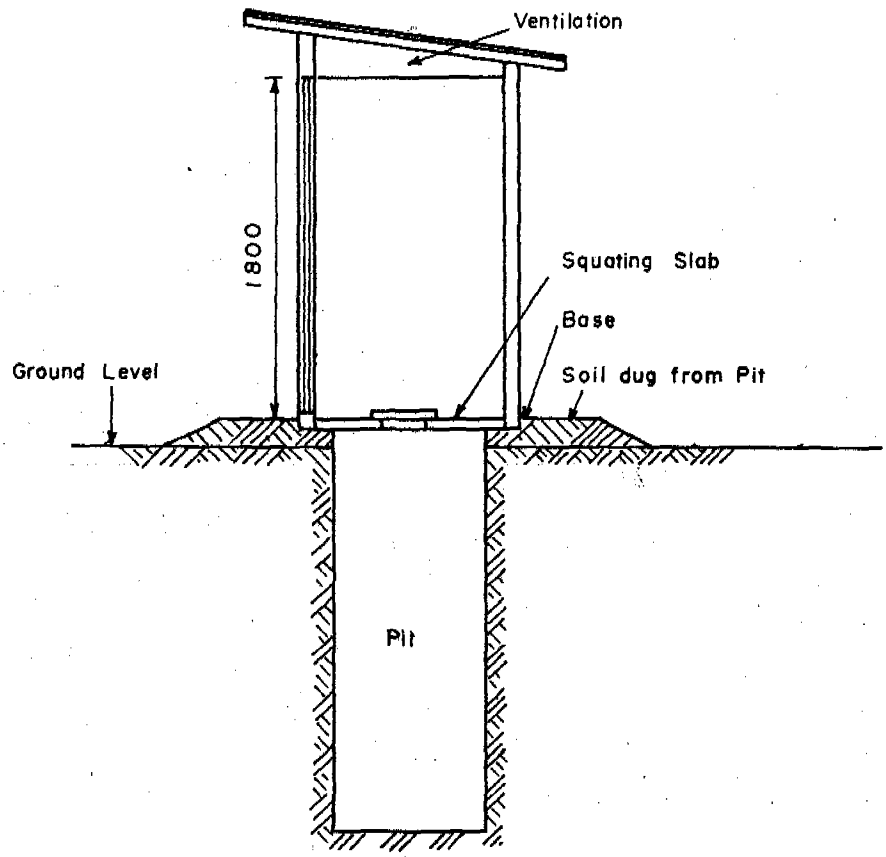
(b) The Squatting Plate

The squatting plate dimensions are shown in Fig.6 and it can be made out of reinforced concrete.

(c) The Super Structure

The super structure could be made out of lined Brick walls and tiles or corrugated sheets. The structure must be able to last the life time of the pit. The size of the compartment varies from 0.75 x $1m^2$ to 2 x 2.5 m^2.

Note- All dimensions are in Millimetres



DIRECT PIT LATRINE WITHOUT WATERSEAL

SCALE-1:50

Fig 5

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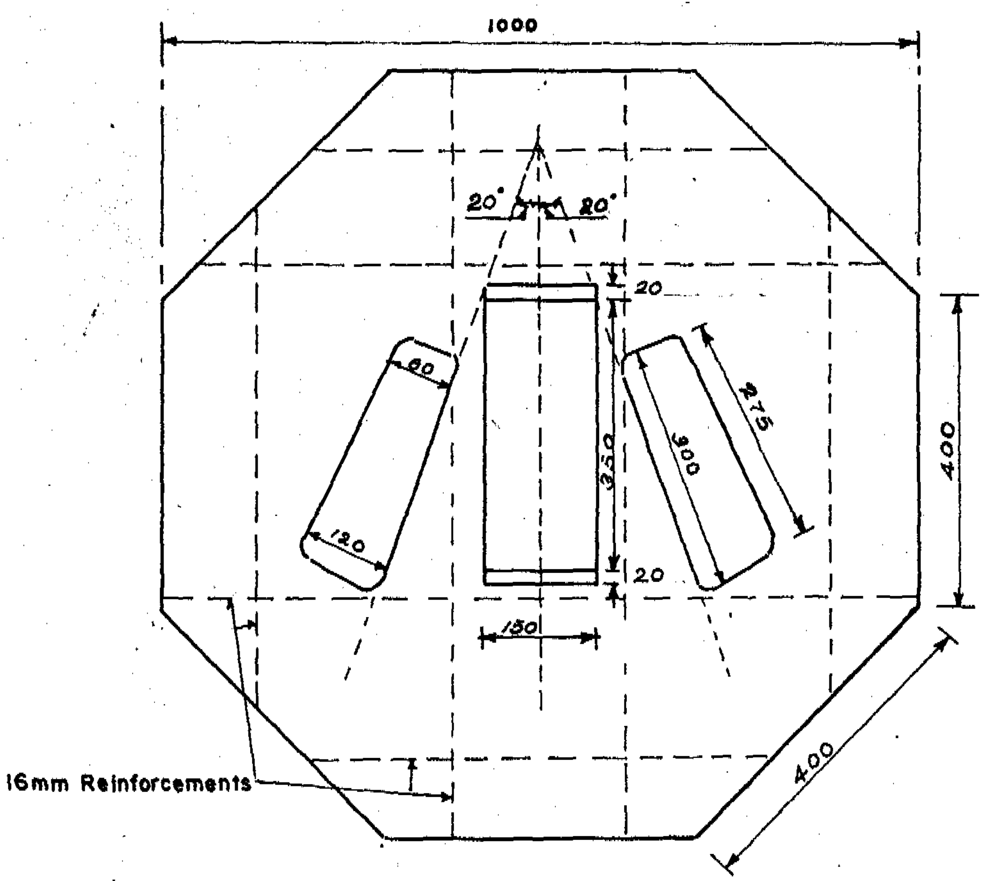


SQUATING PLATE

SCALE-1:10

FIG 6

(B) Direct pit latrines with water seal

The water seal pan is inserted in the squatting plate and this type is almost similar to the direct pit latrine (fig. 7). The water seal may be designed with provision to remove it when there is a shortage of water.

Design Criteria

The principles in the designs are almost similar to a direct pit latrine except in the water seal. The details of the removable type cement water seal pan are shown in fig.8. The outlet is in the opposite direction of the inflow and the thickness of water seal is assumed as 25 mm.

(C) Pour Flush latrine with offset pit

The super structure is completely seperated from the pit in this type of latrine and when this is filled a new pit can be easily dug and connected without moving the superstructure (fig. 9).

Pour flush latrines have 3 main advantages:

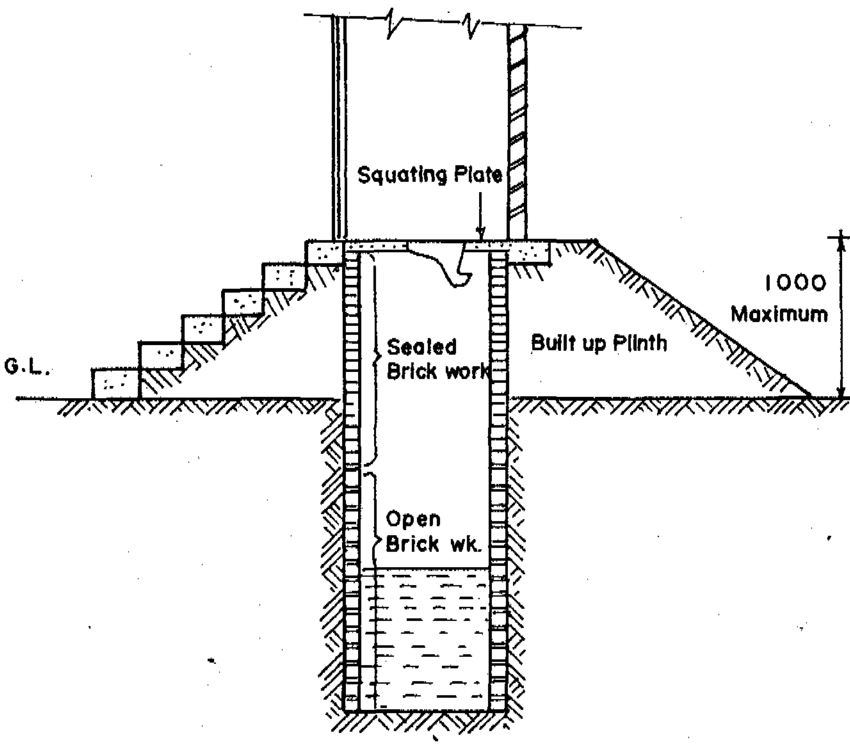
1. Low water requirements of 1 - 3 ltres/flush as opposed to 9 - 20 ltrs/flush for most cistern toilets.
2. Complete odour elemination by the shallow water seal and also they can, if desired be located inside the house.
3. They are particularly suited wherever water is used for anal cleansing criteria.

Design Criteria

The volume of the pit and the super structure designs are similar to the previous systems.

TYPICAL DIRECT PIT WATERSEALED LATRINE

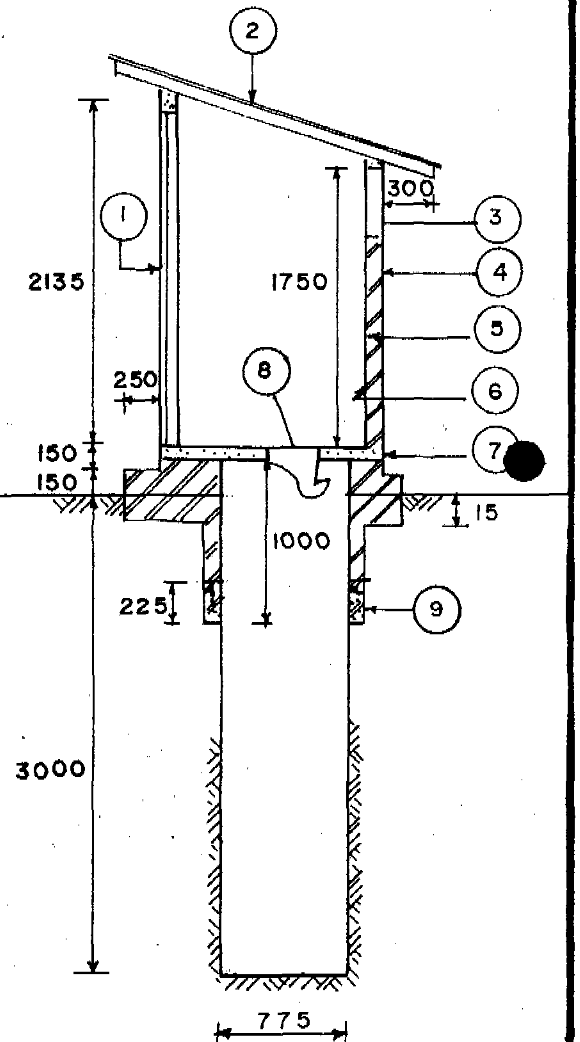
NOTE – ALL DIMENSIONS ARE IN MILLIMETRES



17

SECTIONAL ELEVATION

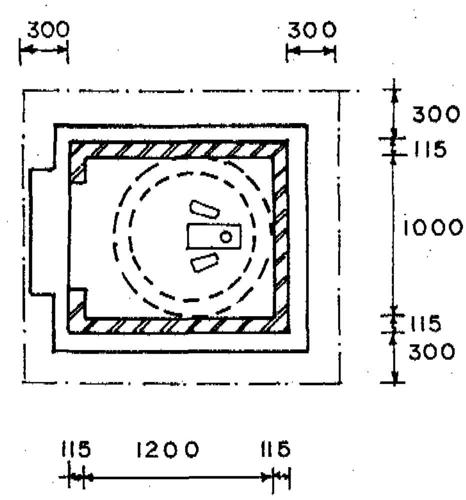
RAISED PIT LATRINE FOR USE IN AREARS OF HIGH GROUND WATER TABLE



SECTIONAL ELEVATION

KEY

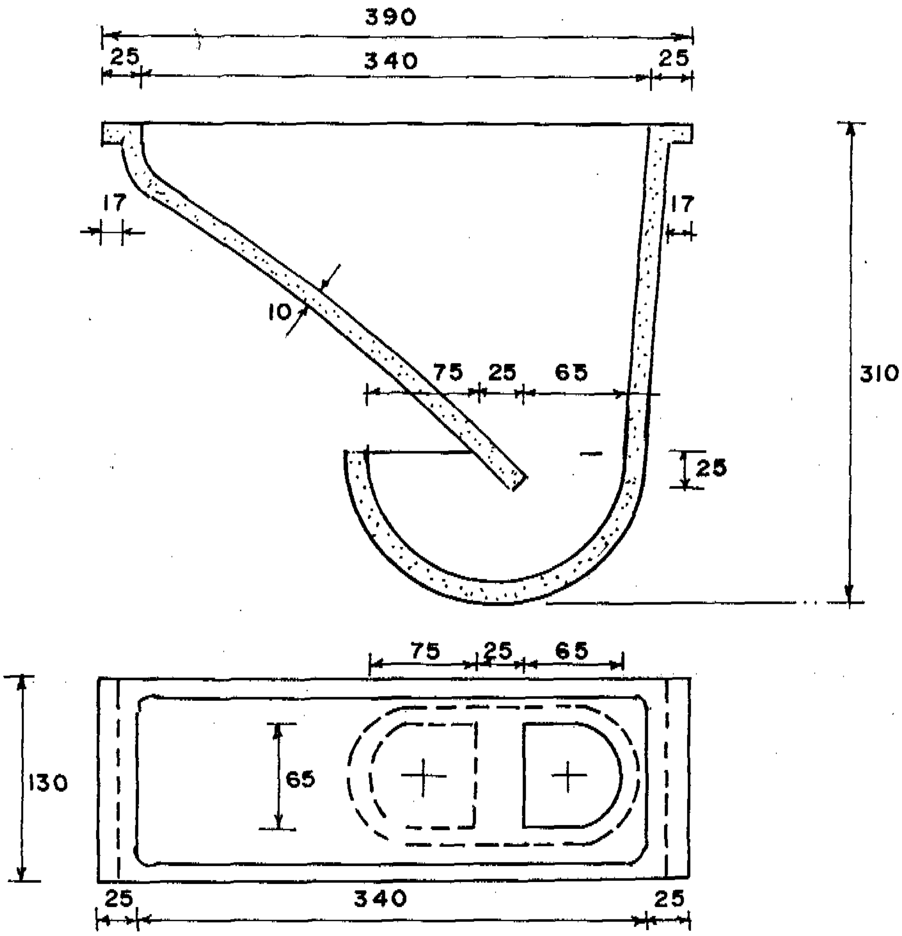
1. 660 X 1625 Ledged Braced & Baltened Door
2. Calicut Tile Roofing over 25 X 50 Reepers
3. 600 X 400 Opening
4. 12 thick Lime Cement Sand Plaster 1:1:5
5. 115 thick Brick Work in Cement Sand 1:5
6. 12 thick Cement Lime Sand Plaster 1:1:5
7. 75 thick Preconcrete Slab in 1:2:4
8. Precast Cement Concrete Water Seal Pan
9. 1:2:4 (20) Concrete



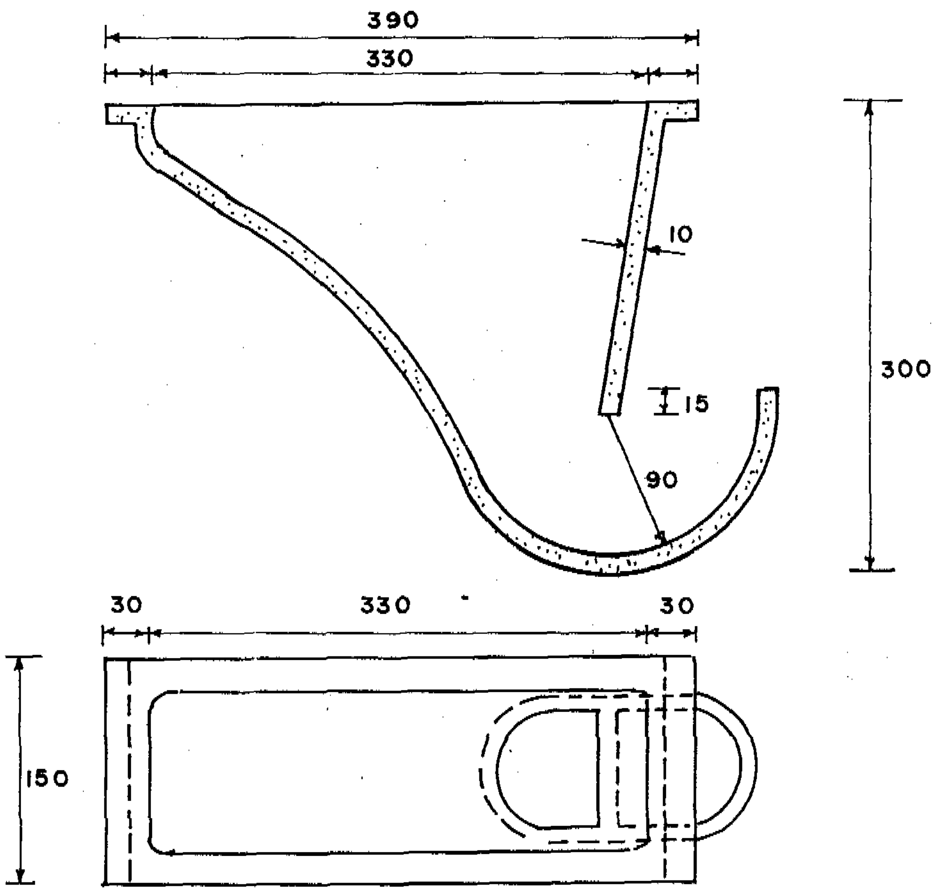
PLAN

SCALE – 1:50

FIG 7



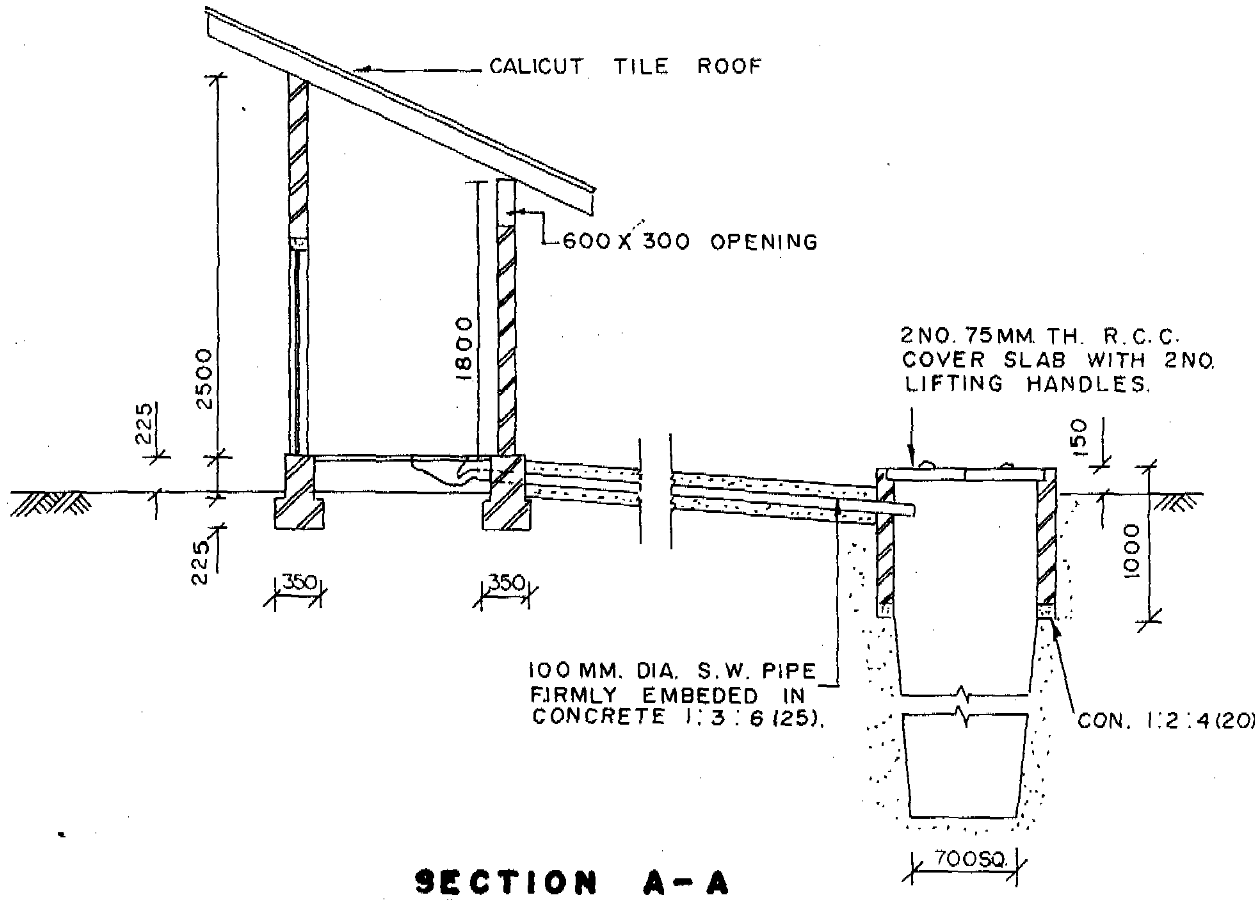
CONCRETE WATERSEAL PAN IN USE



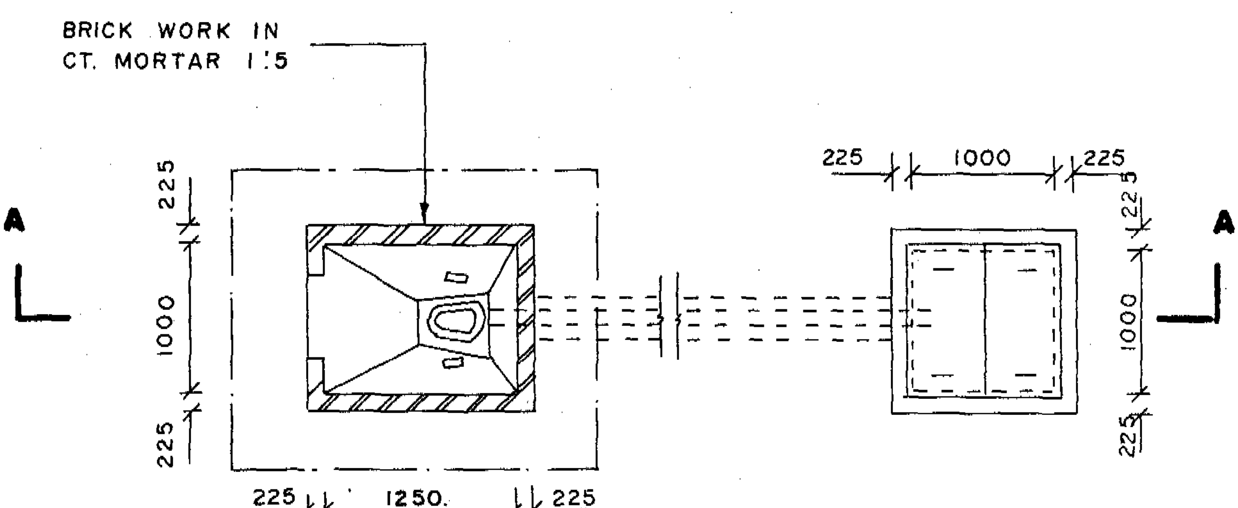
WATERSEAL SQUATING PAN RECOMENDED TO BE USED ON DIRECT PIT

SCALE - 1:10

FIG 8



SECTION A-A



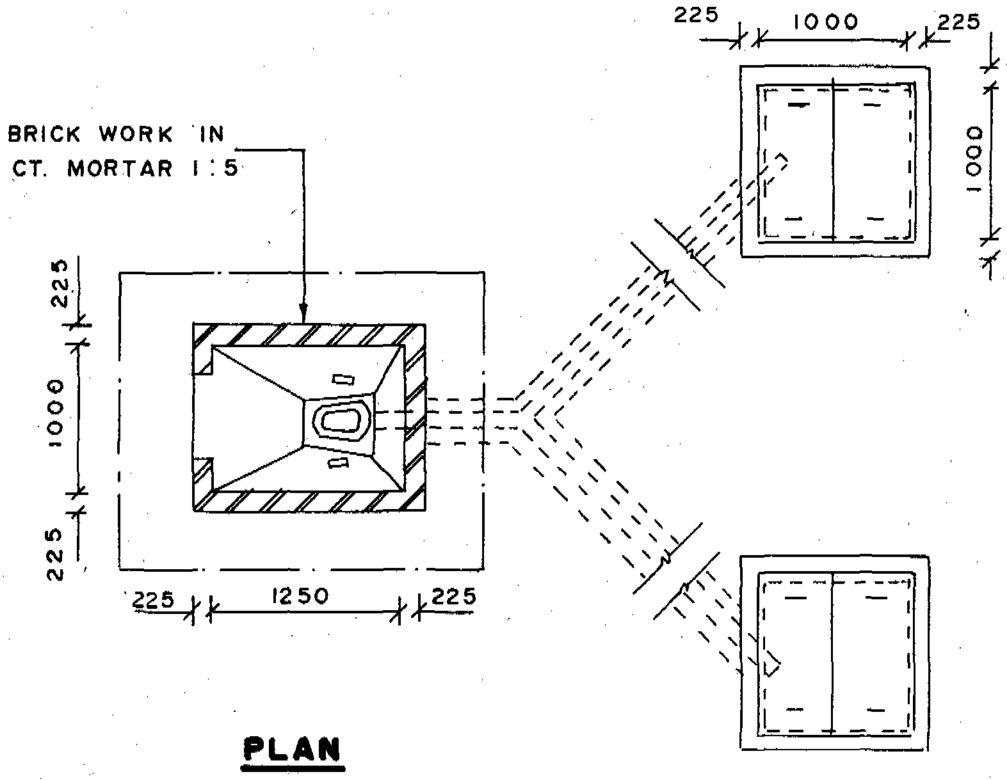
PLAN

19

POUR FLUSH LATRINE WITH AN OFFSET PIT

(TYPE I)

FIG. 9



POUR FLUSH LATRINE WITH AN OFFSET PIT

(TYPE 2)

FIG. 9

The squatting plate and water seal pan

The water seal pan is cast with the squatting plate and the pan is made out of cement, clay ceramic or PVC (. .). The height of the water seal varies from 10 to 20 mm.[redacted]. The cement clay pans are less expensive but cleaning is not as easy as in PVC. The Sewer Pipe from the pour flush pan to the pit should be as short and straight as possible, and the maximum should be 3m. and a sufficient slope should be provided to avoid clogging of the pipe.

D. Pour Flush Toilet - Septic Tank

This is the most sophisticated excreta disposal system considered. The principle is similar to that of the pour flush latrine except that the offset pit is replaced by a septic tank discharging to a soakaway or absorption trench.

21 Design Criteria

The super structure and the squatting plate are similar to the pour flush off-set pit latrine.

a. The Septick Tank

This is a water tight tank in which sewage is retained sufficiently long to permit sedimentation of suspended solids and partial anaerobic digestion of settled sludge while lighter solids and grease form a thick scum on the surface. Although digestion of the settled solids is reasonably efficient same sludge accumulates and the tank must be desludged at regular intervals, normally once in every 1 to 5 years (fig.10).

Septic tanks may be constructed of brick work, rubble masonary or concrete. Selection of the size of the Septic tank is given in Table 1

TABLE 1 RECOMMENDED CAPACITIES AND SIZES OF SEPTIC TANKS

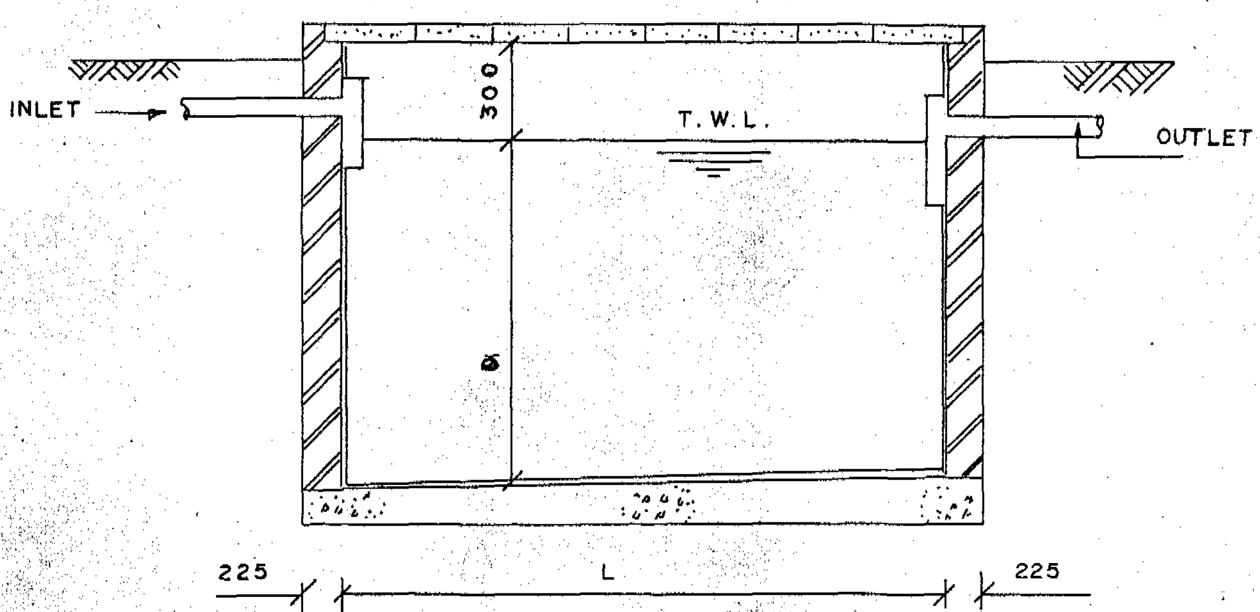
No. of Users	Length L	Breadth B	Liquid Depth D (For Cleaning Interval of)			Liquid Capacity (for Cleaning Interval of)			Depth of Sludge to be Withdrawn in		
			6 months	1 year	2 years	6 months	1 year	2 years	6 months	1 year	2 years
	m	m	m	m	m	m^2	m^2	m^2	m	m	m
5	1.50	0.75	–	1.00	1.05	–	1.12	1.18	–	0.32	0.64
10	2.00	0.90	–	1.00	1.40	–	1.80	2.52	–	0.40	0.80
15	2.00	0.90	–	1.30	2.00	–	2.34	3.60	–	0.60	1.20
20	2.30	1.10	1.00	1.30	1.80	2.53	3.30	4.55	2.28	0.57	1.14
50	4.00	1.40	1.00	1.30	2.00	5.60	7.28	11.20	0.32	0.64	1.28

Ref. 2

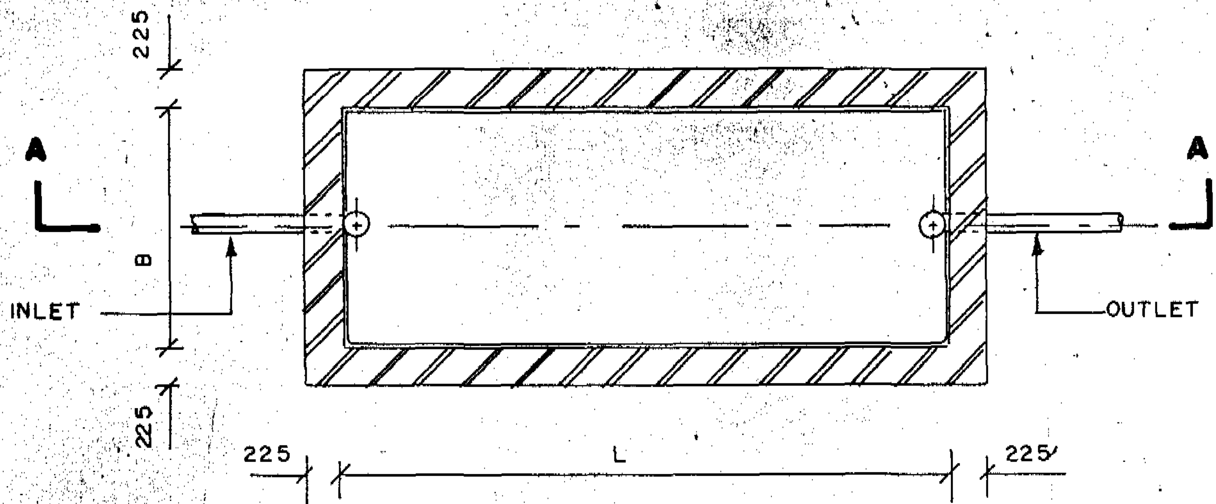
NOTE 1 – The capacities recommended provide for wste water also

NOTE 2 – A provision of 30 cm should be made for free board

23



SECTION A-A



PLAN

SINGLE COMPARTMENT

SEPTIC TANK

FIG. 10

(b) The Soakaway Systems

The effluent from the septic tank is disposed of either to a soakage pit or an absorption trench of which the soakage pit is the most simple and least expensive (fig.11).

As the effluent from the septic tank is comparable to raw sewage in pathogen content no soakage pit should be located within 30m of the drinking water source. With regard to ground water pollution the absorption on trench system is a safer way of discharging the effluent from the septic tank as the waste water is distributed over a larger area and as the trenches are located in the upper 1m of the soil where micro-biological activity is generally higher.

The necessary size of the absorption trench is determined from the allowable water dosage per m^2 per day. This is highly dependent on the type of soil and varied from 50 - 100 $1/m^2$/day coarse sand to 20 $1/m^2$/day.(clay)

Based on daily waste water flow of 0.05 m^3 (5 persons of 10 1/cap/day) and assuming a clay type soil, the necessary length of the absorption trench is found to be 5m, if the infiltration area is taken as 0.5 m^2 per meter trench

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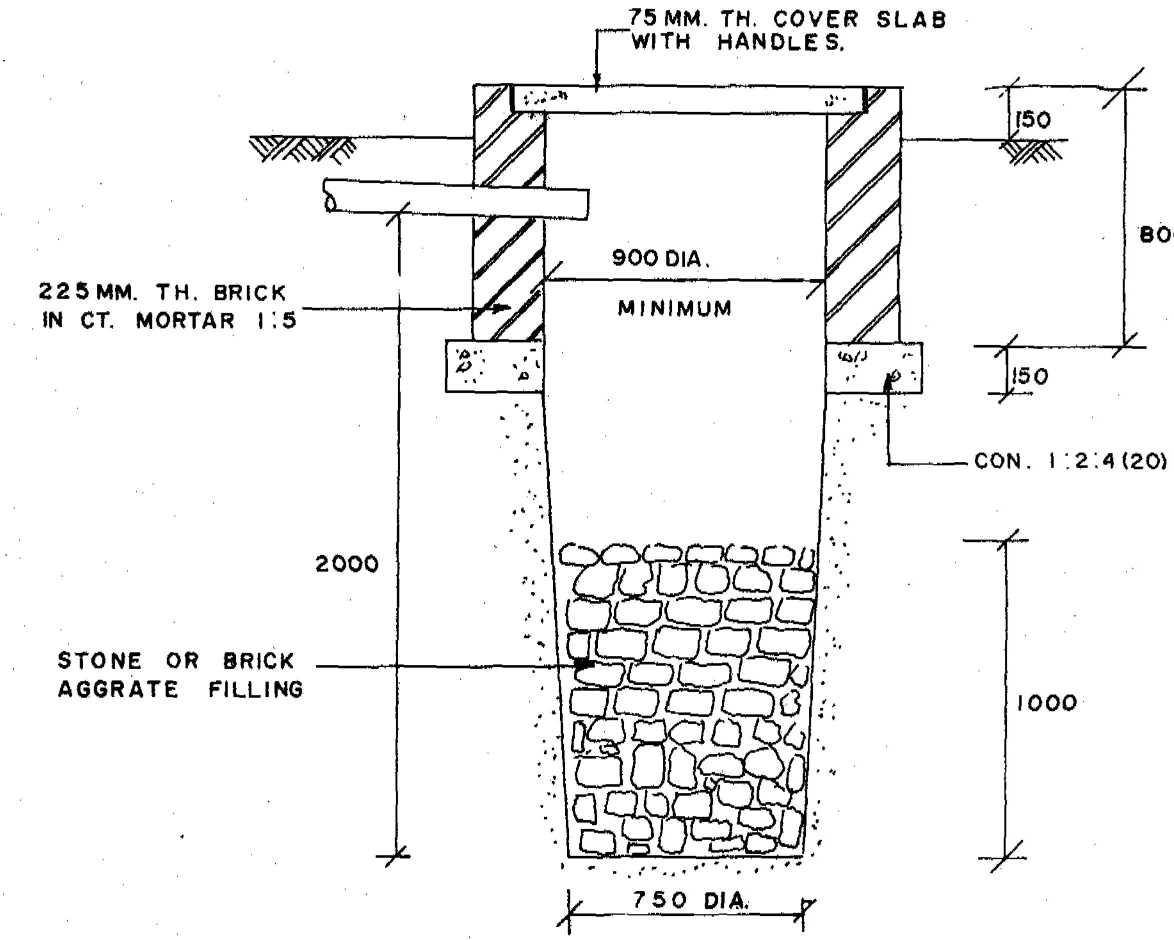
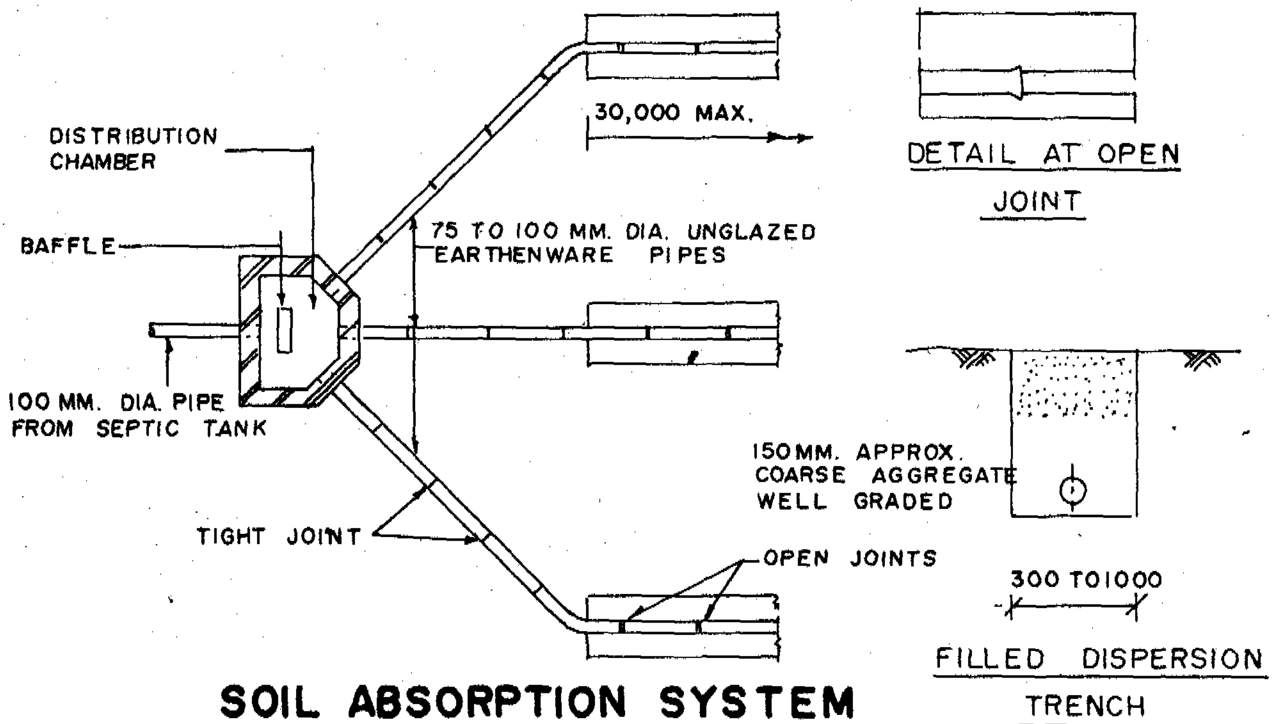


25

SOAKAGE PIT

FIG.



SOIL ABSORPTION SYSTEM
WITH DISPERSION TRENCHES

FIG. 11

COST ESTIMATES

Cost Estimates for each excreta disposal system considered are described in the Tables.

For every system the cost estimate is divided into materials and labour cost.
26 These cost Estimates are extracted from the Rural Water Supply and Sanitation Programme which is to be launched in the Matale District of Sri Lanka.

****

EXCRETA DISPOSAL SYSTEM	COST IN RUPEES		
	Materials	Labour	Total
1. Direct pit latrine without water seal, 1m diameter 3.5m deep semilined pit, precast concrete squatting p late and 1 x 1.2 m brick wall superstructure with calicut tile roof and door	1030	490	1520
2. Direct pit latrine without water seal as per 1 exclusive of superstructure	300	125	425
3. Direct pit latrine as per 1 inclusive of removable cement water seal pan	1055	490	1545
4. Direct pit latrine as per 3 exclusive of superstructure	325	125	450
5. Pour flush offset pit latrine with 1m diameter, 3.5m deep semilined pit with concrete slab, creamic water seal pan and 2m E.W. Pipe. 1 x 1.2m brick wall superstructure with calicut tile roof and door.	1530	600	2130
6. Pour flush offset pit latrine as per 5 exclusive of superstructure	800	230	1030

EXCRETA DISPOSAL SYSTEM	COST IN RUPEES		
	Materials	Labour	Total
7. Pour flush latrine with in situ or precast septic tank and soakage pit. 5 persons capacity septic tank and 1m diameter, 1.6m deep soakage pit with concrete slab, ceramic water seal pan and 2m E.W. Pipe. 1 x 1.2m brick wall superstructure with calicut tile roof and door	2800	950	3750
8. Pour flush latrine with in situ or precast septick tank and soakage pit as per 7 exclusive of superstructure	2070	580	2650
9. Pour flush latrine with in situ or precast septic tank and absorption trench. Septic tank and superstructure as per 7, 5m absorption trench	3080	935	4015
10. Pour flush latrine with in situ or precast septic tank and absorption trench as per 9 exclusive of superstructure	2350	565	2915

SUMMARY AND CONCLUSION

With the increase of Bowel Disease in the island, the sanitation facilities require urgent attention of the Government. But the Government of Sri Lanka is unable to launch massive sanitation programmes throughout the island due to prevailing economic problems. An ideal alternative for this problem, is to introduce less expensive sanitation systems to the community. Therefore, this study was conducted to investigate the best suitable excreta disposal systems for the low income settlements in the midland areas of Sri Lanka. Present sanitary conditions and sociological standards were analysed with the available data, and low cost excreta disposal systems have been brought forward to complement with the sanitation programmes under-way and to promote the present programmes. Excreta Disposal Systems described are particularly to meet the requirements of the low income settlements and the financial figures clearly indicate the low cost of the selected systems. Therefore, these systems can be implemented to promote sanitation facilities in the areas under review.

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Problems related to Emptying On-Site Excreta Disposal Systems in Developing Countries

by

Roland Schertenleib and Peter Hawkins

International Reference Centre for Waste Disposal (IRCWD)
Ueberlandstr. 133, CH-8600 Dübendorf, SWITZERLAND

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Management for Low Income Settlements
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1. INTRODUCTION

With the increased activity in the field of excreta disposal promoted by the UN Water and Sanitation Decade, it is intended that substantial progress will have been made in the provision of sanitation for at least 1500 million people who at present have totally inadequate facilities. Most of these people live in the periurban and rural areas of the developing countries and have household incomes of less than US $ 500 per year. They are not only unable to afford piped sewerage, it may also be technically inappropriate for them. The need therefore exists to use alternative, well-proven technologies which, if properly designed, will safely dispose of excreta on site, while being both socially acceptable and affordable to the householder. The on-site excreta disposal technologies appropriate for most developing countries are the Ventilated Improved Pit Latrine (VIP) and the Pour Flush Waterseal Latrine (PF).

These latrines are best designed in such a way that when their pits are full, the superstructure can be moved to a new site, or a second pit used while the contents of the first are left to decompose into harmless and inoffensive material. In some cases, however, it may be necessary to empty a pit containing fresh, hence pathogen-laden excreta. This is likely to occur if the householder cannot afford to dismantle the superstructure and re-erect it elsewhere, if only one single pit is available due to financial limitations, or if there is insufficient space on the plot to accommodate a second pit. These constraints are common in fringe and urban low-income areas. In this context, even small to medium sized towns must be counted as urban areas if they have locally high population densities.

The scale of the pit-emptying problem is therefore very large, and it will be even larger in future since many cities and towns in developing countries are embarking on major latrine-building programmes. Most of these programmes of urban excreta disposal provision are currently proceeding without a sufficient technical basis for the removal technology. In particular, removal is rarely considered as imposing any limitations or adaptations on the overall system chosen.

The IRCWD-study presented in this paper was initiated in 1981 with the aim to examine the problems on four levels, namely:

- the pit contents: their composition, physical properties and accumulation rate,
- the technology: currently available and used removal technologies, their shortcomings and possible further development,
- management: case studies of currently operating removal services,
- planning: the mutual consequences of removal technology and latrine design.

There is little published literature relevant to this study which is based mainly on the results of field investigations. These were carried out in two quite widely differing African cities (Dar es Salaam, Tanzania and Gaborone, Botswana) and in one or two cities in each of Taiwan, Japan, South Korea and Thailand. Between them they represent most of the types of urban excreta disposal technology currently being advocated, and a range of physical and socio-economic conditions. No doubt, further areas could usefully have been included in the study, but it was felt that at this stage, further efforts would be best directed towards practical developments, before a second round of evaluation.

2. LATRINE SYSTEMS AND THEIR EMPTYING REQUIREMENTS

Table 1 shows the basic types of latrine and compatible collection systems and the fate of excreta and sullage when each is used.

Table 1. Latrine and collection system types

Latrine system	Collection system	Fate of: Liquids	Solids	Sullage
Pit latrine	Build new latrine	1	1	1,2
Emptyable pit latrine	Manual (bucket, scoop) Vacuum truck	1,3	3	1,2
Vault latrine	Manual Vacuum truck	3	3	2
Bucket latrine	Manual	3	3	2
Septic tank	Manual Vacuum truck	1,2,3	3	1,2
Sewerage	Pipeline + water	3	3	3

Key: 1 - remains in or seeps into ground
2 - dispersed on surface to seepage or water body
3 - removed

The liquid fraction of the excreta includes urine, anal cleansing water and some of the water associated with faeces. The solid fraction is the remainder of the faeces, solid anal cleansing materials (paper, stones, corn cobs, etc.), absorbent materials used by menstruating women and a surprising variety of rubbish. Sullage is the domestic wastewater from washing, bathing, food preparation etc. and can have quite a high organic (particularly fat) content.

There are three ways in which these three major components can leave the house plot: by subsurface seepage into the soil and thence sooner or later into shallow aquifers; on the ground followed by a combination of evaporation, seepage and flow in surface drains and other water bodies; and by technological means which can be broadly divided into manual methods employing buckets and scoops, mechanical pumping, usually by vacuum trucks, and sewers.

As far as emptying is concerned, there are in principle only two major types of latrine systems: those (pits) which allow some of the liquids to be disposed of by seepage, and those (vaults) where all the liquids and solids (but no sullage) are retained for collection. In the former case, the sludge tends to be thicker and more compacted. The remainder of the waste not assimilated by the environment has to be removed by technological intervention. Disregarding sewerage, this means manual or mechanical removal followed by cartage to a treatment, disposal or re-use facility.

Manual methods employing scoops and buckets are suitable for the more fluid type wastes, but present obvious health and aesthetic hazards to the workers involved. Thicker sludges have to be dug out, and this can involve almost total immersion in the sludge, as, for instance, by the "vyura" (frogs) of Dar es Salaam who may spend up to six hours in the pit, digging it out. Twin pit systems can overcome the unpleasantness and health hazards involved by allowing the excreta to digest and become virtually pathogen-free after two or more years' storage in the pit. This is the only method devised to date which makes manual emptying an acceptable practice.

Mechanical methods revolve at present almost entirely around the use of vacuum trucks, where atmospheric pressure forces the pit or vault contents along a hose into a tank under partial vacuum. This method of pumping is preferred because the pump does not have to come into contact with the sludge, which may contain solids capable of blocking or damaging it. Again, the thicker sludges can present problems, since the system relies on fluid behaviour by the material to be pumped. In some cases addition of water and/or manual agitation of the contents may be practised to increase fluidity.

3. THE SHORTCOMINGS OF EXISTING PIT EMPTYING SERVICES USING VACUUM TRUCKS

In many Third World countries, pit emptying services using Vacuum Trucks (developed in industrialised countries) have been in operation for many years. However, most of these services have proved inefficient and unsatisfactory due to organisational as well as technical reasons. Three main shortcomings have been identified during the study.

Firstly, the physical size of the machinery can prevent adequate access to latrines. Currently available vacuum trucks are of sizes from two tonnes upwards and are too big to be able to drive into the hearts of the ancient cities of Asia or the more recent urban squatter settlements around the world, with their narrow, winding streets adapted for pedestrian traffic. Depending on sludge consistency and strength of the vacuum pumps, hoses of up to 30-70 m length can be used, but in many cities and towns a sizeable proportion of houses can be further than this from the nearest suitable roadway. Even in planned sites and services schemes, where road access is generally good, latrines are often situated at the back of the plot, creating unnecessary difficulties for collection workers.

A more fundamental problem is the absolute constraint that vacuum systems cannot handle some of the thicker, compacted sludges in old pit latrines. In a few cases this can be overcome by mixing extra water with the sludge, using a pole. The principle of vacuum systems demands fluid behaviour of the material to be removed, and an alternative concept is required for sludge not exhibiting this type of behaviour.

The third problem area is in the management of vacuum trucks. Their engines must be kept running all day, either to move the truck or to operate the vacuum pump when stationary. This causes rapid wear and makes them especially susceptible to breakdowns resulting from poor preventive maintenance. Fuel consumption is high, and vacuum trucks may be prime targets for cuts in fuel supplies if the operating agency is forced to make economies. These and other similar problems are typical of high cost, high technology equipment in poor countries, but this does not make them any less real. In addition, a very interesting behaviour of the crews has been observed in places where the fleet of available vacuum trucks is by far too small compared to the requests for emptying. Instead of trying to empty each pit as well as possible, the crews are mainly concerned to serve as many houses per day as possible. This behaviour can easily be explained by the fact that a houseowner is only served by the crew if he or she is willing to pay a considerable amount of money to the crew directly, in addition to the official rate.

4. CHARACTERISTICS OF PIT CONTENTS

In order to determine what kind of material has to be handled by an appropriate pit emptying device,the content of pits and vaults in Tanzania, Gaborone, Taiwan, Japan, South Korea and Thailand were analysed for its properties.

4.1 Distribution

As excreta is stored in a pit or vault it tends to separate into different layers. In the most general case there are three layers, but depending on circumstances one or two may be absent. The three layers are, from top down:

- floating scum
- liquid
- sludge/sediment

For a well-drained or "dry" pit latrine there is no liquid layer and therefore also no floating scum layer.

When liquids are retained in the vault or pit, a scum layer is possible. Its formation appears to be related to at least two factors: the use of paper for anal cleansing, and the number of users of the latrine. When paper is used for anal cleansing there is nearly always a floating scum layer, usually 100 mm - 200 mm thick, which may give the appearance of being very solid. If pressed with a pole, it flexes considerably before the pole breaks through to the liquid below. However, observations show that it is possible to break up such a scum layer with a little persistence, and mix it with the underlying liquid to a consistency allowing easy removal by vacuum truck. Large balls of paper may cause blockages, but these are relatively easily cleared.

In areas where water is used for anal cleansing, scum is less common, and, when it occurs, usually in a thinner layer (50 mm - 100 mm) and with a softer consistency. Scum samples taken in Thailand had a moisture content around 85 % and did not need to be broken up prior to removal by vacuum truck. Data from a survey of 192 pit latrines in Dar es Salaam showed that latrines with large numbers of users are more often completely covered with a scum layer. Strictly speaking, it is probably the number of users per unit cross-sectional area of the pit which determines scum formation. This means that in practice nearly all vault type latrines are scum-covered because of their relatively small size.

The formation of a sediment below the liquid layer appears to be a much slower process. Observation of regularly emptied vaults suggests that it takes about 6 months before an appreciable sludge layer starts to build up. This is probably related to the digestion process, fresher excreta floating as scum due to the entrained gases produced during the early phase of decomposition, and sinking when digestion has proceeded to a certain degree. This is borne out by analyses which show non-volatile solids comprising 12 % - 23 % of total solids in scum samples, but 30 - 50 % or more in sludge. However, once a sludge layer is laid down, its composition and properties are broadly similar to those of sludges from "dry" pits at a similar stage of digestion.

4.2 Sludge composition

As stated previously, any scum layer can easily be mixed with the underlying liquid to form a fluid presenting no handling problems. It is the deposited or well-drained sludge layer which proves to be the most difficult to move. The sludge has therefore been studied in more detail.

Sludge composition was measured in Dar es Salaam, Gaborone and Bangkok, whilst in the other countries visited, so little sludge was found that no measurements were made, and published figures for the average composition of nightsoil are presented. Average and extreme values of water content, NVS (as % of total solids) and density are presented in Table 2.

Table 2. Sludge composition and density

Country	% water		NVS %		Density kg/dm^3		Source
	mean	range	mean	range	mean	range	
Japan	97	97-98	40	30-50	-	-	Magara et al. 1980
Taiwan	97	96-98	41	19-87	1.01	-	Camp, Dresser, McKee 1970
S. Korea	95	94-96	29	24-34	1.02	-	Dept. of Preventive Health, 1978
Thailand	86	81-89	40	12-84	1.04	0.97-1.13	Measured
Botswana	68	43-91	59	37-76	1.27	1.03-1.43	"
Tanzania	46	26-74	42	23-59	1.45	1.11-1.75	"

In addition to these basic components, many latrines contain a certain amount of rubbish, the nature of which reflects the users' lifestyle. In practice, however, the rubbish causes few problems when pits are being emptied, any blockages being relatively quickly and easily cleared. When vacuum trucks are used, it is the bulk flow properties of the sludge which causes problems.

As shown in Table 2, the density of the sludge can be as high as 1.75 kg/dm^3, which obviously greatly increases the static head against which any emptying device has to work. In the case of a large vehicle emptying a deep pit, the difference in level from the base of the pit to the top of the tanker may be up to 7 m. With a density of 1.75 this would generate a static head of 1.2 bar, rendering any vacuum-based emptying system useless.

4.3 Sludge flow properties

The dynamic properties of the sludge may cause further difficulties once the static head is overcome. Sludge generally exhibits a yield stress, shear thinning behaviour and a degree of thixotropy. All these phenomena have the same practical implication: starting the sludge moving is the most difficult part of the operation, but once it is in a fluid state it can quite easily be kept moving.

The addition of small quantities of water can also have a dramatic effect on sludge fluidity. Two effects are involved: simple dilution, and thixotropy. Tests with sludges from different pits with water contents of 83 % and 64 % have shown that the addition of an extra 2 % of water can reduce resistance to flow 30-300 fold, respectively. This effect is probably due more to thixotropy than to dilution.

Another factor of great importance in determining the properties of the sludge is the compaction which occurs over time as it is stored in the pit. This compaction is due partly to pressure from the pit contents overlying the sludge, and partly to the continuous leaching of liquids down through the sludge, washing out soluble digestion products and leaving a matrix of inorganic matter and less easily degraded organic material such as fibre. In the African samples it was observed that a significant amount of sand and soil particles were also to be found, washed in from above and also from the surrounding soil during times of falling water table.

The results of this process can be seen most clearly in the rise of yield stress, density and solids content with time. The overall tendency appears to be for most of the compaction to take place during the first year or so of storage. In addition the measurements showed that the presence or absence of free water in the pit does not correlate with the sludge properties, and that compaction proceeds at an equal pace in both "wet" and "dry" pits.

4.4 Sludge accumulation

The sludge accumulation rate was found to be between 7 and 17 (average 12) kg of dry matter per person per year. Thus for the compacted pit latrine sludges of Dar es Salaam and Gaborone with typical moisture contents of 50 - 60 % this represents around 25 - 30 litres of wet sludge per person per year. In Bangkok, with a typical moisture content around 85 % this comes to around 80 litres, and in Japan and Taiwan, with nightsoil of 97 % water content, to 400 litres per person annually.

4.5 Implications for pit emptying

In summary then, it is apparent that the major pit emptying problems are associated with the sludge layer that starts to be deposited after about 6 months' storage. The longer it is stored and the more water that is allowed to leach out of it, the more stiff and resistant to flow it becomes. Organic content too tends to decrease over time because of digestion, and this again reduces fluidity. The mixing in of small quantities of extra water can greatly increase sludge fluidity, mainly because it is thixotropic and reduces its viscosity after the shearing necessary to mix in the water.

Considering this analysis, various possible options for pit emptying would appear feasible:

a) Use vaults or small pits of limited leaching capacity to maintain water content and provide less than one year's storage capacity, thus yielding a fluid material which is easily pumped out.

b) Use pits of more than one year's capacity and fluidise the sludge deposited by some device to apply shear, mixing it with water already present as a separate layer or, in well-drained pits, with additional water.

c) Use pits of more than one year's capacity and remove the sludge as a solid material. The simplest way of doing this is probably by adopting twin pits and desludging manually. For single pits, a solids handling device would be required.

5. CURRENTLY AVAILABLE PIT EMPTYING TECHNOLOGY

Because access to the sludge is very often only through the (small) drop-hole, and the latrine itself may well be inaccessible, the use of a flexible pipe to convey the sludge from the pit to the removal container appears the most attractive option for a pit emptying device. Accepting this constraint, there are four major options currently available:

- vacuum trucks
- helical rotor pumps
- diaphragm pumps
- air drag systems

In the longer term, solids handling technologies such as bucket or screw conveyors might be developed for pit emptying purposes, but currently available devices of these types are too heavy and bulky for this application.

The first three systems are only effective on liquid wastes and wet sludges which have not been stored long enough to become compacted. Manufacturers of these types of equipment recommend a minimum moisture content of around 80 % if sludges are to be effectively shifted. Thicker sludges can be moved by a "gulping" technique, but this is slow and laborious. With these technologies, therefore, there is a need for concurrent use of some fluidising device when handling thick, relatively dry, compacted sludge.

The last-mentioned system, air drag, does not rely on the sludge being fluid, as the fluid flowing in the collection hose is a high velocity air stream which entrains solids or liquids and deposits them in the removal container when the air stream enters and slows down.

5.1 Vacuum trucks

By far the most widespread of these four systems in use for pit emptying is the vacuum truck. The main problem with these is engine wear, since the engine runs under load throughout the working day, either hauling the tanker or driving the pump. Some models are fitted with an auxiliary engine to power the pump, but this merely spreads the same maintenance requirement over two engines.

There are two generic types of sliding vane vacuum pump, and these do show significant differences. Most European and North American manufacturers make high-speed pumps with fabric-reinforced resin vanes lubricated by a total loss drip-feed system. This reduces capital cost and is effective in the countries of manufacture where maintenance is efficient and spare vanes and bearings are easily obtained and stocked. In developing countries, however, spares and maintenance are perennial headaches, while capital costs are often met, wholly or partially, by foreign assistance. Even where this is not so, a municipal capital budget is more likely to receive central government support than the recurrent budget. This makes the other (more expensive) type of vacuum pump, manufactured primarily in Japan, much more attractive. Rotational speeds are generally lower, increasing pump lifetime, and the vanes are made of thick steel plate which does not wear or shatter in the same way as resin. In addition, the lubrication system is enclosed, with oil circulating from a reservoir. This allows a much higher lubrication rate than is affordable with a total loss system and hence more reliability.

5.2 Other fluid pumping equipment

Helical rotor (also known as progressive cavity or ("Mono") pumps and diaphragm pumps are both capable of handling only liquid sludge and, additionally, the sludge must pass through the pump. This calls for more rugged (and expensive) construction than for vacuum pumps and for some device to prevent rigid solid debris from damaging the elastomeric casing (of a helical rotor pump) or diaphragm.

The diaphragm pump has one advantage in as much as it is the only one under consideration which can easily be hand-powered. It also has a minimum of moving parts: check valves, the linages in the reciprocating mechanism and the diaphragm itself. A hand-powered unit would obviously have a much lower capacity than a motor-powered one and would thus really only be suitable for small pits and vaults where the time spent pumping is relatively small compared with setting up and removing the equipment. However, in small towns with ready supplies of cheap labour, hand-operated diaphragm pumps used in conjunction with vaults of a few hundred litres capacity would be a cheap and simple option. Field trials would indicate the range of sludge conditions over which they would be suitable.

5.3 Sludge fluidisation

All the devices discussed thus far would require some ancillary equipment or operation to fluidise thicker, more compacted sludges if they are to be shifted. Vacuum trucks can perform a certain degree of fluidisation without ancillary equipment, provided the hose can be forced down into the sludge, which may not always be possible. Various techniques have been recorded in investigations by the World Bank in U.S.A. and Haiti. These involve switching the vacuum pump into pressure mode and pumping air or water (possibly previously removed from the same pit) into the sludge from below. If the sludge is thin enough to enable the hose to be pushed through it, then the limited pressure available will probably be sufficient to achieve effective mixing. In any case, high pressure would cause erosion of the pit walls and probably also excessive splashing (observed in trials with sewer jetting equipment operating at 100 bar). Sludge of this intermediate consistency can also be fluidised by mixing with a pole (if the pit is not too large) or even removed directly (but slowly) by a "gulping" procedure whereby the hose is pressed into the sludge to enclose a small quantity and then lifted clear until the sludge is removed up the hose along with some entrained air.

However, in very well-drained or mature pits, it is impossible to push the hose through the sludge. In this case, a mechanical, rather than hydraulic, fluidisation technique would be required. No such devices have been field tested, and this is an important area for development. A device along the lines of a vibrating concrete poker has been suggested as a possible solution. The only commercially available equipment for this purpose encountered during the study was a caged propeller, rather large to be lowered into a typical pit and probably not capable of mixing really compacted sludges in any case.

5.4 Air drag systems

Air drag systems rely on drag from a rapidly moving air stream rather than an atmospheric pressure to shift material. Thus, in addition to not requiring a fluid sludge, static head is also unimportant, and dense sludge could in theory be easily lifted. The major problem with this type of equipment is the cohesive and adhesive properties of sludge. Three types of air drag equipment were tested by the Building Research Establishment in U.K. (Carrol, R.F.,1981) on simulated sludge consisting of topsoil adjusted to 20 - 40 % water content. Because of its cohesiveness, a gulping technique was required to separate chunks of sludge for entrainment, but the net result was up to five times as fast as a vacuum tanker. Build-up of sludge on the hose walls was a problem when flexible hoses were used, leading to decreased air velocity and eventually to blockage. Small quantities of water fed in near the mouth of the hose alleviated this problem.

Thus, although in principle offering the advantage of a simple one-step operation for removing compacted sludge, this type of machine would require further development to make it suitable for desludging. A serious disadvantage is the large auxiliary engine required to drive the air blower, increasing maintenance costs and probably quadrupling fuel consumption, compared with vacuum trucks. Air drag machines of a specification intermediate between most typical air drag machines and vacuum trucks are available in Japan, and possibly elsewhere, with the blower driven by a power takeoff (P.T.O.). Capital cost and fuel consumption are both still considerably higher than vacuum trucks, however.

5.5 Equipment size

Apart from reflecting differences in cost, the weight and size of pit emptying machinery are important factors in determining suitability. Low-income urban areas are typically laid out in a haphazard manner without roadways big enough for large vehicles, and, where roadways do exist, they are often impassable in the wet season because of mud. Big, heavy machines will therefore be unsuitable in most cases. The usual capacity of European and North American vacuum tankers is 4.5 m^3 (1000 gal) whilst Japanese tankers are commonly 1.8 m^3 with correspondingly smaller chassis. This brings in a further incidental advantage, which is that the top of such a tanker may be 1-2 m lower than a typical European model, thus reducing the necessary static head to lift the sludge.

6. MUTUAL CONSEQUENCES OF REMOVAL TECHNOLOGY AND LATRINE DESIGN

Many urban areas have established traditions of latrine construction and use, and any pit emptying service must clearly adapt itself to the requirements of the particular latrine technology used. This will entail the removal of liquid material and, in some cases, compacted sludge as well. The kinds of technological developments needed to deal with this latter problem are discussed earlier in this article.

Nevertheless, current estimates indicate that only about a quarter or, at most, a third, of all developing country urban residents have access to a latrine of any kind. Against this background, substantial efforts are being made, particularly during the U.N. Water and Sanitation Decade, to provide excreta disposal facilities on a mass scale for the people as yet unserved. When planning the large projects involved, the overall system of excreta deposition, storage and removal must be considered rather than, as up to now, the latrine technology alone.

The current state-of-the-art presents planners with a choice between vault latrines which can be emptied by a (reliable) vacuum truck service, but cause a greater amount of sullage to be discharged to the environment, or, alternatively, pit latrines which can accept considerable quantities of sullage and are less liable to overflow in the absence of reliable pit emptying services, but accumulate compacted sludge which is very difficult to remove. The value of soakage in reducing pit emptying requirements is illustrated by the case of Dar es Salaam, where only 17 % of a random sample of pit latrines had called on the vacuum truck service for liquids removal, the remainder requiring only sludge removal.

Twin-pit latrine systems retain all the advantages of pit latrines, whilst allowing for the cheap and simple manual removal of pit contents. These systems take maximum advantage of locally available resources: subsoil for liquids removal by soakage and manpower for solids removal. Thus, in addition to providing a high level of service, another equally important objective, non-reliance on imported technology, is achieved. Where ground conditions and span permit, this is definitely the technology of choice. Even in areas of high water table, twin pits can be used, if the ground is permeable, by building them up above ground level.

Impermeable substrata such as clay or rock, however, preclude the use of pit latrines. In these cases, any latrine built will essentially be a vault, in the sense which has been used throughout this analysis. The studies on compaction indicate that these should be sized for a maximum of one year's storage. Assuming a minimum household size of two and a mean of 5-10, this would necessitate collections every 2-5 months for the average household. The installation of small-bore sewer systems for sullage disposal would be a logical second step in upgrading these systems.

Where ground conditions dictate the use of vaults, some kind of pumping system will be required to empty them. The operation and maintenance of this service will almost certainly be the single most difficult task in the provision of hygienic excreta disposal for the population. The allocation of foreign exchange for the purchase of fuel and spares, the stocking of these (and prevention of their theft), manpower training and the development of an effective revenue collection and subsidy system are thus central to the planning of the whole sanitation project if vaults are to be used.

The widespread adoption of single pit systems is to be avoided except in cases where sufficient land is available on house plots to accommodate several relocations of the pit. Single or double pits can be used in areas of intermediate soil permeability, in conjunction with a liquids removal service for those pits where liquid accumulation exceeds seepage rate, but the same remarks apply to the central importance of this removal service.

7. SUGGESTIONS FOR FURTHER WORK

After having identified the main problem areas in connection with the operation of pit emptying systems and technologies in developing countries, and considering the fact that many cities and towns in developing countries are embarking on major latrine-building programmes which require the existence of such emptying systems, we suggest that further field tests and investigations should be undertaken urgently. Thereby, emphasis should be put on the difficult conditions encountered in many African cities.

a) There is still very little information on the suitability of pit emptying devices, other than European-type vacuum trucks, to handle relatively thick sludges found normally in African pits. Future field tests should be undertaken with further desludging devices available on the market, but which have not yet been used or tested in Africa:

   - Japanese type vacuum trucks which appear to be more robust and cheaper than those used in African countries up to now.
   - Vacuum tanks mounted on a trailer and pulled by a farm tractor. This is a relatively simple device used by European farmers to spread the liquid manure on the fields.

   At present, IRCWD is trying to identify manufacturers in Europe and Japan who are willing to cooperate in these field tests.

b) Investigations and tests should be undertaken in the laboratory and in the field in order to develop new or adapt existing equipment. Currently available fluid handling technology could be combined with some device for fluidising the sludge. Alternatively, "solid" sludge could be removed by an air drag or conveyor system, though these, too, would require development to a form specifically designed for pit emptying. It is probable that vacuum or diaphragm pump systems in conjunction with a sludge fluidisation device will turn out to be more cost-effective than other options.

   The British Building Research Establishment (BRE) and the Swedish Building Research Institute (SBRI) have shown great interest in carrying out investigations and field tests. In both organisations, projects could be started thanks to the support of the British Overseas Development Administration (ODA) and the Swedish International Development Authority (SIDA).

Authorities in developing countries, development agencies, research institutes and manufacturers interested in helping to find solutions to the pit emptying problems are kindly invited to write to the Manager of IRCWD.

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HUMAN EXCRETA MANAGEMENT - TOILET MAINTENANCE

Dr. LE VI HUNG

I.- *Excreta and public health in rural areas-*

Numerous studies have indicated that the waste of a community contains the complete spectrum of enteric pathogenic microorganisms excreted by the community, which is a function of the endemic disease rates prevalent in that community. Beside the pathogenic bacteria, night soil from human sources may contain viruses of enteric diseases. In warm, tropical and subtropical areas of the world, diseases caused by the pathogenic protozoans and helminths are common.

Concentrations of these pathogens in night soil may be quite high. For example, one fertilized female Ascaris worm living in the human intestine produces 200,000 eggs per day while a female Ancylostome deposits between 25,000 and 35,000 eggs per day...From the above, it can be seen that the concentration of parasites in night soil or in sewage is a function of the type of parasite and the number of infected persons in the community serving as a source.

Vietnam is a subtropical country where the environment is a factor favourable for the development of germs of intestinal infection (diarrhoea, dysentery typhoid fever, cholera, poliomyelitis, infectious hepatitis, helminthiasis...) and arthopods vectors of diseases (flies)

Besides the environmental factors, the unorganised excretion in gardens, in rice fields..., the removal of feces from privy-container over the country side without adequate hygienic measures, the bad habit of using fresh waste in agriculture and fish-breeding... have brought about the most serious pollution factors to the environment such as ground, water supply and food-stuff. This constitues a serious danger as regard epidemiology for the excreta of patients and germ-carriers are a source of propagation of intestinal diseases. This "fecal peril" is especially great not only in the region where the population has the bad habitof using fresh waste but also where the crops are eaten raw.

According to statistic data of the National Institute of Hygiene and Epidemiology, the morbidity rate due to intestinal pathogens in rural areas was very high :

more than 70 p.c. for A.Lumbricoides;
more than 60 p.c. for Tricoce-phalus;
about 35 p.c. for Ankylostoma duodenalis
to 12 p.c. for Shigella
8-15 p.c. for Salmonella
30-40 p.c. for Pathogenic coli (G.E.I.)

Recently field-studies have indicated that the diarrhoeal diseases of children under 5 ages are very serious-data of National Institute of Hygiene and Epidemiology -Hanoi Medical Faculty (Tab. 2-6)

Besides, the drinking water used in the country side mainly comes from shallow wells and unchlorinated before use.

In the regions which lack any hygienic and acceptable method of excreta disposal, the environment (soil, water) is constantly polluted by excreta. (Tab.7)

II.- Composting toilet.-

To solve the problem of fresh excrement the Ministry of Public Health of Vietnam launched a patriotic hygiene compaign with a view to preserve environment purity and man's health and to make of it a source of fertilizer.

Just in that hygiene movement throughout the country is born the typical double vault composting toilet "DVC" which meets the hygienic requirements.

Principle : The excrement is packed with buffer-matter in closed bin: Under the activity of micro-organisms, especially of anaerobic microbs, the composting process takes place anaerobically *and changes organic proteins into nitrates and eliminates pathogenic germs in several weeks.*

The design details vary, but all DVC toilets have certain operational and architectural requirements in common. There are two adjacent vaults, one of which serving as receptable for defecation (urine being channelled into a separate vessel being used first while the other, full of human excreta, being left to on-the-spot composting of its excreta together with buffer-matter (kitchen ash, powder earth, household refuse, leaves...) Organic excreta and buffer-matter will be made compact and then composting process in hermetically closed tank, left to itself for 60 days (Fig 1 - 3)

DVC toilet is a work aimed at collecting and treating the excreta after the principle of anacrobic composting. Ash and biodegradable organic matter are added to the vault to absorb odors and moisture. To produce good compost , the optimum moisture content in the vault should be between 40 and 60 percent. This can be achieved in this way : the urine is drained to a separate vessel and collected for use as a nitrogenous liquid fertilizer. The buffer matter (kitchen ash, powder lime...) is a absorbent matter and the worm-powder.

The temperature in the composting vault is higher than the surrounding one by 2 - 6'C. In summer it may rise up to 45'C while the surrounding one varies between 28 and 32'C. In short the time, the buffer matter, the temperature combine themselves in the closed bin to eliminate the pathogens.

A wide variety of materials may be used to construct the toilet. Material requirements are for the pit lining, the squatting plate and the superstructure. Although a variety of materials can be used, brick or concrete blocks are chosen for the construction. They are the best and also the dearest, so in some regions we can use materials on the spot (loam, adobe, bamboo, wood...).

The use and toilet maintenance must be strictly carried out.

1/ The cesspool and the composting bin must be used alternately, and never simultaneously;

2/ After each defecation buffer-matter, especially kitchen ash, must be regulary added in the correct quantities (one part of feces and two parts of ash) to absorb odors and moisture and to maintain a suitable carbon-nitrogen ratio in the composting material. The toilet paper is thrown into the vault. The lid is again put on the inlet for fecal discharge.

3/ Periodically one keep clean the urine outlet, the opening for fecal discharge and the compost removal port;

4/ When the vault is three-quarters full, one throws in buffer matter and seal it with battered clay; the other vault is emptied and put into service. The late of composting should be noted and it must last 60 days.

D.V.C. toilet is the most common type of batch composting toilet. It presents some advantages:

1/ Collecting and compost processing takes place on the spot, avoiding thus transport difficulties as well as direct manual contact with fresh human excreta and scattering pollution material among the environment.

2/ This model is the most commonly accepted and used in almost villages. On certain areas all households possess those typical toilets for their own house. On average an unit of D.V.C. toilet is available for 1,5 family.

3/ The organic excreta is removed from septic bin after going through complete composting process in hermetically closed bin and shown as non-pathogenic, non toxic manure with high nitrate concentration, excellent fertilizer for vegetables and cereals (Tab. 8-9) Nevertheless this type of toilet is unsuitable in areas where:

- *there is not custom of agricultural reuse of excreta;*
- *there is unsufficient buffer-matter for composting process;*
- *there is high-density of population;*
- *sufficient user care cannot be reasonably expected;*
- *every year the overflooding and intense rain-fall bring about the demolition of toilets especially those made of battered earth:*

In those regions D.V.C. toilet become antihygienic, excreta are not appropriately treated and pathogens can be develop in the environment and constitue sources of propagation of intestinal infections.

III.- Water-privy

To resolve above difficulties and to preserve public hygiene the National Institute of Hygiene and Epidemiology has devised a new type of self-sterilising water-septic tank. This type called "Improved septic tank" is being studied in the regions where "D.V.C. toilet" still develops very little effect.

Principle. *- This type of water-privy and that of renovated siphon drainage channel are both different from that classical S.like siphon. The biological decomposition process of organic excreta and cellulosic substances will be speeded up along with the active participation of anaerobic bacteria already present within the excreta, creating thus a very strong biological membrane, which enables the septic tank to maintain constant temperature, tightness, the organic manure to change rapidly into humus and at the same time helps producing a lot of biological gas (mainly methan) that can be used as fuel for the cooking. In this composting process, pathogens of cholera, dysentery, typhoid fever, diarrhoea..., various species of viruses, eggs of ascaris...cannot survive long, then will be readily killed. The effluent and mould of this toilet become non toxic, non pathogenic manure and can be used as a soil fertilizer.*

Structure.- This toilet consists essentially of a suatting plate situated immediately above a septic tank. The squatting plate has a siphon, in diameter 150 millimeters, the bottom of which is 10 to 15 centimeters below the water level in the tank. In this manner a simple water seal is formed between the squatting plate and the tank contents. In order to maintain this water seal, which is necessary to prevent fly and odor nuisance in the toilet, it is essential that the tank be completely water-tight and the toilet user add sufficient water to the tank via the A superstructure. is provided for privacy and a small vent pipe is normally incorporated in the design to expell the gases produced in the tank. The advantages of the siphon, inportant component of water-privy, are:

1/ small volume of water for each flush (about 3 liters)
2/ an opening must be holed for the deplugging when necessary;
3/ easy to build and replace.

Thanks to the combination of autodecomposition tank with depot of excreta residues recovery, the biological menbrane of the autodecomposition tank is constantly preserved so that the tightness and the anaerobic condition are quite ensured which is particulary favourable to the activity of anaerobic micro-organisms. Thus:

1/ excreta quickly change into humus;
2/ biological gases (mainly methane) emanate in greater amount:
3/ disease-causing agents of intestinal infections are eliminated
4/ the depot of excreta residues recovery acting as a safety-valve; after 1 year they are taken out and reused in agriculture.

The effluent of depot of water recovery is limpid and odourless. It can be mixed with urine, which increases the percentage of nitrates, and collected for use as a nitrogenous liquid fertilizer.

The water-privy must be applied;

- *in populous areas and on the littoral;*
- *in agricultural and aquacultural reuse;*
- *in enterprises, schools, markets, bus-stops...(model for public spots)*
- *in urban centers or provincial chief-towns*
- *in new economic zones*
- *to replace D.V.C. toilet....*

The toilet user must respect the following rules:

- *discharge just in the shitting hole so as not to dirty the seat;*
- *throw used toilet paper in the basket provided to this* ***effect;***
- *pour water in the shitting hole immediately after each defecation (about 3 liters) to maintain the water seal;*
- *avoid pouring in the tank soapy water or antiseptic solutions so as not to kill necessary for the decomposition of orgenic substances.*
- *avoid using sharp and hard stick for the deplugging.*

IV.- Biogas production.-

When organic wastes are digested anaerobically, a mixture of mathane, carbon dioxide, and other gases is given off. This gas has become known as "biogas" and can be produced on various different technologies. The biogas plants are fed with diluted ***dung*** *with or without human excreta and with or without vegetable refuse. The effluent is reused in agriculture or in aquaculture to enrich fishponds. The gas is used primarily for domestic cooking and lighting. The dung from one cow, or similar animel, may producd around 500 liters of gas per day and the calorific value of this gas may be arount 4-5 kilo calories per liter. In contrast human excreta only produce 30 liters of biogas per person daily. The process is very sensitive to temperature. In the mesophilic range, optimum gas production occurs at around 35'C. In some regions of our country a complexe of septic tank and system of recovery of biological gases from dung, human exereta for one family has been studied and tested (Fig.6-7). The aqua-privy* *is connected to pigsty and to cow-shed in order to provide material for composting and for biogas production. This amount of gas suffices to boil water for daily dringking and to cook meals for one family of 5 to 10 persons. Thus a source of fuels and fertilizers will be available while risk of pollution of environment in set aside.*

A litte information from the field-studies on the biogas plant effluent indicate that helminth ova, especially Ascaris ova, may be survive in it. Therefore the work of popularisation of this model is now in progress./.

Total of children under 5	Total death cases	Mortality according to difference causes				
		perinatl	diarrhoea	ARI	other diseases	accidents
16,803	67	11	23	14	2	17
% compared with all death cases	100	16.42	34.33	20.90	2.98	25.37
% compared with population under 5	0.40	0.06	0.14	0.08	0.02	0.10

MORTALITY OF AGE
GROUP UNDER 5

DISTRIBUTION OF ENTEROPATHOGENIC BACTERIA AMONG
DIARRHOEAL CASES

Total of exam cases	Positive cases	Salmonella	Shigella	E.Coli	other enteropathog. bacter.
1,470	693	16	52	262	363
% compared with examined cases	47.14	1.09	3.54	17.82	24.69
% compared with positive cases	100	2.31	7.50	37.80	52.38

DISTRIBUTION OF INTESTINAL PARASITES AMONG DIARRHOEAL CASES

Total Examined cases	Positive cases	Ascaris	Tri-Chiuris	Anky lostoma	Enterobius Vermicularis	Entamoeba histolytica	Giardia	Entamoeba Coli	Mixed infection
1,531	435	147	30	3	1	189	4	30	31
% compared with total exam, cases	28.41	9.60	1.96	0.20	0.06	12.34	0.26	1.96	2.02
% compared with total positives cases	100	33.80	6.90	0.70	0.23	45.52	0.92	6.90	7.13

ETIOLOGY OF DIARRHOEA CASES

Total of specimens examined	Total of positi-ve specimens	Bacterio	Parasito	Mixed bact-parasit
1,531	949	514	256	179
%compared with total of specimen examined	61.98	33.57	16.72	11.69
%compared with total of positive specimen	100	54,16	26.98	18.86

Table ENVIRONMENTAL POLLUTION BY EXCRETA

	Number of samples	Fecal colititre	St.Fecalis (1ml)	CL.Perfringens (10 ml)
Well water	2,500	0.1-0.01	20-100	2-15
River water	1,000	0002-0.004	over 100	25-100
Waste water	600	0.0007-0.0009	over 100	over-200
Soil	1,500	0.02-0.005	20-70	10-40

Table EFFECTIVENESS of COMPOSTING TOILETS

LENGHT OF TIME	ORGANIC PROTEINS 2/100g OFFECES	NITRATES 2/100g Offeces	E.COLI (Per G. Offeces)	ASCARIS OVA (% removal)
Before composting	1.102	0.011	11.100000	
After 1 week	0.997		1.110000	0
After 4 weeks	0.395	0.210	100	35%
After 8 weeks	0.020	0.446	Probably Eliminated	50 - 85%

Table AGRICULTURAL REUSE OF TREATED EXCRETA

(Produce/ha)

FOOD CROPS	FRESH EXCREMENT	COMPOST
VEGETABLES	100%	144%
POTATOES	100%	220%
SUMMER RICE	100%	127%
WINTER RICE	100%	131%

Environmental Conditions in Bangkok Slums

Sumet Manoharn

Introduction

There are about 400 slums, scattering around, in Bangkok, approximately 1 million people or 20% of the city's population.* Slums are characterised by irregular dense settlements and a general absence of infrastructure services.

Since 1977, The National Housing Authority (NHA) has implemented a slum improvement programme. During 1977 - 1983, 33,000 families or about 200,000 people in 82 slum areas are expected to benefit from the programme.

Cause of Slum erection

1) Migration

Since Bangkok is the center of business, administration, politics, education and development. Every year, a significant number of people from the provinces has migrated to the city. Most of them came to bangkok in order to find job, education, utilities, facilities and securities.

According to the survey, the rate of migration per year is about 2% of the city population

2) Population growth

The housing that provided by the state is not sufficient for the middle and low income population.

The city population growth rate per year is 4% of the city population. At present, the housing demand of the middle and low income population are increasing about 20,000 units per year. But the housing supplied by the state (include slum upgrading) is about 10,000 units per year.

* In 1982, the population in Bangkok is 5.4 millions.

3) Land Tenure

The main land tenure structure of the low income housing is renting a piece of land without any basic infrastructure and erect their own houses. The land is normally belong to the private rich. Basically government can not improve the land unless the land lord give the permission.

Topography

Bangkok is located in flat and low land. The existing elevation is about 1.70 metre above mean sea level (msl.). The surface water level in the flooding season is about 1.50 metre above msl.. The soil condition is very soft, and the upper layer (2 - 3 metre) is clay.

Building Technology

In the past

Most of the houses were made of timber which was very cheap and easy to purchase. Normally the floor of the house was elevated from the ground.

At present

Since 20 year ago, the technology of using reinforce concrete and brick was adopted and it is very popular among the rich and higher middle income.

Instead of elevating the floor like timber house, normally they fill the land (1-1.50 metre high) and construct the reinforce concrete house on grade.

But most of the low income houses are still made of timber. Although at present the cost of timber are rather high, for the temporary of semipermanent houses use second class timber are still much cheaper than the reinforce concrete ones.

Normally, the houses in the slum area are made of timber. The land is not filled and the floor is elevated. That make the ground level in the slum areas are lower than their neighbour. Cause the problem of stagnant water and flooding.

Access

Normally, the existing walkway in the slum area is made of old timber and also elevated from the stagnant water or flooding.

In NHA's slum upgrading project, the existing old wooden walkway will be replaced with a elevated reinforce concrete walkway.

The space along the circulation in the slum is usually very narrow. It is very difficult to construct the new walkway.

Drainage

In Bangkok, the drainage system is taken care by the Department of Drainage under the Bangkok Metropolitan Administration (BMA). The waste water from the houses and the storm will be drained to the public drainage line along the road to the canal to the river and then to the sea.

While poor drainage is the problem, flooding can affect the whole city after heavy rains. Currently the Department of Drainage has developed a temporary flood protection system, dikes and pumping stations, which reduces flooding problems in the central areas of the city, but increases the length and severity of floods outside the protection areas.

Most of the slums are located near the canals or river. In NHA's Slum upgrading project normally the drainage which was provided is the open channel drainage underneath the walkway, drain the waste water directly to the canals or to the river. It is not possible to drain the waste water to the public drainage on the road, because the ground level in the slum are lower than the public drainage. It is very difficult to construct the drainage in the slum areas due to the stagnant water and flooding problem. In order to solve the problem. The Slum Upgrading office has developed a prefab flume which is very easy to install.

Garbage disposal

The collection of solid waste from each house in the city is serviced by the destricts under the Bangkok Metropolitan Administration (BMA).

Currently the districts have the total collection capacity about 2,500 Ton/day which is only half of the total solid waste.

Most of the slum areas do not get the service from the districts. The reason is the truck can not reach in slum area. The other reason is the slum dwellers refuse to pay. In the slum area, solid waste is dumped where else on the ground or the canal which is very bad for the environment.

In NHA's slum upgrading project, the garbage baskets and garbage house were provided at the place where the truck can reach. But the system do not work well. Because the truck did not come.

Water supply

In Bangkok the potable water is supplied by the Metropolitan Water Work Authority (MWWA).

The most common problem is low discharge pressure and often there is no water at all for long hours. To cope with the unpredictable supply, most houses in Bangkok have to store water and install pummps to increase water pressure. When ever the water pipe is broken, the pumps may suck the dirty water into the pipe especially in the flooding season the problem is more seriously.

Generally, most of the slums in Bangkok have access to MWWA's water supply. The minimum charge for individual connection including water meter is about us $ 150. The number of metered individual connections could range between 30 - 70 percent, the rest of the families being supplied by neighbours or water vendors. Housing areas outside the center of Bangkok are usually serviced by privately operated independent network from deep wells. Shallow wells, near by canals or rain water collection is also a source of water supply in outlying slum area.

Electricity

The Electricity in Bangkok is responsible by the Metropolitan Electricity Authority (MEA).

Every house in Bangkok, even in the slum areas, has access to MEA's Electricity and basically has individual meter. Currently, the minimum charge for individual connection including meter is about us $ 100.

Human Waste Disposal

There is no central sewage system in Bangkok. Except in the public housing projects, have the sewage line with the treatment plant. Generally almost every house has the septic tank which normally has 2 chambers, the first chamber is the cesspool with squating plate, water seal on top and a ventilation pipe, the second chamber is the seepage one which has holes for the affluence to soak out into the earth.

Except in the slum areas, almost every house has cess pit which has only one chamber. There is a squating plate, water seal on top and a ventilation pipe, But do not seal the bottom in order to let the affluence to soak out into the earth.

Either the septic tank or cess pit let the affluence soak out into the earth. Which may cause the disease spread out and contaminate the other. Especially in the stagnant water area or in the flooding season the disease will come up and contaminate the environment.

When the cess pool is full, we can use the BMA's service truck to empty the sludge in the pool. The fee for sludge removal is about us $ 10 once.

The BMA's truck will dump the sludge at the dumping station located in the fringe area and the sludge will be composed in the open.

In the slum area, where the truck can not reach, when the pit is full, it has either to be empty and burry the sludge nearby or construct a new one.

Generally, every house has a toilet.. But basically the existing toilet is not suitable for the population density, soil condition and topography in Bangkok. It is not possible to ask the families who own the houses to chance the existing toilets to a new suitable one. It will be practically to persuade the families who are going to build a new house to construct a suitable toilet. At least the enveronment will not be worse than present.

So far nobody can say that what kind of toilet is suitable for Bangkok. The author may has a chance to do a research on the appriate human waste disposal in Bangkok. It is just the beginning of the Slum Upgrading Department to solve human waste desposal problem, especially in the new housing project like sites & services project. At the beginning we will study on the up flow filter which is similar to the existing septic tank in term of material and cost. But for the quality, the affluence can be directly drained to public drainage system. The major problem of the up flow filter is the problem of clogging. If we can solve the problem of clogging in the up flow filter, we may say that it is a suitable toilet for Bangkok.

*Slum Upgrading Department
National Housing Authority
Thailand.*

IMPROVING THE CESSPOOL FOR THAI SLUMS

Krisno Nimpuno

Institute for Housing Studies - BIE
Rotterdam, Netherlands

The low-cost sanitation solution of the slums in Bangkok has found general application in the slums. It has become one of the most successful sanitation systems in relation to the general applicability in the slums.

The excellent acceptability the system has not been reported very widely. It has, however, hardly ever been visualized how the long-term pollution effects of the system may be.

The success of the system would justify some systematic analyses of the cesspool performance to identify possible bottlenecks and strong points of the system.

This paper discusses some of the attitudes of the uses while an evolutionary approach for the application of the cesspool is recommended.

THE ORIGINAL CESSPOOL DESIGN

The cesspool design, as it was launched in the early seventies as a low-cost solution for urban areas in Thailand, consists of two interconnected tanks.

The first tank is for settling solids, while the partly purified effluent flows into a second tank - a soakage. The first tank has a vent pipe, since most of the biogas is produced here, and an inlet in the form of a squatting plate with a water seal. Both tanks are made of concrete rings, the first one has a tight bottom, and the second one has an open bottom. This design requires a regular removal of the sludge, while the system percolates a considerable quantity of unstabilized organic matter and pathogens into the ground water. It is, however, very easily constructed and requires little maintenance.

The system works well in areas with a high ground water level, which keeps the second tank filled with fluids. As a result, secondary treatment takes place before the effluent soaks away. If there is a low ground water level, however, the overflowing fluids from the first tank soak away into the ground before any secondary treatment takes place. The pollution effect will therefore be considerable.

The cesspool, as it was introduced, still assures a reasonable environmental protection, but although the system became widely accepted and applied, it performs less well than could have been expected. This is to a large extend caused by the simplified version that was applied in most cases. This system as described in detail in the following pages is still very acceptable to the people, but its performance is very inadequate.

For all its faults, however, even the simplified cesspool has made two major contributions to public health: it limits contamination and makes organized sanitation in dense areas a fully accepted element in housing.

THE SIMPLIFIED CESSPOOL

Very few houses in Bangkok lack a toilet facility. The sanitation campaigns have resulted in a very high acceptance rate of individual facilities - well over 95% of the slum households have one kind of toilet system or another, in most cases a cesspool.

Two important factors have played a role in the rapid acceptance of these toilets in the Bangkok slums. Firstly, the effective water seal prevents unpleasant odours, and the vicinity of a toilet is therefore no longer provoking strong negative reactions.

The second factor contributing to the general acceptance relates to the simple construction methods developed for the system. The whole construction is readily available in pre-fabricated parts from a multitude of suppliers at a very low price. The system is so cheap in its implementation that many households build a second toilet instead of emptying the original one.

In summary, easy and economical supply, and the elimination of pleasant sights and odours are the key factors behind the high implementation ratio of toilets systems in Thailand.

A second look at the system, however, discloses a very different picture. The actual installations that one finds in the slums are very different from the original cesspool design. Instead of two tanks, there is only one, which consists of a set of rings without a bottom plate and has a squatting plate with a water seal, but without a vent pipe on top. The tank sometimes hardly enters into the soil, but rises through the surrounding surface water up to the floor of the house. The user still enjoys the same advantages as in the case of the correct double-pit cesspool: cheap and easy installation, and an effective water seal keeping out all unpleasant odours.

The treatment process, however, has changed radically. The fluids leach directly without treatment into the surrounding surface water. There is no secondary treatment of effluents and the percolation of fresh faecal matter into the water body is quite possible. There are many operational problems with this type of toilet, but from the users point-of-view it is satisfactory: it is cheap to construct and pleasant to use. The operational difficulties are not immediately apparent, but the leaching effect constitutes a long-term health hazard and causes severe pollution.

The direct soakage reduces the mineralisation process of the settled solids. The lack of a vent pipe results in a build-up of biogas in the tank and causes blockages.

The adverse environmental conditions in the slums are partly related to this malpractice of building simplified cesspools. The upflow filter as described later in this paper is suggested as a solution.

THE CONSTRUCTION OF THE CESSPOOL

The cesspool consists of a few simple pre-fabricated components which are widely available and can easily be assembled. A complete unit can be installed for about Baht 700 (US$ 31) in a few hours' time. The unit consists of a number of concrete rings, a concrete cover slab, and a porcelain or terrazzo squatting plate with a water seal. The rings have a diameter of 80 cm and a height of 50 cm, and are cast in simple steel molds. These components are produced by many small contractors and building material outlets.

Installation consists of making a small excavation in the ground and putting a few rings on top of each other up to the floor level of the house. The joints between the rings are sealed with mortar and then the cover slab is masoned on top. This slab has an oval opening which allows the water seal of the squatting plate to enter the tank. In its simplest form, this last element is made of concrete with a terrazzo facing; the more expensive model is made of porcelain. Only the squatting plate protrudes from the floor. The water seal is flushed with a small quantity of water either by hand or with an automatic flush. This type of squatting plate is also used in public buildings which are linked with a septic tank system.

The rings have four small dents in the sides which allow the rings to be punctured. This arrangement was made in the original cesspool design to allow cesspool effluent to leach out of the tank. The rings were therefore to be surrounded by a mantle of gravel so that the fluids through a soakage around the tank could percolate into the ground. The high water table of Bangkok and the clay soil, however, prevent this from happening. The rings are therefore usually left unpunctured, the backfill is the excavated soil from the pit, and the gravel mantle is omitted. The bottom of the pit is left open and thus the water level in the cesspool corresponds with that of the ground water. The volume of the cesspools are related to the number of rings used in the construction, and this differs widely. Where the original design is basically intended to be an underground, leaching tank, the present practice is often very different. Many houses are built on stilts, sometimes on flooded land, and the floor of the houses may be as much as 150 cm over the surrounding soil. In these cases, the tanks may have been built more above ground than underground. In some cases, only half a meter of the tank penetrates the soil and the main volumes rises from that level to the floor of the house. As a result, the leaching effluent does not percolate through a thick layer of soil but comes straight out into the surface water.

The cesspool should be built with a vent pipe, but 74.2% of the installations in the surveys lacked a vent pipe, while only 5.5% had a vent pipe protected with wires against flies. The others used open vent pipes (3).

There are many complaints about blockages which are said to be related with a gas build-up in the pit. A small puncture in the side of the tank is often made to ventilate the tanks.

The households in the Bangkok slums have very good access to sanitation facilities. In the Rama IV area, 95% of the households have individual latrines (5), while in other areas the figure may be lower, everybody has access to toilets. It is often among the very small households that toilet facilities are shared, especially in the case of the very poorest (2). It was observed that these shared toilets were not maintained as well as the single family units. The system which is generally applied is the cesspool: over 96% (3), while only 1.2% are pit latrines and 1.5% septic tanks (3). There are no detailed figures available about the types of cesspools which are used. By impressions from unsystematic observations, it is suggested that a great majority of the cesspools in the slums are of single pit types. It was also very evident that while the toilets in the houses were spotless, the collective outhouses tended to be quite messy and unpleasant.

USERS SATISFACTION

All surveys show a considerable satisfaction with the present system. The effective water seal prevents unpleasant odours inside the house. As many as 62.8% of the respondents desired no change at all. The main complaint concerned the necessity of emptying the cesspool, and 4% of the people would like to have better emptying methods (3).

When asked whether they would like to have a WC and a septic tank only, 4% answered affirmative (3). In spite of a number of obvious and some less obvious shortcomings of the present system, few slum dwellers see any reason to change their sanitation methods and have other priorities in life.

The complaints very often center on disturbances created by their neighbours' latrines rather than their own, as was the case with 27.4% (3) of the interviewed. The main complaint referred to the pollution caused by careléss emptying procedures, especially desludging by breaking the tank and spilling its contents on the surrounding land. This was indicated as a nuisance by 16.3% (3) of the people, whereas only 1.5% of the cesspool owners use this method of desludging (2). It is not surprising that this habit causes considerable resentment from the neighbours.

The main desire to improve the toilet concerns the superstructure of cesspools: 23.1% (3). The families with bigger houses, the upper social layer at the slum, always have their toilet room integrated in the house itself. The references to superstructures concern therefore mainly the smaller houses which outhouses, especially those who share toilet facilities. To a certain extent, this indicates that the people see their toilets often in terms of status rather than in terms of protection and health. This is confirmed by the statement by 11.1% of the people (3) that a smelling, poorly built latrine does not disturb.

The successful introduction of the cesspool in Bangkok has achieved a very unified sanitation method which satisfies the people. The easy construction system and the widely available and cheap components brought this method within everybody's reach. The absence of offensive odours and the simple cleaning requirements give much satisfaction.

The result is that people feel that sanitation is adequate as it is. Public health and technical and environmental considerations are not felt to be questions within their control, and do therefore fail to attract much interest. It certainly suggests that the absence of evil smells give the people a false sense of security.

ITS USE

The cesspool design is suitable for the Thais because water is allowed into the tank. As little as two litres will do to flush it and the use of water for anal cleansing - as 94.8% (3) of the population are practising - helps. Only few people are using toilet paper, 4.3% (3), and this may cause blockages of the water seal. It is fairly common to throw this paper in a waste bin next to the toilet and dispose of it later with the garbage of the house. This habit offers still many possibilities for vector transmission and fly breeding. It is not unusual to throw waste water into the cesspool: 17.5% (3) do so. Garbage, on the other hand, is not flushed down, the 1.2% who do so are the users of pit latrines, not of cesspools.

The cesspool needs to be emptied periodically, when the solids have filled most of the tank. The procedure is to use a vacuum truck and insert the hose through a metal lid that has been mounted in a socket in the cover plate. It is however often difficult to unscrew this lid and the truck operators seldom attempt to unscrew it. They find it easier to scissel away the mortar that holds the squatting plate, lift it off and seal it into place after completion the procedure.

The Municipality (BMA) operates 16 vacuum trucks to service a population of 5.5 million people to empty the cesspools and septic tanks of Bangkok (1). The official charges seem to be about Baht 500 (US$ 23) per service, but it often takes some extra contribution to persuade the driver to come to the house. The higher income groups prefer this method of emptying (2).

The sludge is dewatered and composted in two locations in Bangkok and then mainly used for landfill.

There are quite many slums areas, for instance many of the flooded areas, which are not accessible to the trucks. The use of the trucks is limited to 17.8% of the slum dwellers (3), while 14.7% empty the pits by manually digging the contents out. These figures refer to a variety of areas and can differ in individual cases. For instance, the Rama IV area - a well situated, dry and not very dense area - reported in 1979 that as many as 70% of the cesspools were emptied by vacuum trucks. But in the same area, 1.5% of the cesspools were desludged by puncturing the rings and discharging the material over the surrounding ground (2).

The surveys indicated a very relaxed attitude from the users: many respondents declared that the toilets never gave any disturbance and that there was no need for emptying. Another method for avoiding emptying is simply building a new cesspool and sealing the old one. It may be more economical to do so, and 13.8% of the people reported to have chosen replacement over emptying. This is especially common among the poorest groups (2).

SLUDGE AND EFFLUENT

Comparisons with sludge collected from Japanese concrete nightsoil tanks show that cesspool sludge is much less concentrated due to the inflow of flush- and ground-water into the cesspool.

The cesspool sludge has a high concentration of amonia-nitrogen, because it has had a long period of absorbic digestion and much of the remaining organic material is no longer biodegradable (4).

"Cesspool sludge is Bangkok is unique in its characteristics and is not similar to nightsoil and sludge from anaerobic digesters. Most of the organic pollutants in the cesspool sludge are in solid forms and are readily removed by chemical coagulation using alum or polyelectrolytes. The chemical coagulation could reduce over 80% BOD and 95% SS of the supernatant, and over 80% specific resistance of the thickened sludge" (4).

HEALTH AND ENVIRONMENT

The pollution resulting from the cesspool system is very significant, since the system is based on leaching, and also because many of the tanks hardly penetrate the ground and much undigested material can reach the surrounding ground. This is especially evident during the rainy season when many areas get flooded and the standing water quickly turns black, revealing its heavy organic loads.

There is much reason to believe that the high density in the slums and the use of a simplified single pit or a cesspool in clay soil forms a dangerous combination.

During the 1981 visit to Rama IV, ground water samples and soil samples were taken around six randomly chosen cesspools, and the results were confirming these fears. The soil samples were taken from the surface a distance of one to two metres from the cesspool and from a depth of about six centimeters, and were checked for E. coli, and a variety of bacteria and parasites.

Among the many bacterial pathogens, cholera bacteria, Dr. Pichit's findings in July 1981: Vibrio parahaemolyticus and non-agglutinable cholera gr. I, II, III, Aeromonas hydrophilla etc. were found throughout. Parasitic larvae and eggs were found in all the surface samples and in fifty percent of the subsoil samples. It may be possible that this can be explained by surface water dripping into the excavation polluting it with surface material, but even so a picture emerges of a thoroughly polluted and dangerous environment.

The heavy organic load and the pathogenic pollution emitted from the cesspools today call for viable alternatives. Two successful solutions from elsewhere are described: the Vietnamese toilet and the Indian pour-flush latrine. These are not seen as suitable solutions for Bangkok because the first solution does not work if cleansing water enters into the vault, while the second type should be applied in areas with low ground water. The aqua-privy has been applied successfully in a.o. Botswana and may be good for Bangkok. The upflow filter is suggested especially to suit Thailand.

Result of Soil Examination by Simple Sedimentation and Flotation Technics

Sample No.	Top Soil	MPN Index/ 100 ml.	Sample No.	Underground Soil	MPN Index/ 100 ml.
1 S	Toxocara eggs Opisthorchis-like eggs Nematode larvae	79×10^3	1	Negative	49×10^2
2 S	Nematode larvae Mite; adults and eggs	13×10^6	2	Nematode larvae Mite eggs	24×10^5
3 S	Opisthorchis-like eggs	79×10^2	3	Opisthorchis-like eggs	49×10^4
4 S	Mite; adult and eggs	13×10^3	4	Negative	33×10^4
5 S	Mite; adult and eggs Unidentified eggs	17×10^5	5	Nematode larvae	33×10^4
6 S	Nematode larvae	13×10^3	6	Negative	33×10^3

Examiners : Dr. Jirasak Rojanapremsuk and
Associate Professor Pichet Stulbhram

THE UPFLOW FILTER

In order to improve the performance of the cesspool, several complementary designs have been tried, in most cases aiming at eliminating the leaching and treating the effluent to a level where it can be safely disposed. The most promising design is the cesspool with an upflow filter.

The upflow filter cesspool is a two-tank system similar to the cesspool, but with an overflow instead of a soakage outlet from the first tank. The degree of purification is therefore much higher, while the effluent also can be sewered if wanted.

The system offers the same treatment process as a good septic tank and its effluent is well purified. The system consists of two interconnected tanks. The squatting plate with a water seal sits on top of the first tank, which also has a vent. The tank is connected to the second compartment with an inverted U-shape tube which ensures that only the cleanest effluent flows into the second tank, which is filled with gravel.

In the second tank, little sedimentation takes place and here the effluent is further reduced in BOD, because it bubbles up past stones covered with bacteria, which further breakdown the organic matter. From the top of this tank, the clear effluent is discharged through a overflow. It is then so clear that it can be led into an open drain. The construction parts of this system are the same as for the cesspool system.

The upflow filter design can be built with the same elements as the cesspool. It is also possible to develop a cesspool or a simplified cesspool into an upflow filter installation in stages. It offers, therefore, an excellent upgrading option for the existing situation. A well constructed upflow filter system will reduce the environmental and health risks by over 90%.

It is still necessary to remove the sludge periodically, but the sludge will be of much less offensive nature than in the standard cesspool design or in the simplified type. It is also conceivable that the system gradually attains perfection by joining up the outlets with a simple small-bore sewage line.

The maintenance of the system is, however, more complicated than for the simplified cesspool. Not only sludging is required, but also the filter tends to clogg when overloaded. This means an excessive bacteriological development which blocks the space between the stones. Then the filter has to be cleaned, and this can be done by flushing excavation or blockflowing.

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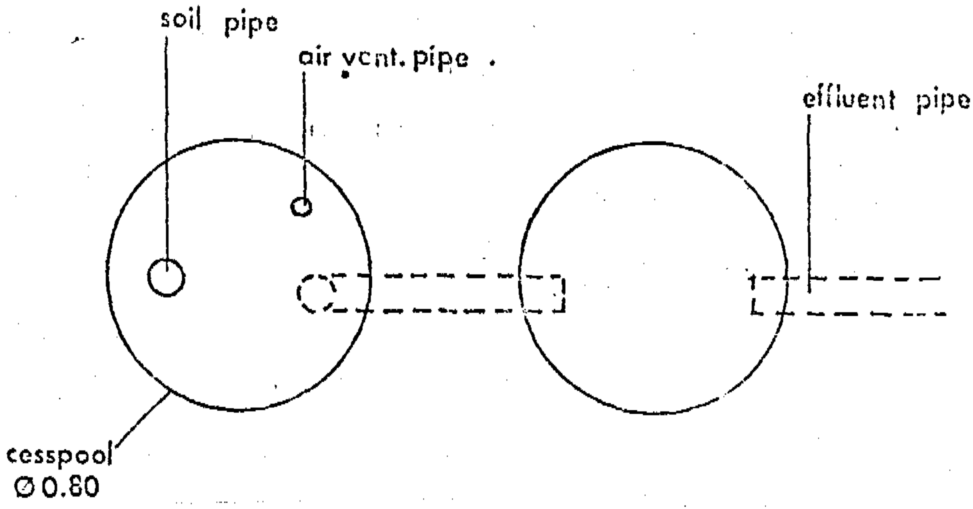
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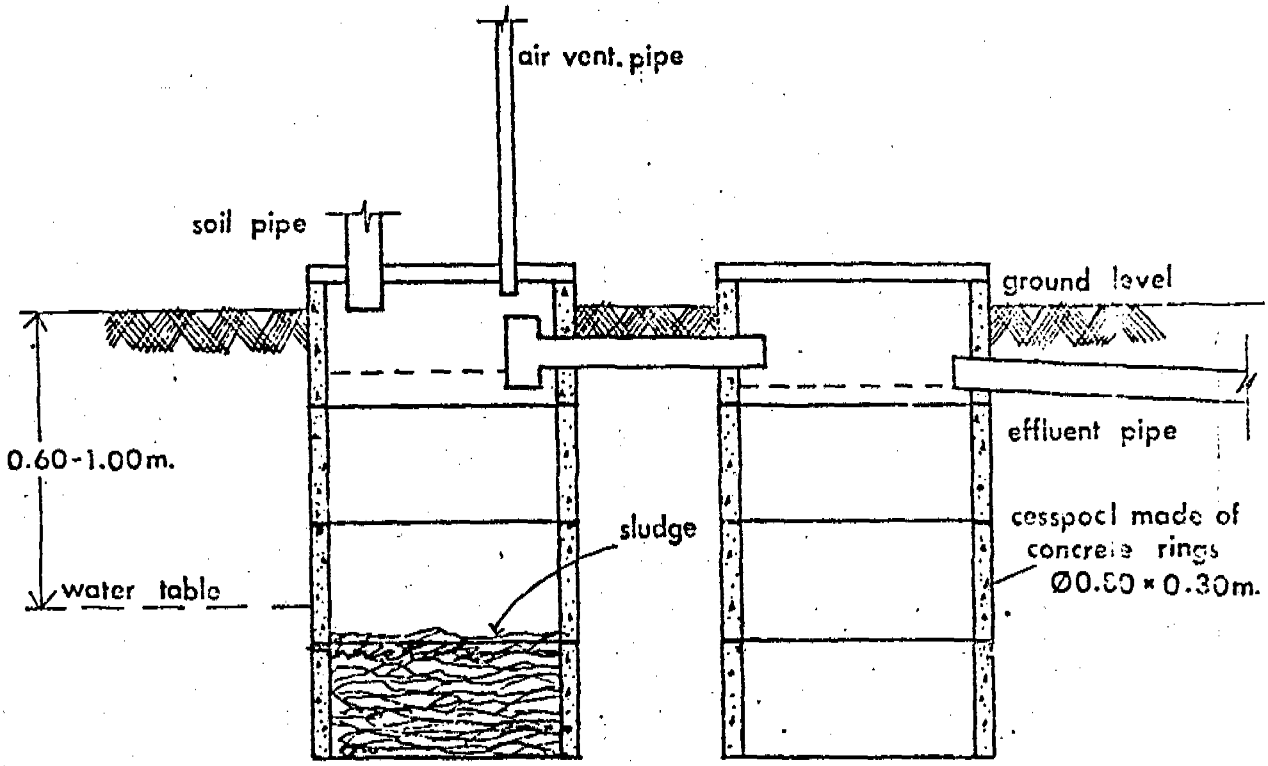
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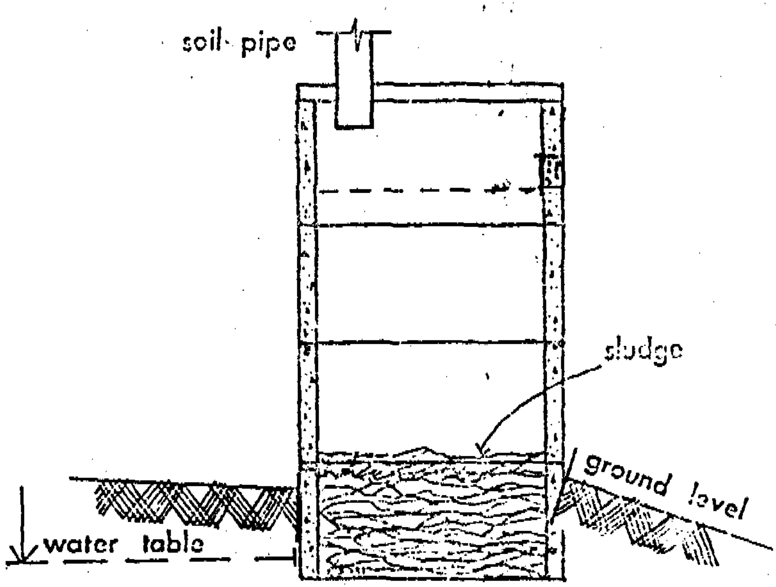
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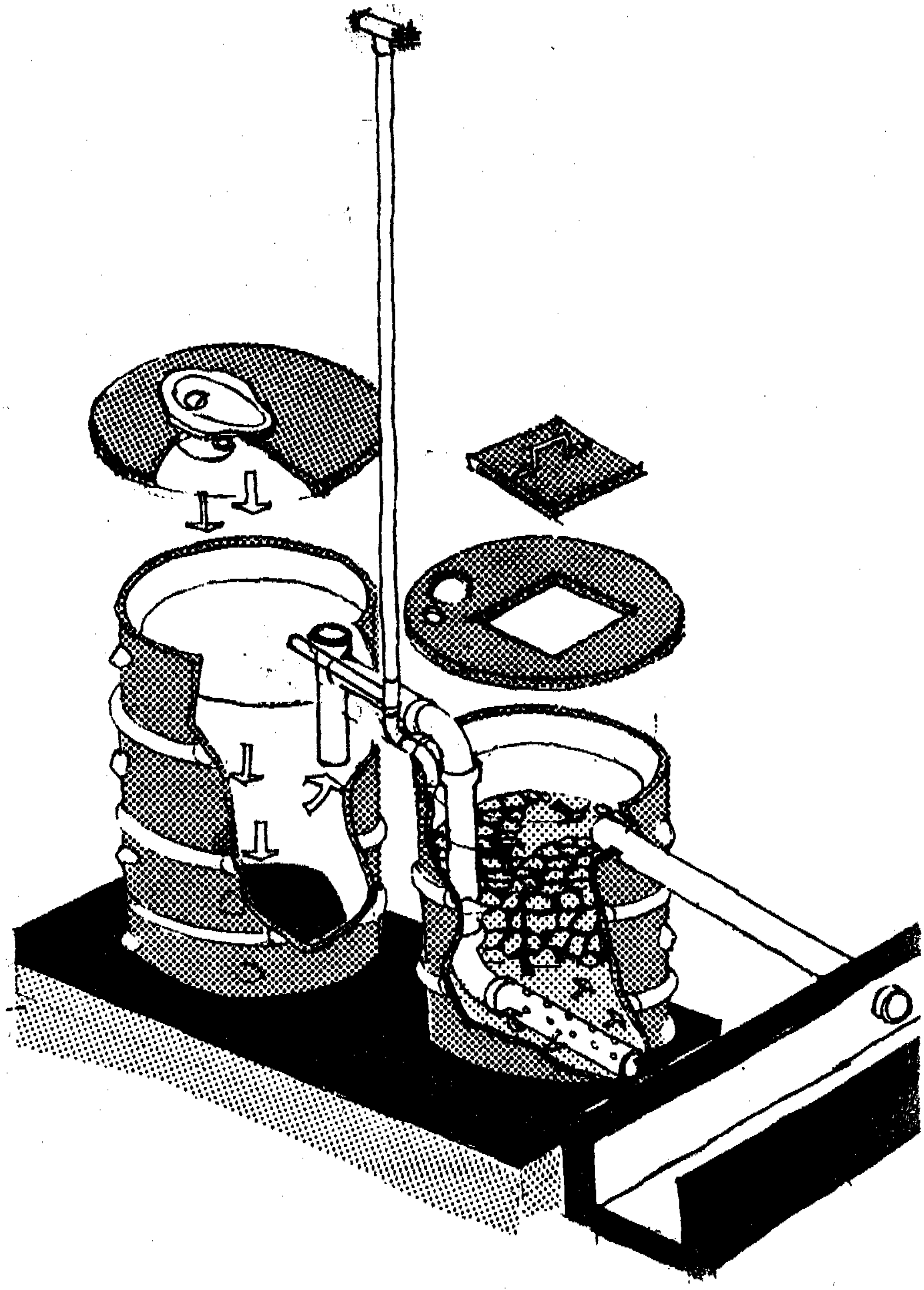


Indonesian presentation:

THE GOVERNMENT CONTRIBUTRIBUTION TO SOLVE COMMUNITY SERVICES IN INDONESIA

By: Irman Leonsalim

THE GOVERNMENT CONTRIBUTION TO SOLVE COMMUNITY SERVICES IN INDONESIA.

I. BACKGROUND.

Indonesia is an archipelago of more than 13,000 islands of which 3,000 islands are inhabited. Java is the main island, having a population are about 91 million or about 62 % of the total population of 147 million people. There are six major islands which have different rate of densities as shown on table 1.

Table 1. Population distribution and growth rate.

No.	Island	Population		Area		Density per sq km	Growth Rate
		Per Island sq km	Percentage	Per island sq km	Percentage		
1.	SUMATERA	28,016,160	19.00	473,606	24.67	59	3.32
2.	JAVA	91,269,528	61.88	132,187	6.89	690	2.02
3.	NUSA TENGGARA	8,487,110	5.76	88,488	4.61	90	2.01
4.	KALIMANTAN	6,723,086	4.56	539,460	28.13	12	2.96
5.	SULAWESI	10,409,533	7.05	189,216	9.85	55	2.22
6.	MALUKU/ IRIAN JAYA	2,584,881	1.75	496,486	25.87	5	2.79
	INDONESIA	147,490,298	100	1,919,443	100	77	2.32

The table shows that 62% of the population live on Java where some of the big cities in the country are found. See table 2.

Table 2. The five big cities in Indonesia.

No	City	Area sq km	Total Population	Density Per sq km	Growth Rate
1.	JAKARTA	587.62	6,053,449	11,067	3.93
2.	SURABAYA	274.06	2,027,913	7,399	2.95
3.	BANDUNG	81.25	1,462,637	18,002	2.20
4.	MEDAN	264.00	1,378,955	5,027	8.88
5.	SEMARANG	99.90	1,026,671	10,329	5.21

Data based on 1980 Census.

The Government is concerned over the average growth rate of the population, which stands at 2.3 % and will double by the year 2,000.
Only 20 % of the population live in the urban areas.

II. CONDITIONS OF HOUSING AND COMMUNITY SERVICES.

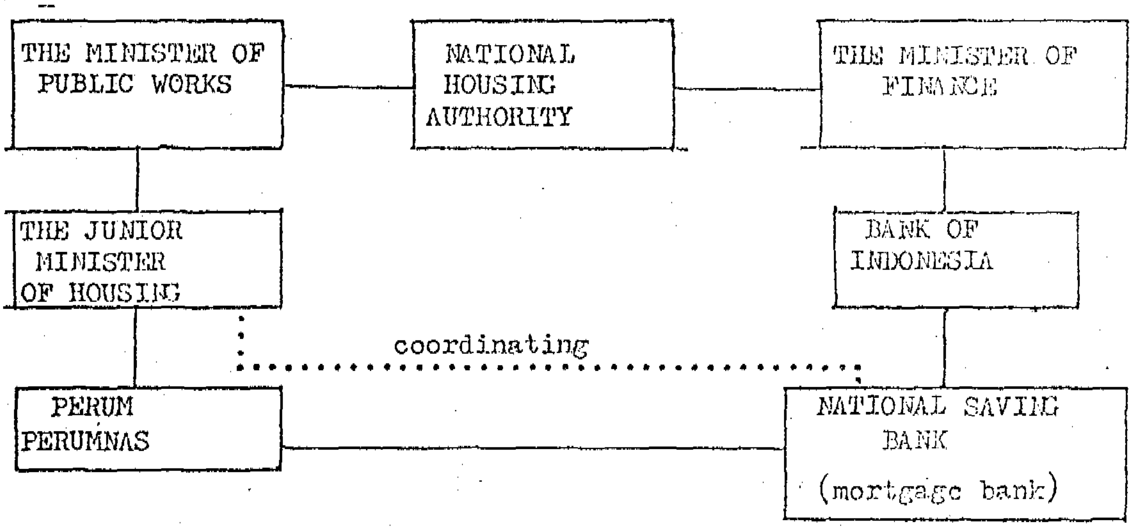
Housing conditions depends on the local situation and the geographical land specifiwation. Most of the big crowded towns are located on the island of Java. The biggest island in the country is Kalimantan (Borneo) , a flat and swampy area with sparse population.
Most of the towns in Indonesia grow naturally and unplanned, where one can see slums behind the spacious and luxury homes of the wealthy minority. The poor, who live in the slum areas have poor sanitation and hardly any community services. The problems for them look endless and hopeless. These areas just continue to grow unplanned and uncontrolled. For those in Kalimantan, the rivers, swamps and ponds are used for toilets.

III. THE PERUMNAS AS NATIONAL URBEN DEVELOPMENT CORPORATION.

Aware of its increasing population problem, The Government has taken several steps in order to accomodate the unequal population distribution. One of them is to establish the PERUMNAS as the National Urban Development Corporation in June 1974. The agency was to provide homes for the low income group of the population.

Fig 1. shows the structure of the housing institutions.

Fig 1. Inter-relationship among housing institutions.



Perumnas organisation shows on Fig 2.

Perumnas is a non profit Government enterprise where the general policies are set by the Minister of Public Works. Specific policies are set by its own Board of Directirs.

IV. NATIONAL HOUSING PROGRAMS.

Because of the deteriorating of the growing urban areas and the decling public services, the Government has introduced three main programs :

1. Kampung Improvement Program.

   (to restore community services)

2. New project of mass housing with completed or part community services.
3. Urban Renewal.

   Demolish slum areas and construct planned mass housing with facilities.

Perumnas work oover the last two programs while the local Government work on the first program. During the second Five-Year-National-Development Plan, Perumnas has built 73,000 homes and in the third Five-Year-National-Development Plan the number of houses built by Perumnas increased to 120,000. The work was only part of total housing programs, where the biggest portion of work can be undertaken by the private sectors. Table 3. shows the application of Perumnas programs.

Table 3. Application and programs of Perumnas

SUB PROGRAMME	TOTAL PELITA II	1979/ 1980	1980/ 1981	1981/ 1982	1982/ 1983	1983/ 1984	total PELITA III	total PELITA II/III
LAND ACQ (Ha)	1,810.6	465.2	756.8	860.7	1,541.6	2,819.4	6,443.7	8,254.3
PLANNING (Ha)	1,765.1	249.1	115.0	912.5	2,076.7	2,114.0	5,467.3	7,232.4
CONSTR. (Unit)	50,670	26,243	14,700	10,203	42,350	48,811	142,307	192,977
ALLOC. (Unit)	38,380	32,346	10,668	15,243	47,529	48,811	154,597	197,977
SALE	350	4,617	7,475	26,869	57,578	47,578	143,601	143,906

Source : Program 1982/1983

Fig 2. Geographic distribution of housing projects.

V. COMMUNITY SANITATION.

In the rural areas, the traditional way to build a toilet os to a box-shaped space above the river water or just a platform without a box-shaped located on the edge of the river. Some areas use the open beach or in more primitive areas like Irian Jaya, the forest to do their toilet.

Types of sanitation:

a. Fish pod box.

a very simple form, where the toilet box stand above the fish pond.

b. Open pit privy.

A sImpleloped hole laid beside or below the toilet box.

c. Closed pit privy.

The closed hole laid beside or below the toilet box.

d. Individual septic tank.

e. Communal septic tank.

f. Communal oxidatioh pond

g. Town or City public sanitacy sewer.

VI. SEWERAGE PROBLEMS.

Problems of sewerage system for low income community area

1. To find minimum budget and easy maintenance.
2. To use right materials to prevent polution.
3. To reduce maintenance budget.
4. To minimizé water polution.
6. Sanitacy system for mass or flat housing.

The low-income people cannot meet the cost of expensive housing or high budget for maintenance.

The scale of housing project will determina the shape and kinds of sewerage system to be laid. A better solution to the sewerage problem has not found so far.

I have tried to identify major keys of the sewerage problem in the paper and will now discuss and answer question on my presentation.

The Organization

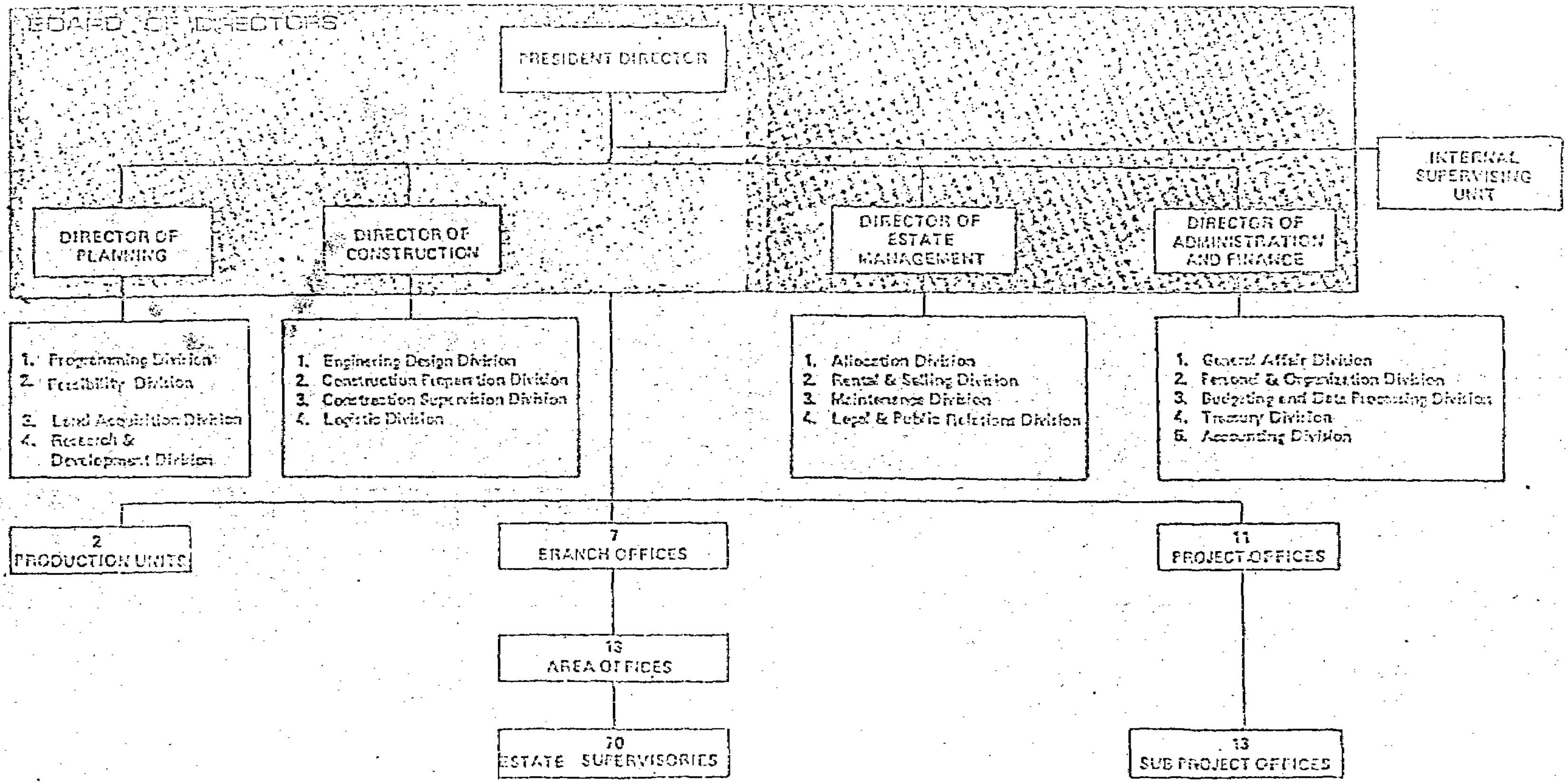


Figure - 9

Geographic Distribution of Projects

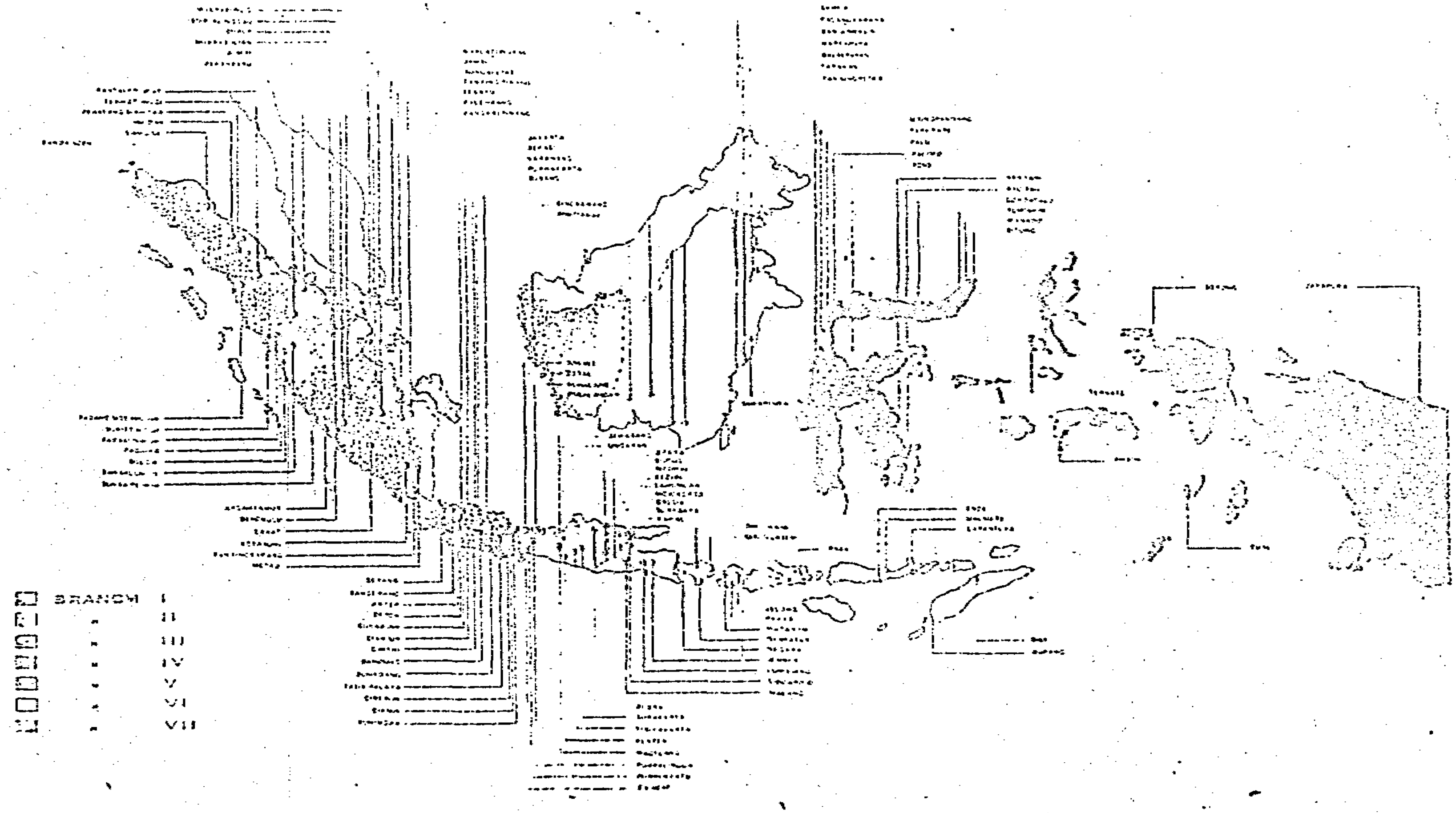


Figure 1

THE ECONOMIC, POLITICAL AND SOCIO-CULTURAL PROBLEMATICS OF HUMAN WASTE MANAGEMENT IN RURAL PHILIPPINES: LIKAS EXPERIENCE

by

EDDIE G. DOROTAN, M.D.

I. INTRODUCTION

When I was in elementary school in our small town of Irosin, I can still vividly remember when my classmate buddies and I would, once in a while, sneak out of the classroom unknowingly, just to push our way to the shrubby part of a nearby brook. And with trousers off, our own mouths busy chewing gums or licking lollipops, we would squat hurriedly with feet about a foot apart, buttocks nearly touching the cold rolling waters. At an instant of sheer concentration (but often interrupted by sudden noise around), the bomb would drop out and would disintegrate instantaneously, carried by the gush of water into a place of no return. And the rest is a sigh of relief.

Then when I was brought to Manila to study in an exclusive boys' high school, I was exposed to the initially culture-shocking flush toilet comfort. And up to my early pre-medical years, excreta disposal was not my problem as there were all around me the "American Standards" to provide the classy type of comfort.

But with the advent of my gradual social conscientization and my frequent live-in exposures to the countryside during my college days (as a member of the University of the Philippines Student Catholic Action) and even during my medical student years (as a member of LIKAS or Care for the Health of the People), I was thrown back to my original problem of controlling my anal sphincters during daytime and releasing them with a lot of sighs during night time under a coconut tree, inside thick sugarcane plantations, or even in open fields. Most of the time, a candy or a stick of cigarrette would help much in easing some tension and anxiety while doing the act.

And most often than not, it is a hell of a struggle!

So you see, excreta disposal is really such a problem to us working in small depressed communities (and I guess, to a lot of you here, too!) I jokingly tell my friends in the Philippines that I'm going to Bangkok to address an international forum of human waste management experts on our own art and technology of defecating indiscriminately in the rural areas.

Seriously speaking, I am here in Bangkok to share with you the problems we, as community or primary health workers, encounter in rural Philippines regarding human excreta disposal. And when I say share with you the problem. I do mean three (3) things: first, to inform you about the objective existing rural human excreta disposal situation in our country especially in our field of work; second, to present our analysis of the problem; and third, to portray our ongoing attempts to offer solutions to this problem.

Before I begin, I think a short introduction and backgrounder on my health group is in order:

Three years ago, we, a small group of medical and paramedical students and emerging professionals, felt and identified three pressing needs: the need to put relevant meaning to our formal health education, the need for a socially-oriented group to belong to, and the need to respond to the increasing misery, not only in terms of illnesses, of the vast majority of the Filipino people.

The logical response to these needs was the formation of a health group named LIKAS (acronym for Lingap Para Sa Kalusugan ng Sambayanan or Care for the Health of the People), which would implement a community-based people's primary health care program in remote rural areas of the country. And for just a couple of years, the group has grown and developed steadily, both in membership and in experiences. To date, the group is working and living with the rural poor in 23 depressed communities in four provinces, actively engaging in health education, health organization and health mobilization towards building self-reliant communities.

II. THE PROBLEM

A. Historical Perspective

Looking back into the past places current events and challenges into a perspective. It relativizes the immediate and situates us in larger context by clarifying our past and offering insights into our future (1).

Dr. Juan Flavier of the Philippine Rural Reconstruction Movement (PRRM) briefly cited in 1967 some of the following important events in the history of rural human excreta management in our country (2):

1. Human waste disposal was not much of a problem during the pre-Spanish and early Spanish times as population was sparse then. There were also plenty of areas far from the habitation that could be used for excreta disposal. But as the population gradually increased, disposal became more and more proximal to housing lots, causing some inconveniences to the inhabitants.

2. The Americans in 1909 started what could be the first national sanitary program with the launching of the pit privy campaign, only to be met with apathy of the Filipino people. The antipolo toilet introduced later was also a dismal failure.

3. A modified pit privy by way of bored hole latrine was experimented by Dr. Yeager in 1930. But the heavy metal equipment parts rendered the invention impractical. At about this time, septic tanks and sewerage systems were introduced in a few affluent cities - a system financially impossible for rural setting.

4. In the early 1960's, intensive studies on rural hygiene and sanitation documented the poor sanitation in the countryside. Dr. Lara et al, in a study of sanitary

and welfare conditions in the barrios and haciendas of the Victorias Milling Company in Negros Occidental found that more than 91% of the houses had unsanitary rating (3).

Dr. Rivera and Dr. McMillan published a book entitled The Rural Philippines in 1952 which showed some important facts on the sanitation of 13 barrios: 25% of the total households studied procured water from unprotected tanks, springs, rivers, and lakes while 50% secured water from surface wells; there was very serious dearth in medical service in rural areas with health expenditures in 1950 amounting to only ₱18 million or a very low average of ₱0.93 per capita (4).

Dr. Ethel Nurge, in a mimeographed paper entitled, "Some Remarks in the Resistance to the Use of Pit Latrines", put forth the following observations on the sanitary conditions in Leyte in 1956: 22 out of 231 households studied used the nearby river for disposal of human waste, 98 used the "pig system", 109 had pit latrines, and 2 had flush toilets; only a fraction of the families with latrines actually used them; and the author went a step further by posing the question of why people objected to the construction of sanitary toilets. She unravelled, though still vaguely, the inter-relatedness of political, economic and cultural dimensions of toilet construction - non-ownership of the lot, no space in the backyard, lack of money, unpleasant odor of the latrine, short life of the latrine, non-familiarity with the use of latrines, and ignorance of the germ theory of diseases. These were some reasons why people resisted the construction of sanitary latrines (5).

5. It was not surprising that during that same year, data gathered from a national sample of rural households by the Philippine Statistical Survey of Households showed that: 1) only 26% of all households surveyed had sanitary toilet; 2) 46.4% of all households disposed of their

refuse by burning, 1/3 by throwing, 1/10 had it collected, and 1/16 collected it in compost pits (6).

6. In 1957, a drum-type of toilet was introduced by the then Philippine Bureau of Health. Again, this did not gain momentum as there were some shortages of drums.

7. In 1960, a comprehensive sanitary survey of 200 households in Bay and Los Baños showed that 52-63% of the households surveyed were without latrines. It ended with the conclusion that the barrios surveyed are with poor health, hygiene, and sanitary condition. The primary reasons for such conditions seem to be ignorance, poverty, superstition, and unscientific health practices handed down from generation to generation (7). Three years later, another sanitary survey, this time in Muntinlupa, done by Abesamis et al also showed almost the same findings: 69.4% of the households surveyed were without sanitary toilets (8). Dr. Flavier in 1967 estimated that only 20-37% of all rural homes have some semblance of latrines; actual count in some barrios even point to as low as 4%! This is a credible claim in as much as ascaris infection was reaching 85-90% prevalence among school children during this time (9).

8. Recognizing the failure of the sanitary drive for the past 60-70 years, the Philippine Rural Reconstruction Movement (PRRM) popularized in 1955 the water-sealed toilet and the Department of Health launched it sometime in 1962. It claimed that the new toilet is simple, economical, non-foul smelling, practical, duplicable and does not pose any danger for persons to fall into the pit. To date, it is still the toilet type being supported by the Ministry of Health.

9. Aside from the apparent breakthrough in low-cost, affordable and acceptable toilet model, a Sanitary Code was formulated in 1976 to provide legal strength to the sanitation drive (10). And it was projected that the

Philippines will be within acceptable sanitary standards in the coming years.

10. But again, despite the alleged massive campaign drive, invention of a low-cost latrine model, formulation of the Sanitary Code, and the millions of pesos poured into the sanitary budget (23.5 million in 1981), excreta disposal remains a big problem just like before (11).

Why do I say this? Let us take a good look at the present picture.

B. Present Status

Even government officials admit the unsanitary picture of our country. Dr. Suplido, one of the Regional Health Directors during the SEAMIC Conference in Tokyo last 1978, reported that ½ of the total national households are still without toilets (12). Last 1981, the Ministry of Health through its Division of Environmental Health claimed that the percentage of households without toilet ranged from 9.68% (Region I) to 41% (Region V); the percentage of those with unsanitary toilets in rural areas ranged from 8.8% (Region II) to 73% (Region VI). The Bicol Region has 48% of its total households with toilets that are sanitary, leaving 52% which still have unsanitary ones. Table 1 shows the breakdown of households with and without sanitary toilets according to types in the Bicol Region (13):

Table 1

PERCENT OF HOUSEHOLDS
WITH SANITARY AND UNSANITARY TOILETS,
BY TYPE, BICOL REGION, 1981

	No. of Households	Percentage
Sanitary	121,526	48.0
Flush with Septic Tank	14,787	5.8
Flush Direct to Sewerage System	1,685	.7

(Table 1, continued)

Water-Sealed with Hand Flush Direct to Drainage Sytem . .	45,280	17.9
Water-Sealed with Hand Flush Direct to a Pit	38,246	15.1
Sanitary Pit Privy . . .	21,528	8.5
Unsanitary	131,489	52.0
Antipolo	74,995	29.6
Open Privy	35,667	14.1
Drop Type	4,766	1.9
Overhung	6,469	2.6
Others	4,209	1.7
Not Stated	5,383	2.1

In its achievement blackboard, the Provincial Health Office in Sorsogon has the following tabulation of water-sealed toilet construction in 1982 (14):

Table 2

Water-Sealed Toilet Construction
Beginning 1982, Province of Sorsogon

	Population	No. of Dwellings	No. With Water-Sealed Toilets	%
Municipality of Irosin	34,978	5,830	3,138	53.82
Province of Sorsogon	500,685	83,447	42,621	51.08

Concrete statistics in the barrio level is even worse, at least in the different rural communities we have been working for the past years. Table 3 shows the percent of households with toilets in different barrios.

Table 3

Percent of Households with Toilets

Barrio	Province	Economy	No. of Households	Household with Toilets	%
Kalabuso	Cavite	Subsistence	83	8	9.64

(Table 3, continued)

Calantas	Quezon	Coconut	81	6	7.40
Palma Uno	Laguna	Coconut	104	20	19.23
Magdagosong	Sorsogon	Rice	76	26	34.20
Cavite	Sorsogon	Rice	104	6	5.77

We have thus seen that from the village, to the provincial and up to the national levels, a lot of Filipinos still do not have access to sanitary toilets. And to some who have toilets, their use of such facility is another problem.

III. IMPACTS OF THE PROBLEM

The consequences of unsanitary excreta disposal is, of course, very clear to us: fecal-related diseases such as typhoid fever, cholera, schistosomiasis, amoebiasis, gastroenteritis, intestinal parasitism will rise in prevalence. The World Health Organization estimates that 80% of all sickness and diseases can be attributed to inadequate water or sanitation (15). Gastroenteritis directly killed 22,176 Filipinos in 1980 or at a rate of 46.3 persons per 100,000 population, to emerge as the number 4 killer during that year. And there were 503,640 some more Filipinos, mostly children, who got sick due to gastroenteritis that same year (16).

In the riceland barrios of Irosin in Sorsogon, amoebiasis is prevalent. I was practically treating at least 1 amoeba case per day in these areas during the past 6 months when I was doing my medical rural practicum. Schistosomiasis, which afflicts 200 million around the world, is endemic too in Irosin (17). A lot of patients consulting me because of Jacksonian types of seizures are later found out to have Schistosoma ova in their stools. We have a Schistosomiasis Center in the town, but the doctor in charge comes around only about once a month. In a remote barrio in Tagaytay City, bordering the provinces of Cavite, Laguna and Batangas, where there is indiscriminate defecation under the coconut trees or in the open fields, majority of the children present with huge tummies, and everytime they defecate, you'll be 99% sure there is at least 1 ascaris worm with the feces! I would not be surprised then if I hear that intestinal parasitism prevalence rate in rural areas is about 85-90%.

With sickness, the subsequent economic, political and socio-cultural impacts are also clear. A sickly person cannot work much, thus becoming a family liability, and cannot participate in community development. Table 4 depicts the detailed impacts of poor sanitation (18). As Dr. M.G. Candau says, "Countries can't release the full talents of the people unless they have healthy bodies".

Table 4

Impacts of Unsanitary Human Excreta Disposal

PRIMARY IMPACTS	1. Health -increased fecal-related diseases -increased mortality -malnutrition -less energy for work and learning	2. Social -more burden to the family -less time for productive family and community activities -less satisfaction with rural life	3. Environmental -dirty home and community environment -more stream and ground-waste pollution
SECONDARY IMPACTS	4. Economic -more work time lost from sickness -decreased labor use -decreased farm output -lower income and purchasing power -increased unemployment	less income and eroding confidence for less social and economic improvement	5. Less time for Other Activities Like - - health care - nutrition - education - housing - family planning - animal husbandry - others

(Table 4, continued)

LONG-TERM IMPACTS	6. Cumulative, Reinforcing Impacts Can Include: Health : increased medical cost, increased health services needed Social : less use of human resources, less community development, less self-help prospects Environmental: poor natural resources management, poor population-potable water balance Economic : decreased production and public revenues, increased rural/urban income disparities

IV. TOWARDS A STRUCTURAL APPROACH TO THE PROBLEM

A. The Need for Structural Analysis

Now, we ask ourselves: "Why, after so many decades of sanitary campaigns, the sanitary problem still seems to be undented?", "How come we have been working for so long, trying to do something about the problem and still, we don't see any tangible improvements?", "Despite the advances in technology and the numerous undertakings launched, how come the sanitary situation remains inadequate?"

A community-based health worker has this to say, and I quote:

"For us involved in seeking solution to the present problem, it is not enough that we do something about the situation. We may have the sincerity, the necessary theories and skills, but these are not sufficient. We must also know the directions we are going to and for whom the improvement or transformation of the situation will be. In other words, we must find out the social meaning of our work.

The structural approach to the analysis of the health problem provides such an understanding. It helps to situate our involvement in a scientific framework whether our actions are transforming or re-inforcing the present health situation (and this will) make our direction clear, give consistency in our planning and provide us with the guidelines for a truly transformative action (19)."

Structural analysis, then, becomes a potent tool for understanding fully the seemingly isolated problem of rural waste management. And it is a truism to say that how we see a problem determines how we respond or offer solutions to it.

Let me now share with you how we in LIKAS see the problem using the structural approach.

B. Basic Assumptions

We start off with the basic theoretical assumptions, which will be proven as we go along our discussion:

1. The human waste problem in the country can't be solved unless we take into consideration the economic, political and cultural problems of society.
2. The human waste problem is an element within the health system which functions as part of the bigger social system and therefore, it can't be isolated from the economic, political and cultural systems of society.
3. The human waste disposal problem is not a mere technical problem which can be solved through improved techniques and in isolation from the other systems of society.
4. An approach, therefore, to the disposal problem, to be effective, must define its role vis a vis existing structures of society.

We will now see how the excreta disposal problem is inter-related with the economic, political and cultural systems.

C. The Economic System and the Problem

The Philippine economy is a semi-feudal and semi-colonial one in which the rural is subservient to the urban sector. The domestic economy is, in turn, dependent on world capitalism. Hence, uneven development ensues with the many who are poor, getting poorer and the few rich, getting richer; the urban sector sector is more developed while the rural is more depressed. It is estimated that 15 million Filipinos subsist on a daily budget of ₱ 1.38, an amount that cannot even buy ¼ kilo of rice and six pieces of dried fish. The daily ₱43.65 needed by a family of 6 to live decently is way above the minimum wage of ₱18.00 (20)!

The health system, of which excreta disposal is an element, also follows the same pattern of the economic system. Health personnel and facilities are concentrated in urban areas where the rich live. Only 27% of physicians and 12% of nurses are in the rural areas to serve the many who are poor (21). It is no wonder why the urban sector get more health services than the depressed rural sector. We are lucky enough (in our areas) if a sanitary inspector goes to the barrios at least once a year!. Only a few in the urban areas could afford to construct a flush toilet with septic tank worth about ₱5,000.00 or more, while majority of the rual poor cannot even afford the ₱20.00 water-sealed toilet bowl! So, the rivers and fields become the biggest sprawling toilet of the rural masses.

The subsistence standard of living of the poor really becomes a determinant factor in assessing the failures of human waste disposal campaigns. A farmer in Kalabuso, Cavite who averages about ₱100.00 a month for selling root-crops in a buyers' market about 10 kilometers away, could hardly buy fresh fish for his family. An agricultural worker in riceland Magdagosong, Sorsogon who earns about ₱200.00 a month for harvesting, plowing, clearing the rice-fields often times (and ironically) gets out of rice supply! With the sharing system of 1/7 or 1/8 of the coconut sales going to the tenant in Palma Uno, Laguna, he only pockets some ₱130.00 to ₱220.00 every 45-50 days, good enough for repaying previous debts. Surely, all of them can't afford to construct sanitary toilets! They would tell us: "Our problem is not what comes out below, but what goes into our mouths!. This certainly is an economically-loaded no joke.

The feudal set-up in the rural areas has also a big bearing on the failure of the toilet campaign. Many of the rural folks, though wanting to construct one, fear the reprisal of their landowners. Their tenant status renders them temporary residence - for anytime, they could be ejected. So why construct a permanent structure such as a toilet? Besides, some landlords really discourage them to construct one. Why? Toilets are evidences of occupancy, and occupancy implies that the land could be subjected to land reform.

So you see, toilet construction is very much economic!

D. The Political System and The Problem

When we talk of political system, we mean decision-making, people's participation and organization, not just the bureaucratic structure of the government. Generally, there is centralization of decision-making in the hands of the few (upper classes). The vast majority are powerless to participate and organize in decision-making affecting their lives. Thus, the political system becomes dominant in that it protects and strengthens the economic system.

Parallelism is very evident in the organizational structures of the delivery of health services. Policies are made without consultation with the people, so the people are left with minimum participation, ifl at all. Health laws and codes, like the Sanitary Code, though inherently good for the people, becomes inutile as these are not consulted or informed to the people. The national budget is not allocated according to the pressing needs. For example, the health budget of ₱1.8 billion in 1981 pales in comparison to the huge ₱7.1 billion defense budget (22). In simpler form, this would mean an allocation of about ₱70.00 per Filipino for guns and only ₱7.00 per person for health. To compound the problem, of the total health budget, a big portion goes to infrastructures and only ¼ of the health budget is left for rural health services (23).

At the level of the most basic unit for the delivery of health services in the rural areas - the Rural Health Unit - we may ask: how much participation do the people have in planning, implementation and evaluation of the different health programs? One clear example of this is an incident reported by one community health worker in Leyte:

"The sanitary inspector decided to schedule an immunization for typhoid and cholera. Upon his arrival in the barrio, only a handful were there to be vaccinated. He immediately gave out a comment that the people were not interested in taking care of their health and welfare. What the sanitary inspector did not know was that it was harvest season for rice during that time in the village. It was a matter of letting the farmers choose between food for their stomach and a cholera-typhoid vaccination. Had the sanitary inspector consulted the people and involved them in the planning of the immunization, the people would have advised him to come after the harvest season. This way, the people will not be blamed for being uncooperative, and health services would have been more effective (24)."

Another concrete example is what happened in one of the villages in Sorsogon. One day, a truckload of water-sealed toilets were distributed to the residents for free. Without much ado, almost all households got hold of one toilet and were instructed in 15 minutes to build their own latrines. After 1 month, the senitary inspector came back for spot checking only to be shocked with what he saw: toilet bowls are being used by the people as chairs, flower and plant pots, containers, decorating piece outside the house, and playing pans for children! Certainly, people's participation in planning and people's education were lacking.

The prevailing mood is that the RHU personnel, especially the doctor, are the experts in delivering health care, ergo they are the only ones who can decide correctly. The people whom services are supposed to be rendered are too ignorant to be consulted.

We have seen, therefore, that the top to bottom method of decision-making in both the health and political systems are similar and supportive of each other.

E. <u>The Cultural System and the Problem</u>

Values, beliefs, and knowledge being propagated in the society constitute the cultural system. Basically, the predominant culture is colonial, elitist and feudal, forming an "ideology that justifies the status quo". And this is understandable in as much as the mass media (newspapers, radio, television, magazines, others), education, and others are controlled by the same economic elite who wield much political power. "All is well, don't rock the boat" is the prevailing hidden message. Counter-cultures which are nationalistic, democratic and humane are being suppressed.

The health system is permeated by the very same culture. For example, Filipinos dream, clamor, and in fact struggle much just to get an American Standard flush toilet instead of the more economical water-sealed one. We prefer the clean, expensive, Western type of toilets. Anything Western or foreign is best. Cure- and hospital-orientations are emphasized instead of the preventive aspect. Therefore, we become elitist in building first class medical centers confined in urban areas, instead of training dependable community health workers in the rural areas who will be adept in tackling prevention of spread of communicable diseases - proper excreta disposal of prime example.

The feudal tendency is seen in too much dependency on doctors as if they were gods. Patients remain passive and subservient and ignorant of common ailments. Thus, health care becomes disease-oriented and crisis-oriented, instead of health promotive and rehabilitative.

It is no wonder if a lot of rural folks still do not appreciate the relation of sanitary toilet to disease causation. Ignorance, superstitions and fatalism are still around. Sometimes, one will encounter "herbolarios" or local healers who do not believe in improper excreta disposal as a cause in the incidence of gastroenteritis and parasitism, and would instead attribute these to evil spirits. And as the people are not educated with the scientific basis of disease and well-being, the more they become shrouded in mystery.

The same colonial, elitist and feudal tendencies dominate both health and cultural systems harmoniously.

F. Summary Analysis and Implications

We can now briefly say that the human waste excreta disposal problem is only an element of the health system which can best be understood if dissected in its economic, political and cultural dimensions; that the health system, of which excreta disposal is an integral and inseparable part, runs in interlocking harmony and unity with the economic, political and cultural systems of the society.

Two closely-linked implications are then evident. One is that any solution to the human waste disposal problem that only involves the economic, technological, political, or cultural aspects separately from one another will, in the long run, be re-inforcing the existing social structures, although giving some short-term benefits. This means that the solution will touch only the problem at the tip of the iceberg, that is, superficially.

The other logical implication is that as long as the economic, political and cultural structures are unchallenged and unchanged, the excreta disposal system within the health system will remain as is. It will continue to cause a lot of sicknesses and misery to the many in rural areas who are poor; it will be managed with top to bottom approach by the elite experts instead of evoking greater participation from the grassroots; colonial, elitist, feudal and unscientific views and beliefs will permeate and captivate the minds of the people.

V. LIKAS AND THE PEOPLE'S HEALTH PROGRAM MICRO-SOLUTION TO A MACRO-PROBLEM

The above discussion ultimately brings us to the inevitable and pressing question: What do we do then? How do we solve the problem?

LIKAS through its People's Health Program, just like some agencies involved in community-based health programs (CBHP), is trying to offer microsolutions to a macro-problem at the concrete level of small, poor rural communities.

The wholistic approach is reflected in our general objective of developing healthy persons who are responsible to themselves and others in building Filipino Christian Communities based on truth, freedom, justice, love and participation in everything which affects themselves, their families and their communities.

Health education, health organization and health mobilization towards building self-reliant communities are key elements in our program.

<u>The Educational Aspect of the Program.</u> The people's potentials and capabilities in taking care of their health needs are best developed through action-reflection praxis: the people and the community health workers learn the art and science of preventive medicine, proper human waste disposal included, through learning by doing activities. And we go beyond health and medicine into the realms of social, political, and cultural conscientization in uplifting the WHO (World Health Organization) credo that good health is not merely absence of disease; most

importantly, it refers to the physical, mental and psychological well-being of a person. Thus, attacking other community problems becomes an integral part of the educational process.

The Organizational Aspect of the Program. One coconut midrib, by itself, cannot clean a small dirt. But dozens of small coconut midribs bunched together to make a broom can clean even the biggest thrash there is. The same is true with the people. A disorganized, individualistic community can't solve its problems but an organized, collective community can tap all resources to provide solutions to its problems. This is the political aspect of the program: organization.

The community is organized into small groups called "Munting Pangkat Kristiyano" or Basic Christian Communities and each group elects its own paramedic who will assume the roles of leader, teacher and health worker. In so doing, through people's participation and initiative in planning, implementation and evaluation, they take responsibility and slowly veers away from too much dependency on doctors and technocrats and therefore, assume self-reliant status.

The Self-Reliance Aspect of the Program. "Don't give the people fish everyday, for you might run out of fish; teach them how to catch fish so they will have fish everyday", so goes one Chinese saying. Self-reliance then is a key objective in our program. The dependence on high cost medical treatment is greatly avoided by putting emphasis on the elimination of environmental causes of diseases like sanitation drive/campaign. The consumption of indigenous food crops with high nutritive value is promoted. Likewise, the use of traditional forms of treatment like herbal medicines are encouraged. To tap it all, the training of dependable local health workers cuts the dependence cord of the people on the doctor in matters of primary health care.

An example of how the above three key elements in our program becomes operative is our experience in Kalabuso, Tagaytay City, Cavite - about 200 kilometers from Manila.

The village is one of the most economically depressed areas of scenic Tagaytay City where the people earn only about ₱100 - ₱200 per month for selling rootcrops and vegetables in a buyers' market (the buyers dictate the price, not the farmers) about 10 kilometer-walk of winding dirt road from the village. Intestinal parasitism, gastro-enteritis and pulmonary tuberculosis are endemic in the place. No doctor nor any personnel from the Rural Health Unit have visited the place for the past years. So, the people decided, with our help, to launch a People's Health Program, where they elected their own community health workers through their Basic Christian Communities.

At the start, a project was envisioned: the construction of a multi-purpose health center where meetings, trainings, or actual medical treatments are to be held. In a matter of two months, with the people's own labor and tapping of local woods and nipas, a simple and beautiful nipa center was built in a sitio overlooking another sitio and the Manila Bay.

After the learn by doing session of the paramedics on sanitation, a community-wide sanitary toilet construction was planned. The pit privy was their choice as it was what they could afford. In the process of doing the toilets, the Rural Health Unit heard about it and promised to give the people free water-sealed bowls. Toilet construction was temporarily stopped as they waited for the bowls that never came. But as the people became impatient, the construction of the pit privy was nevertheless continued only to be disturbed again by the arrest and detention of some farmers suspected of being subversives. Initially, the people were terrified such that no one initiated a talk or an exposure of the matter. Then slowly, issues were talked about and the people rallied for the release of the farmers. In mass, they went to the prison camp and asked for the support - moral and financial - from sympathizers while taking good care of the families of their detained barrio-mates.

A few months after the release of the farmers, another issue cropped up. Bulldozers leveled the mountain tay overlooking the barrio to make way for a big National Government Center. Rocks, gravel and sand came cascading down the mountain slopes, destroying the farmers' rootcrops and vegetable plantation. News that the people will be transferred to another place further hovered them with fear. Meetings were then held to clarify the issues and plans were made. At present, they are fighting for their right to get compensation for whatever damages have been made to them. More, they are fighting for their land and survival as a people.

The above experience just wraps up our whole discussion. As one of our health workers in Kalabuso would say: "Health issues and problems like sanitation cannot be separated from our daily economic, political and cultural lives. They are part and parcel of it. Therefore, we, community health workers should not confine ourselves with only healing the sick. We also have the task of leading and teaching the people in curing and healing the structural illness of our society."

Not unless the people are educated, organized, and mobilized, can community problems like human waste disposal be genuinely solved. People's education, people's organization and people's mobilization are key strategies towards building self-reliant people.

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THE OPTIMISTIC OPTION OF DESIGN FOR SELF-RELIANCE

Reinder van Tijen, Designer

Michel Bikker, Anthropologist

The Optimistic Option of Design for Self-Reliance

This is a personal statement. It contains the experiences of a technical designer and a social-anthropologist. It concerns research on the possibilities of technological alternatives. This research has been centered around the potential of self-reliance: enlargement of one's own capacity to realise less dependence together with better living conditions. This research takes place in the borderline between the formal sector - the modern institutions, industry and government - and, on the other side, in the informal sector - the networks of people who are not, or are less, orientated in centralised relations.

This research does not only concern problems in the so-called Third World. Problems in rich countries are identical to a high degree.

The Job

According to the framework of technical aid, we have engaged ourselves in the development of the age-old Chinese chain-and-washer pump to a comparable modern version - the rope pump.

The design proved, in its practical application in Indonesia and Peru to meet standards for self-reliance.

Next to the pump and similar devices, a tool and a method was developed to make fully illustrated construction manuals an easier job.

The design method seems at least for this part, effective. The question remains how to achieve a wider implementation of these and similar results.

Background

The technical designer who gained his experience in industry has been involved in design for self-reliance since 1970. In a tough learning process he discovered many similar points between designing for industry and designing for self-reliance.

- the design activity should be valuable for a great number of users
- the design uses only materials and skills readily available
- the design tries to realise the lowest possible cost aspect together with the largest/highest possible use/value or attraction.

Also there are fundamental differences :

- the design for self-reliance does not aim at centralised manufacturing, but instead aims at manufacturing by the user or local craftsman
- the design is only of value to the user. There is no manufacturer who benefits
- there is no existing structure which makes modern information directly productive for the user. On the other hand, there exists an extensive market structure favouring industrial manufacturing.

This (theoretical) opinion has been obtained through practice. The development of the rope-pump from a concept to an effective contribution to the potential of self-reliance constituted these thoughts which appear to be of general use.

The design process has been started in an institution in Holland, far away from the future user. The technical concept was correct: the first prototype worked well on the test-site in Holland, but for practical application in Upper Volta it proved to have no value. It took many years to combine the local reality with the technical concept: now a procedure exists to construct a very effective water pump in any given village with the materials and skills which are readily available and within easy reach.

Starting from a basic concept, different capacities, adaptation of materials, different methods of activation such as hand-power, animal traction, wind and motor traction can be realised.

Important is the fact that the user decides - and not the designer!

After the introduction many pumps have been built and copied on site. No formal organisation was engaged.

Transfer of Information

Besides the design method, an amount of action should be allowed for spreading new information to other areas. It is clear that 'normal' technical and formal information, like blueprints and technical specifications, are of no use. The wrong language is applied. Of all possible methods, demonstration at the sites is the most valuable, but also the most difficult to realise at all the many different places. TV, radio and newspapers arouse interest, but do not contain enough information for realising the concepts.

Also in view of the limited capacity of a designer or design group, it seems to be a practical option to make small illustrated construction manuals. They can be printed for a relatively low price and reach a high spread of people. Local adaptation to language and, if needed, to design is possible.

This should not happen with the expectation that every potential user can work it out from such a manual. But one can expect to reach 'starters' for whom the offered information is sufficient to reproduce the tool. With their results, they can invite other people to follow the example.

A further technical problem is the quality of the illustrations which act as bearers of technical information - this must never be less than very good.

Reading appropriate technology literature does not give the idea that many organisations have good results in this field. However, transferring information by clear illustrations should be of the highest priority.

To make the designer 'self-reliant' in this respect, a tracing-table or drawing-projector was developed. It makes it possible for any person without previous experience to make perfect illustrations after only a few exercises.

The tracing table is a table-like unit, which can be made locally, to project by slide projector or episcope, images on a glass plate table top. These images can be traced with a variable enlargement on plain paper. The tracings (big size) can be used as illustrations to clarify ideas in group discussions. The tracings (small size) can also be used, which was the main purpose, as illustrations for manuals. The cost of a unit, including glass and electric parts is +/- US$40 - labour +/- one day.

Facts and Questions

It was possible to make a design that proved to be of value to "informal" users and to make and introduce this design from the "formal" side. It was also possible to make good and cheap information to sustain this process.

The question remains : is this an incidental result? Or is it an effective approach for the many institutes that have a task in the field of development cooperation, to use "design" as an appropriate tool?

The option - What to achieve?

It turns out not to be possible to make the poorest a little richer; neither does development satisfy the rich.

In on-going development material resources are used too intensively, the mental potential of people, too little.

The inverse - an intensive use of mental and creative power of human beings, together with limited material resources seems unimaginable, as there are no tools to make this option productive.

As the old option of development through specialisation and growing interdependence fails to achieve its goals, it is imperative to research at least on the technology for the option of self-reliance; to enlarge one's own capacity to realise better living conditions with less dependence.

We do not start with empty hands. There is an inexhaustable source of knowledge available.

Why it has not happened

The technology for self-reliance has not been developed; on the contrary, it has been decreased. Why? Why did the rope pump as an efficient tool, not exist as the self-evident further development of the Chinese chain-and-washer pump? Everything was available; ability, knowledge and certainly also the need for this tool.

A characteristic of modern development is that it is generally expected to be the most economic to centralise production around a centralised management. Yet centralised production of the rope pump can never be more efficient or cheaper than the now-realised production in conditions of self-reliance. It is essential that there is no perception that anything can be done better than through modernisation; a religion-like conviction, shared by the formal and the informal parts of society

The more technical answer for the question of the non-existence of the rope pump could be:

"Formal" has no interest in the development of information that favours decentralisation.

"Informal" does not have the potential for integrating knowledge and abilities in research. The adaptation of craft takes more time than was available.

Even if there was a notion on the "formal" side, that there was a need for an "informally" to be built pump, even then a formal designer would feel embarrassed to offer village technology to the villagers. "Formal" expects from itself an advanced input. Informal concepts are realised with modern technological elements or trends. Matching modern manufacturing methods make realisation within self-reliance impossible.

Why it is just as possible

For those who are aware that there is at least a theoretical possibility for technology-choice, it is of interest to study the potential of formally acquired information brought into the potential of informal production activities. This potential is characterised by the direct manufacturing of new materials and the widespread ability to use these means for a certain purpose.

"Informal" development led to adaptation of a foreign design of a plunger pump to the locally available production means, such as cast-iron. But it could not bridge the gap between the old wooden or metal Chinese chain-and-washer pump to the rope pump that uses modern materials, such as PVC pipe and nylon rope, which, although well-known, were never used for similar purposes.

To achieve this result is typical for a design activity where in an extended period of research and development all possible new combinations of existing elements are tested on their value for a set purpose. This design process may result in innovation or adaptation; anyway, it must be guided by a well-defined set of goals, which are partly from political origin and partly from economical origin.

Although it was to be expected, it still does surprise that this combination of formally acquired information and informal potential leads to 'a sea of possibilities'. Their common characteristic is that these answers to problems do not favour centralised production or centralised management. Much research work along these lines has resulted in solutions of high quality. These solutions were not related to 'simple' problems, and often a 'thing' was replaced by a method ... in fact dematerialised!

This happened all over the world, and some of it is already history, such as the spinning wheel of Gandi.

Strategy to promote design for self-reliance

To promote better means for existence for the hundreds of millions of people who are impoverished in informal conditions is the task of most organisations for development cooperation.

Therefore it is in the interest of these organisations to learn to handle the tool of "design for self-reliance".

However, this asks for a mental adaptation or change in expectation that will not easily be made. It can even be questioned if it is possible.

In all cases the change will have to be made voluntarily and this can only happen if "design for self-reliance" gives the better options.

Yet, this design approach itself has still to be developed. A positive interaction and sustainment of individuals and organisations working on this subject is essential to reach the quality needed to convince first of all the users of the new designs and, through them, the development organisations. From the work done on the rope pump and similar designs, it seems the designer needs:

1 Ability to speak the formal language. This may be regarded as a corruption of one's own convictions, but it has to be realised that it is essential for communication.

2 Technical understanding, both fundamental and practical, of the problem, and knowledge of related modern technical solutions.

3 Knowledge of related crafts and the elements of which they consist.

4 Knowledge of the nature of change. What political, cultural or environmental forces have caused the need for adapatation.

5 Knowledge of the actual circumstances, means, abilities, needs and expectations of the future users.

Finally, the designer and the sponsor can fence themselves in within the following design criteria:

- Design within the economical limits of the user. Avoid relying upon credit or aid if this results in unacceptable dependence.

- Design within the means and abilities available at village level.

- Design clearly and with a sense of being self-explanatory, to induce local upkeep and repair and to inspire others to copy the design. Avoid styling.

- Design in such a way as to inspire design modifications to be made to different situations, tastes and even purposes.

- Make it possible for information about this design to be introduced in such a way as those concerned can form an opinion well in advance and decide on sound reasoning. Avoid 'selling' dreams that cannot come true.

- Design for basic needs requires actual interaction with those basic needs, never lose that tie.

Resulting autonomous spreading and further development of the design information cannot be expected before these criteria are answered.

It is a heavy task in itself. Even more so because of the lack of experience all the participants share .... designer, user, sponsor and 'the public'.

Yet it has to be done.

Annex 6 missing

PLANNING & DESIGNING OF LARGE SCALE POUR-FLUSH LATRINE PROGRAMME IN URBAN AREAS

BY

A. K. ROY

Resident Manager, UNDP Global Project GLO/78/006
South East Asia, New Delhi.

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ACRONYMS USED

Cap	...	Capita
GRP	...	Fibre glass reinforced polyester plastic
HDPE	..	High Density Polyethlene
m^3	...	Cubic metre
mm	...	Millimetre
PRAI	...	Planning, Research-cum-Action Institute, Lucknow (India)
PVC	...	Polyvinyl chloride
TAG	...	Technology Advisory Group, UNDP Global Project
UNDP	...	United Nations Development Programme
UNICEF	...	United Nations' International Children's Emergency Fund
WHO	...	World Health Organisation

PLANNING AND DESIGNING OF LARGE SCALE POUR-FLUSH LATRINE PROGRAMME IN URBAN AREAS

SUMMARY

The UNDP Global Project GLO/78/006 with the assistance of the Government of India, and the World Bank acting as the executing agency, has recently prepared a Master Plan Report and Feasibility study of pour-flush waterseal latrines in 110 representative towns with a total population of nearly 5 million (town population ranging between 7,000 to 400,000), having about 800,000 households, in different physical and hydrogeological formations and varying socio-economic conditions in 7 States of India. This is a demonstration project, findings from which would be utilised in preparing similar projects for other towns. Recognising the utility of such a project, the Government of India has now taken up the preparation of similar projects for another 100 towns in the remaining 14 States of India with assistance from the UNDP funds for India and with the World Bank acting as the executing agency.

Any large scale latrine programme should necessarily be : hygienically and environmentally safe; technically and scientifically appropriate; socially and culturally acceptable; economically affordable; and with inbuilt financial and organisational infrastructure, enabling immediate initiation and expeditious implementation of the project. The present paper deals exclusively with only one of the eight possible low-cost sanitation technologies—pourflush waterseal latrines with offset leaching pits—for disposal of human excreta, which has been adopted in India and is equally applicable in many other countries.

The major inputs to the demonstration projects, based on the Indian experience are : evaluation of pourflush latrines or any other latrine programme (household or public) and the lessons learnt; review of the organisational, financial, managerial capabilities and legal authorities of the local government in the project towns; house-to-house survey of project towns to ascertain the size of the family, its income, availability of electricity, water and latrine in the premises and the feasibility of constructing a pour-flush latrine for deciding the financing pattern to households, optimisation of the proposed technology for least cost solution and studies on sub-surface pollution; institutional requirements for implementation of the project; methodology for construction of household and public latrines; and the financial aspect of the project.

PLANNING AND DESIGNING OF LARGE SCALE POUR-FLUSH LATRINE PROGRAMME IN URBAN AREAS

INTRODUCTION

1. History reveals that once it was an universal practice to defecate directly either on the soil or in flowing streams or stagnant pools. With the passage of time, and the dawn of the modern civilisation, rapid urbanisation followed. Non-availability of open spaces for defecation and also the awarness of privacy and convenience, brought the need for household latrines. While in most countries the removal of excreta and its safe disposal from a latrine was a routine practice for the family, without any stigma attached to it, some countries devised the bucket system in which a particular section of the society made a house-to-house collection of human waste from latrines for its disposal at a particular place. As the world advanced towards industrialisation, the economy of many countries improved and with the spread of education, health consciousness arose. This resulted in the adoption of water-borne sanitation, making use of septic tanks or sewerage, with or without sewage treatment. Most of the economically backward countries continued with the old practice. Only a fraction of the population could afford the facility of household latrines and these were in most cases the dry and insanitary types. In the densely populated core sector of the old towns in the developing countries, the conventional water-borne sanitation system has been found to be too costly for adoption. Thus, excreta disposal system in urban areas is in a critical stage, in particular, in the small and medium towns of these countries. This can, however, be overcome with proper planning and by adopting suitable technological devices for low cost solutions.

2. The global survey (1975) by WHO found that the population living in houses connected to sewerage system in developing countries dropped from 27 percent to 25 percent between 1970 and 1975. The house-to house survey (1980) carried out in 7 States of India by the UNDP Global Project (GLO/78/006) in 110 small and medium towns, with nearly 5 million population and 800,000 house-holds having no sewerage system, revealed that on an average, population served with water flush latrines varied in different States between 11% and 40%, those with dry latrines 7% and 56% and those having no latrines 13% and 78%. The United Nations Conference on Human Settlements (June 1976, Vancouver) stressed the need of priority for the supply of safe water and a hygienic system of waste disposal. The United Nations Water Conference (March 1977, Mardel Plata, Argentina) in which almost all the developing countries participated, expressed concern over the poor level of service in community water supply and sanitation. The United Nations in recognition of this urgent need declared 1981—90 as the International Drinking Water Supply and Sanitation Decade to emphasise the world-wide efforts to provide safe drinking water and sanitation to all by 1990.

3. As a contribution to the International Drinking Water Supply and Sanitation Decade, the World Bank is continuing applied research in an effort to develop techniques for design of low cost water supply and sanitation systems. These would allow maximum coverage to provide basic needs in the early years of a project, with progressive up-grading, as more resources become available. In November 1978, the UNDP financed Global Project (GLO/78/006) commenced operations, with the World Bank as executing agency, to implement these results into actual practice.

4. In India, the UNDP Global Project (GLO/78/006) with the assistance of the Government of India and the World Bank as the executing agency, has recently, prepared a Master Plan Report including Preliminary Engineering and Feasibility studies for 110 small and medium towns having no sewerage system. The population of these towns, distributed over 7 States of the country, ranges between 7,000 to 400,000 covering a total population of about 5 million living in 800,000 households. This project provides low-cost pour-flush waterseal latrines with on-site disposal of waste in offset leaching pits to all households, wherever feasible and the remainder by public latrines. Recognising the utility of preparing such large scale demonstration projects of low-cost latrines, the Government of India has now taken up the preparation of similar projects for another 100 towns in the remaining 14 states with assistance from the UNDP funds for India and with the World Bank acting as the executing agency of the Project.

5. The safe disposal of human excreta should be given a high priority as over fifty infections can be transferred from a diseased person to a healthy one by various direct or indirect routes involving excreta.* This paper deals in particular with the pour-flush waterseal latrines with spot disposal of waste in leaching pits—its technology, planning and designing a large scale programme in the urban areas as experienced in India.

6. Water related sanitation for urban areas should be : hygienically and environmentally safe, technically and scientifically appropriate, socially and culturally acceptable; economically affordable and should be simple in implementing, operating and maintaining. The water related sanitation technology has been categorised into the following three classes* :

(i) LOW COST—Pourflush toilet, pit privy, communal toilet, vacuum—truck cartage, low—cost septic tanks, composting toilets and bucket cartage;

(ii) MEDIUM COST—Sewered aquaprivy, aquaprivy and Japanese vacuum—truck; and

(iii) HIGH COST—Septic tanks and Sewerage.

7. Seven different technologies under low-cost sanitation have been enumerated above. The present paper, however, deals exclusively with the pourflush waterseal technology, which has been in use in India and is equally applicable in the countries of the Indian sub-continent and also in many countries of South East Asia where the population at large use water for anal cleansing. Although the technology suggested in this paper cannot be claimed to be purely innovative, the Global Project has studied the various types of such latrines adopted in different countries in the past as well as at present, and has designed an unit of low-cost which is structurally safe and also takes care of all precautions to eliminate health hazards, can be installed under different physical and hydrogeological conditions, is socially and culturally acceptable and affordable by the poor (with a certain element of subsidy).

8. Studies and research on the design of a simple waterseal latrine with squatting toilet pan and suitable trap, disposing the waste into a leaching pit have been going on in India for nearly the last 4 decades, by several agencies such as, the All India Institute of Hygiene and Public Health, Calcutta (1943) in collaboration with Rockefeller Foundation, Research-Cum-Action Project, sponsored by the Government of India in collaboration with the Ford Foundation (1955), the Planning Research-Cum-Action

*Appropriate Technology for Water Supply and Sanitation—by John M. Kalbermatten etc., World Bank/December 1980.

Institute (PRAI) Lucknow assisted by WHO/UNICEF (1958), the Indian Council of Medical Research, the National Environmental Engineering Research Institute, Nagpur and also several social, private and commercial organisations. Based on these studies, nearly 400,000 pour-flush waterseal latrines have been constructed in the urban towns of India, many of which are in the densely populated areas.

THE PLANNING PROCESS

9. The preparation of a demonstration project including evaluation and other special investigations detailed below and actual construction of latrine units, to cover a few towns with different physical, hydrogeological and socio-economic conditions to get a feed back on the acceptability, feasibility and affordability of the adopted technology, is a pre-requisite for the planning and implementation of a large scale pour-flush latrine programme. Findings from such a project could be suitably adopted for a particular local condition without going in for fresh investigations. The major inputs in the demonstration project are :

(i) Evaluation of pour-flush or any other latrine programme and the lessons learnt;

(ii) Review of the existing organisational, financial, managerial capabilities and legal authorities of the local government in the Project towns;

(iii) House-to-house servey in Project towns;

(iv) Optimisation of the proposed technology for least cost solution and study on sub-surface pollution;

(v) Institutional requirements (including health education and training); and

(vi) Methodology for construction of household and public latrines.

EVALUATION OF ONGOING LATRINE PROGRAMME (HOUSEHOLDS AND PUBLIC) IN URBAN AREAS

10. The evaluation of the ongoing household or public water—flush latrine programme, if any, and in its absence that of the existing latrine situation should be carried out to assess the users' preference and habits and also that of the non-adopters or those having no household latrines, of different socio-economic status in varying hydrogeological conditions to identify the constraints and their remedial measures. It would be necessary to determine the promotional or educational activities including financial assistance needed to encourage acceptance and Government's (at state and local levels) commitment to a pour-flush latrine programme. This study should be carried out at different levels—state, local and households (See Annex I). The evaluation of the pour-flush latrine programme in urban areas of India concluded that this type of latrine was acceptable to all, irrespective of income groups and were being used regularly wherever they had been installed. The study further revealed that the public latrines were seldom used by permanent inhabitants. It is thus apparent that in view of the multiple problems faced in maintenance of public latrines, it is economical in the long run to provide a household latrine, wherever feasible, even if full grant is to be provided.

11. As a corollary, there should be a study on the rehabilitation of scavengers (Annex 2), whose services are utilised in some countries for cleaning the bucket latrines, to assess the unemployment or economic deprivation by converting the dry (bucket) latrines into pour-flush ones. The Indian experience however indicates that latrine conversion programme has neither created unemployment nor under-employment among the scavengers.

REVIEW OF EXISTING ORGANISATIONAL MANAGERIAL, FINANCIAL CAPABILITY AND LEGAL AUTHORITIES OF THE LOCAL GOVERNMENT AND SUGGESTED REMEDIAL MEASURES

12. In order to judge the capacity of a local authority to prepare and implement a low-cost pour-flush latrine project, these studies are needed for suggesting the institutional set up that would be required to carry out such a programme. It would also need reviewing the existing legal provisions in local authorities acts, by-laws, and rules and to suggest practical and expeditious remedial measures for overcoming the existing inadequacies. Experiences of the India programme have revealed, that legal sanctions have been a very potent force in the conversion of dry latrines into waterseal ones. The basic requirement is therefore a policy decision by the Government to remove the existing insanitary dry system and ban open air defecation. In order to provide full support to the programme, legal reinforcement appears to be necessary (See Annex 3).

HOUSE-TO-HOUSE SURVEY

13. House-to-house survey should be carried out, comprising of data collection in respect of income, availability of water sources and electricity, type of latrine (flush or dry), to ascertain the socio-economic condition of the individual households for suggesting the financing pattern of the project (loan and grant to individual households); number of persons residing in the household; feasibility of conversion or construction of a new pour-flush latrine in the house with leaching pits inside or outside premises for determining the realistic cost estimate.

SOCIO-CULTURAL ASPECT

14. The socio-cultural aspect of the problem is as important as the technical aspect in a programme of this type. A recent World Bank study says "It is easier to change technology than to change behaviour and it is more difficult to determine cultural acceptability than technical feasibility".

15. Awareness, acceptability, availability, adoption and satisfaction* are the five most important ingredients of a programme which could lead to the changing of the existing practice for a more hygienic method, Therefore, for changing the existing insanitary sanitation system to pour-flush type, people should be motivated and made aware of it. The technology should be such that it is acceptable and easily available.

PROPOSED TECHNOLOGY, ITS OPTIMISATION AND STUDY OF SUB-SURFACE POLLUTION

16. Quite often the planners and administrators lack access to efficient planning and design tools, resulting in non-optimal solution to the given problem, which makes the solution out of reach of the poor. The service level and the technology selected, should be such that it is acceptable and affordable in the first stage of development and could be up-graded subsequently, utilising the existing systems. In most of the developing countries sanitation systems have been built without assessing the requirement, affordability and acceptability of the people, resulting in non-utilisation and leading to the failure of the systems.

17. Some basic questions such as the location of the latrine and leach pits, the size, depth and the structure of the leach pits, proximity of hand-pumps, open wells and street water mains, are factors

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*Dr. W. J. Cousins Senior Urban Adviser, UNICEF—Changing Sanitation practices. Some sociological considerations.

which call for a more discerning judgement from the technical angle. Certain questions arises. What should be the depth of leach pits ? Can the pan have a steeper slope and the trap a smaller depth of waterseal ? Is a follow up action possible to assess the extent and degree of sub-surface dispersion ? Is there a co-ordinating technical unit to research and discover least cost solution for different situations ? Answers to all these queries have been taken care of by the UNDP Global Project while formulating the Master Plan and Feasibility Study of 110 towns in India.

18. The technology developed by the UNDP Global Project is simple, consisting of a squatting pan and a trap, fixed on the floor of the latrine cubicle and is connected to two small and shallow leaching pits through a pipe or drain located away from the latrine cubicle (drawing attached). The leaching pits are of honey comb brick work or of dry stone work according to soil condition. The pits are used alternately and it takes about three years for each pit to get filled up. Because of the steep slope (25° to 30°) in the bottom of the pan and the shallow waterseal, (20mm), water requirement for flushing the excreta to the leaching pits is minimal, about 2 litres per capita per use (See Annex—4)

19. Based on the past studies and experience gained by various institutions in India, a design guideline has been presented (Annex—4). The optimum values have been arrived at, considering the cost effectiveness without disregarding performance.

POLLUTION ASPECTS

20. Studies in India and abroad have revealed that if the leaching pits are located in an unsaturated zone and water table is 3 to 4 metres below ground level, the risk of bacterial pollution is minimal. However, even under unfavourable hydrogeological conditions, the system could be adopted with some precautions and modifications (Annex—5).

INSTITUTIONAL REQUIREMENTS

21. For a successful low-cost pour-flush latrine programme, it is necessary to set up a suitable institution for programme planning and implementation, oriented to people's needs. "In absence of well-planned national or regional programmes, executed by efficiently run governmental bureaucracies, community participation and appropriate technology will count for little*.

22. Experience in India justifies the above statement. Inspite of the presence of an All India Social Organisation (Harijan Sevak Sangh)** in all the States of India, this organisation could meet the success only in one State. The question arises as to what extent the programme owes its success to the supporting input from the non-official advisory agency. Why was this approach not adopted elsewhere, bearing in mind that this organisation operates in every State of India ? What are the factors which made the conversion of dry latrines into waterseal ones an object of special attention in this particular State and not elsewhere ? The answer to this is simple—because the State Government itself was motivated and dedicated to the cause, and committed to the programme. The non-official agency provided the catalytic influence with its experience, expertise and voluntary involvement. The local authorities too were motivated and receptive to the programme. Personal dedication and drive by the advisory agencies gave the necessary stimulus. Thus, the programme was successful with mutually and complementary input by different agencies involved.

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*Dr. Richard Feacham—Rose Institute of Hygiene and Tropical Medicine—London.

**A Social Organisation for uplifting and bettering the living conditions of socially and economically backward community.

23. Based on the experience of the ongoing programme in India, four institutional alternatives could be suggested :

(i) Establishment of an autonomous Latrine Board or Corporation.

(ii) Creation of a State Authority by the Government, as a High Power Committee.

(iii) Existing Sanitary Engineering Departments, and

(iv) Establishment of a Social Organisation at the State level. Their functions and responsibilities appear in Annex—6. → missing.

METHODOLOGY FOR CONSTRUCTION OF HOUSEHOLD LATRINES

24. Whatever be the organisational pattern of the agency to be entrusted with the programme, the actual installation of latrines would best be carried out by small and medium contractors in the town, who will be the best motivators of the programme, as they will earn their livelihood from it. The procedure should be such that all the works which normally a householder is required to do from the time of application to the completion of the latrine, is done by one Agency, at the same time the householder is involved to the maximum possible extent (siting of the latrine, including the selection of design, and full satisfaction with the finished unit). These functions are summarised in Annex—7.

FINANCIAL ASPECT

25. In view of the heavy investment needed for implementing a large scale low-cost pour-flush latrine programme, it would be necessary to phase out the programme in such a way that this is within the financial resources of the government. Highest priority should be given to the conversion of all the dry latrines into waterseal ones, as it involves both social and health problems. Houses without latrines could be taken up under the subsequent phases.

COST ESTIMATE

26. Obviously the cost of conversion of a dry latrine into pour-flush one or cost of installation of a new latrine, has to be kept to the absolute minimum, consistant with the structural stability and functional efficiency of the unit. Keeping above factors in view the average per capita cost of conversion has been estimated to be US $ 18 (Rs. 150) while that of construction of a new latrine with superstructure US $ 25 (Rs. 210) (at 1981 prices for the Indian conditions).

FINANCING PATTERN

27. Past experiences of the implementation of a pour-flush latrine programme in India have revealed, that in poor families sanitation carries a lower priority than water supply, therefore if the programme is aimed to serve the poorest of the poor, a liberal subsidy would have to be provided to them. At the same time those who can afford to pay for the cost of the unit should pay for the full cost. Therefore, determination of the income level of the beneficiaries is very important for such a programme. There could be three approaches to determine the affordability of a household latrine :

(a) Income tax liability,

(b) Assessed value of the property, and

(c) Access to the public utilities in the households.

28. It would be difficult to assess the income level of the beneficiaries in view of the fact that majority of the population in the small and medium urban towns are non-salaried and so income tax liability and household income can only be estimated by guess work. Property value of the households could be another indicator of household income but again it is difficult to rely on the same, as fhe houses are not assessed at proper intervals and they may also be over or under assessed. Therefore, the second proposal also does not appear to be feasible. Thus the only alternative left to assess the affordability of households for participating in the programme is the access to the public utilities (water connection, electricity connection and dry latrines as existing) in the premises. These would be the economic indicators of the households. Therefore grant and loan to an individual household could be based on the number of public utilities a particular household enjoys. In general, the various state governments in India agreed to the following grant and loan components : (i) households having at least two out of the three utilities (water, electricity, bucket latrines)-100% loan; (ii) households having one of the three utilities-50% loan and 50% grant; and *(iii)* households with no utilities within the premises—25% loan and 75% grant.

29. The Indian experience has further revealed that even if a household has all the public utilities, paymet of the entire cost of sanitation unit in one lot cannot be afforded by majority of the people. The evaluation study has revealed that if long term soft loans are made available, there would be wider acceptance of the programme. Repayment of monthly instalment should be within 1 to 1·5% of the monthly income

OPERATION AND MAINTENANCE

30. Day-to-day maintenance of the latrine consists of only washing the latrine cubicle and cleaning the squatting pan. This would be the responsibility of the householders. After about three years, when the first pit gets filled up, the discharge can be directed to the second pit. This is a simple operation and can be handled by the householders themselves.

31. When the pit contents are left for about two years, they become pathogen free, and can be marketed easily. The NPK values of the pit contents are 1.5, 1 and 1% respectively. It has been estimated that its removal and market cost will break even. However in the initial stages, emptying of household pits, including its marketing, should not be left to the individuals but should be municipalised and local authorities in collaboration with local agricultural extension workers and farmers' associations should develop a market for the collected humus.

MANUFACTURE OF PANS AND TRAPS

32. In a number of developing countries the problem of manufacturing ceramic squatting pans and suitable traps may also arise, in view of the limited manufacturing capacity of the existing units or because of the heavy capital investment required to establish a new factory. To solve this problem, TAG* has provided assistance to the manufactures in India in developing light weight GRP** pans and traps which cost less than the ceramic ones and can be manufactured conveniently as a small scale industry. TAG is also providing advice for manufacturing pans and traps of PVC and HDPE in India.

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*TAG—Technology Advisory Group, UNDP Global Project GLO/78/006.

**GRP—Fibre glass reinforced polyester plastic.

EVALUATION OF ONGOING LATRINE PROGRAMME (HOUSEHOLD AND PUBLIC) IN URBAN AREAS

TERMS OF REFERENCE

A. HOUSEHOLD LATRINES

(a) The study at the state level should be done specifically to examine and evaluate :

- means adopted by the Government to orient its administration favourably towards the programme and to mobilise local authorities to actively co-operate with it and equip with needed skills to implement it;
- the Government efforts to promote the programme; and
- whether any financial incentives by way af subsidy and/or loan were provided to local authorities and individual households for installation of waterseal latrines and whether loan is being repaid by the adopters and if not, what are the reasons.

(b) The objective of the study at local authority level should be to examine and evaluate :

- whether the existing Municipal Acts, Rules and By-Laws are conducive to the implementation of the programme; if not, necessary amendments are needed ;
- institutional arrangements availabe to implement the programme; its adequacies/inadequacies and remedial measures to be taken ;
- whether any incentives including financial and technical assistance were provided by local authorities including the procedure and the results obtained;
- the efforts to disseminate knowledge about the programme to the people, to educate and motivate them to co-operate and adopt the programme ; and
- the impact of the above on the people.

(c) The study at household level should be undertaken :

- to know the experience and reaction of adopters about their satisfaction with regard to the technology, implementing agency responsible for construction, health education, motivation and maintenance of the units already installed ;

- to assess the attitude of the non-adopters towards the programme;
- to assess the willingness of the non-adopters to take loan for conversion of existing dry latrines into waterseal pour-flush type and also for construction of new such latrines; and
- to assess the socio-economic profile of the adopters and the non-adopters.

B. PUBLIC LATRINES

The study should be intended to assess :

- the availability of commun ity latrines, stage of their development and their present situation;
- socio-economic profile of the beneficiaries ;
- the extent to which they are being used by permanent settlers and the casual visitors;
- acceptability, inhibitions and constraints; and
- management (including financial, administrative and technical aspects).

ANNEX—2

REHABILITATION OF SCAVENGERS

(TERMS OF REFERENCE)

The study should comprise of :

— the assessment of unemployment problems faced by scavengers, as a result of implementation of low cost waterseal latrine project;

— impact of conversion programme on life style, as well as on vocational and economic aspirations of scavengers;

— analysis of scavengers' aspirations regarding occupational future of their children; and

— finally measures to be taken for their economic rehabilitation.

SUGGESTED PROVISIONS IN MUNICIPAL LAWS

1. Building by-laws should make the conversion of dry latrines into water-flush ones obligatory within a specified period.

2. The Municipal law should include provisions enabling the local authority to carry out the conversion/construction of a new latrine where none exists at the cost of owner. if he fails to do so.

3 The existing by-laws should provide a clause that all houses proposed for construction or reconstruction should invariably be provided with a water-flush latrine.

TECHNOLOGY OPTIMISATION

1. The pit size in case of a 5 user latrine is one metre diameter and about a metre deep (effective depth). Each pit lasts for about three years, before it gets filled up. The pit is then put out of use and excreta is diverted to the second pit. When the first pit is left without use for about two years or so, the pit contents become a rich humus, free of pathogens and can be used as a manure. The first pit is then ready to be put into use when the second pit becomes full in its turn.

2. Leaching pits can be located inside a house, under footpath or main road. An oval pit with partition wall or pits of smaller diameter, but deeper depth, could be constructed (provided the water table is low), if there is space constraint. In case of narrow lanes, latrines of a few houses can be joined to a sewer leading to leach pits located at some distance. Studies in India revealed that there is no choking in the connecting pipes even when the distance between leaching pits and latrine is between 15 to 20 metres. In such cases the connecting pipe has, however, to be laid at a steeper slope (1 in 5 to 10).

3. Design guidelines and optimum values

	Item	Optimum	Other options
(i)	LATRINE CUBICLE	750 mm x 900 mm	900 mm x 900 mm or 800 mm x 1,000 mm
(ii)	SQUATTING PAN		
	(a) Top opening	125 mm	125 mm
	(b) Width of back portion of pan	200 mm	200 to 225 mm
	(c) Vertical drop in front wall	75 mm	50 to 75 mm
	(d) Horizontal length	425 mm	425 to 460 mm
	(e) Slope of base of pan to horizontal	25°	25° to 30°
(iii)	WATERSEAL TRAP		
	(a) Depth of waterseal	20 mm	20 mm
	(b) Diameter of inlet	75 mm	75 mm
	(c) Diameter of outlet	70 mm	70 mm
(iv)	CONNECTING PIPE OR CHANNEL		
	(a) Size of pipe	75 mm	75 to 100mm
	(b) Size of channel	115 mm x 75 mm	115 mm x 75 mm
	(c) Slope	1 in 10	1 in 5 to 1 in 15

Item	Optimum	Other options
(v) INSPECTION OR JUNCTION CHAMBER		
Size	250 mm x 250 mm	250 mm x 250 mm
(vi) LEACHING PIT		
(a) Shape	Circular	Circular, oval, rectangular and square
(b) Effective capacity for sludge accumulation under :		
(i) Dry condition*	0.05 m^3/cap/year	0.045—0.05m^3/cap/year
(ii) Wet condition**	0.066 m^3/cap/year	0.055—0.066m^3/cap/year
(c) Design period	3 years	3 to 5 years
(d) Minimum spacing of pits	1 x effective depth	2 x effective depth@

*Unsaturated zone.

**Saturated zone.

@May be relaxed with proper precautions by providing an impervious barrier like cut-off screen or puddle wall.

POLLUTION ASPECT*

1. Studies carried out in India, USA and elsewhere have shown that alluvial soil (with predominance of silt mixed with clay and fine sand) where pits are located in an unsaturated zone, the risk of bacterial pollution is minimal, provided the bottom of pit is at least 2 metres above the maximum water table and the hydraulic loading in the pits does not exceed 50 mm per day (equivalent to a discharge of 40 litres per day in one metre diameter pit). Where the pit extends in saturated zone, pollution travel depends mainly on the velocity of the ground water. With the continued usage of the pit, clogging of the soil around the pit takes place, resulting in the regression of pollution plume which ultimately stabilises within about one metre distance**.

2. Even under unfavouable hydrogeological conditions such as coarse soil, high ground water velocity and high water table, the leaching pit system can be used provided certain modifications and precautions are taken, such as providing an envelope of fine sand of average size not more than 0.2 mm and a minimum thickness of 500mm all round the pit and the bottom sealed off by any impervious material, such as polythene sheet or puddle clay. If fine sand is not available, whatever coarse material is available may be screened through a sieve of 0.6 mm and the material passing through it can be used. This should also be adopted where bottom of the leaching pit is within 2 m of the water table. In high water table conditions, the inlet to the pit should be kept at least one metre above the maximum water table. This condition may necessitate raising of the latrine floor.

3. In conditions such as rocks with fissures, chalk formations, old root channels, pullution can flow long distances. These conditions demand careful investigation and necessary modification of the system or adoption of alternative technology.

4. In case the pits are located under the roads or streets, the invert level of the connecting pipe to the leaching pits should at least be one metre below ground level, so that the liquid level in the pit does not rise above the water-supply mains, which are generally laid at a depth from 0.8 to 0.9 metre below ground level.

5. It is desirable to monitor periodically the quality of ground water in the area where the programme is implemented. The monitoring programme should cover periodical sampling of ground water and analysis for at least faecal coliform and nitrate.

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*The conclusion drawn is based on a limited study done in India. Further work on the subject is under progress by the International Working Group on Water and Soil Pollution from leaching pits.

**Expert Group on Design Criteria on pourflush waterseal latrines–TAG (India)

FUNCTIONS AND RESPONSIBILITIES OF ORGANISATIONS

The organisation at the State level should be responsible for :

- policy making, mobilising the necessary resources, guiding local authorities in the implementation of the programme :
- setting up of a nucleous of technical and administrative staff to serve as the executive arm of the authority to help in programme planning, fund allocation, co-ordination of field activities and to monitor the field work, provide programme intelligence and report to the authority, establish training to social workers, supervisors, junior engineers, sanitary inspectors, organise concurrent research on sociological, economic and technical problems emerging during programme implementation and to make alternative arrangements, where any implementing agency fails to undertake the programme satisfactorily.

ORGANISATION AT LOCAL LEVEL

By and large local authorities in all the urban centres are primirily responsible for providing water supply and sanitation facilities to their citizens. They have adequate powers to give loans and grants to the beneficiaries and have remedial powers in case of default. Therefore, local authorities in the urban centres should be charged with the responsibility of implementing the programme and made responsible for :

- preparing the detailed programme of work, identifying the target locations;
- receiving and disbursing loan and grant funds from the Government;
- organising training of staff and local contractors;
- implementing the programme;
- arranging for emptying of household leaching pits; and
- recovering the loans from the beneficiaries.

PROCEDURE FOR CONSTRUCTION OF HOUSEHOLD LATRINES

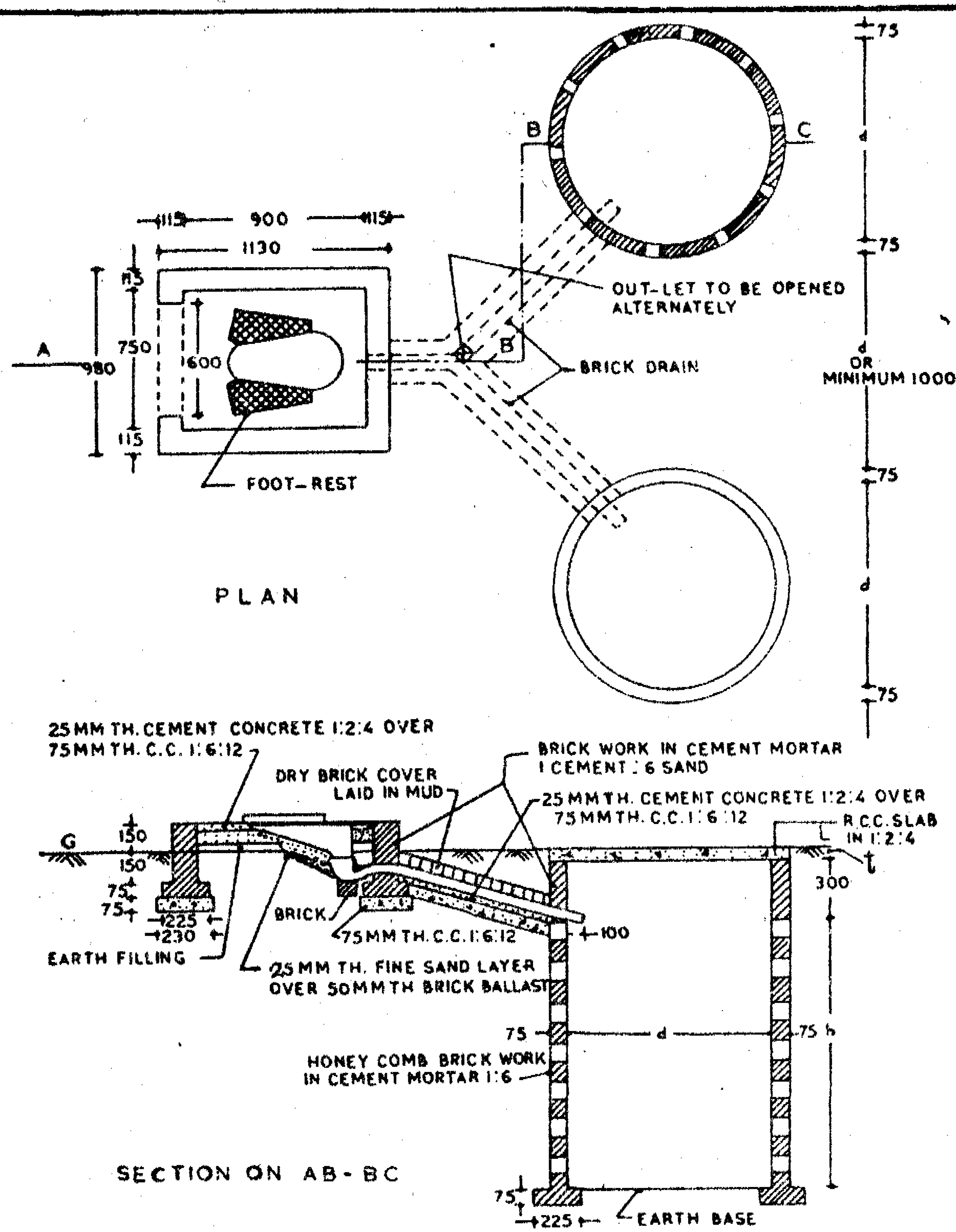
1. A householder wishing to have a waterseal latrine should enter into an agreement with the local authority to ensure timely repayment of loan. The funds available for the construction should be paid to the contractor by the local authority on the completion of the work.

2. The licensed contractor would visit the house of such interested persons to assess the space available for construction of the latrine and leaching pits, the number of users, and decide with the householder, the design which is suitable. At the same time public water supply and electricity connections should be checked, as they would be used as economic indicators to determine the quantum of subsidy to be provided.

3. These details should be set down by the contractor on a standard form, which the houseowner would endorse by signing an agreement The houseowner would also be provided with a list of materials and latrine dimensions.

4. The contractor would take the endorsed form, together with a sketch plan of the proposed installation to the local authority for approval. The junior engineer or sanitary inspector will then visit the site and check the type and location of water supply source, structural condition of the house etc.

5. The completed installation would be inspected by the junior engineer/sanitary inspector, who would furnish completion certificate fully endorsed by the houseowner. The contractor would be paid the standard cost of the latrine on production of the above certificate.



USERS	DIAMETER d	HEIGHT h	THICKNESS t
5	900	1100	50
10	1100	1400	60
15	1250	1600	75

DESIGN OF LOW-COST WATER-SEAL LATRINE FOR PITS WITHIN THE PREMISES

ALL DIMENSIONS IN M.M

SCALE :- 1:300

VIETNAMESE LATRINES AT GONOSHASTHAYA KENDRA

BY Shafiuddin, Programme Director, Agriculture Section, Gonoshasthaya Kendra
and
Sally Bachman, Gonoshasthaya Kendra, Savar, Dhaka, Bangladesh.

ABSTRACT:

Gonoshasthaya Kendra, an integrated rural health and development project in Bangladesh, has been experimenting with Vietnamese Latrines for over five years. Despite the advantages the latrines offer, i.e. they do not require water for flushing, and they produce a load of fertile compost periodically, we are not yet happy with them. Although they have great potential for use as latrines in village areas, they require either a modicum of education and health understanding among users, or else frequesnt supervision of maintenance -- something not easily available in villages. They are also expensive to build, and villagers have other more pressing needs for their extra capital -- namely, food, shelter and clothing. Sanitation will not be a high priority for them until either whole communities are mobilized, or else, people feel they are deriving some benefit from the latrine, like periodic loads of compost. Ideally, political and economic mobilization will integrate questions of health and sanitation -- as in Vietnam and China. This does not, however, appear to be on the horizon in Bangladesh's future.

INTRODUCTION

Ask for a description of sanitation practices in Bangladesh, and anyone can tell you in a few words: bushes, bamboo groves, roadsides and ponds.

The government estimates that only one, or at the most two percent of the whole population has access to adequate sanitation facilities.(1) A survey carried out in 1976 indicated that 5% of all adults and only 1.5% of all children use sanitary latrines. Of the rest of the population, half use 'open' latrines -- a walled off corner near their houses, and half use no latrine at all. (2)

Sanitation is a problem recognized by all health planners. At the same time, it is a field which has not inspired much action to complement the verbal concern. The reason why seems simple: sanitation is not the primary [illegible] of the people. In Bangladesh, where 80% of the population lives below the poverty level, digging a latrine is not a high priority for the villager in need of clothing, shelter, and, above all, food.

Overall picture

In order to run a successful sanitation program, one must look at the existing situation, not only what facilities are currently avaialbe, but what other factors will influence villagers to accept or reject the programme. (3)Village sanitation programmes in Bangladesh have failed in the past because they have not taken either traditions or mechanical questions into account. InBangladesh, water seal latrines are not being bought from government sources because of two main considerations: the expenses of building a latrine, which is beyond the means of most villagers, and the inconvenience of keeping it clean -- especially, the inconvenience of flushing a water seal toilet with teo bucketfuls of water. (In some countries, failure to take all considerations into account has led to such enormously impracticable uses of latraines as chicken coops in Latin America (4).)

The whole concept of sanitation is surrounded with taboos, traditions and the habits of hygiene specific to any culture. In order to give a picture of these , we briefly surveyed two villages: Village M in Manikganj subdivision, about 15 miles from Gonoshasthaya Kendra; and Village S, in Savar Thana, about 3 miles from the central G.K. project. No development agencies have ever worked in Village M, apart from the government's various outrreach and extension agents. In any case, there are few enough of them, and they arrive so seldom, that in effect, there have been no external influences on the progress of development, or lack of the same. One of G.K.'s most enthusiastic paramedics comes from Village S, and lived there while doing primary health care work full time for three years.

Village M is poor in comparison to Village S, and may be more representative of conditions all over Bangladesh. Apart from the lower percentage of landless families in Village S, it contains more houses with tin roofs -- an indication of greater prosperity than a chapra (mixed tin and thatch) or thatch roof.

Village S. also contains one sanitary latrine. It is used by four families, although it belongs to another family whose members live in town abroad.

side of a hillock. Most houses are built on such hillocks to lift them clear of yearly floods. During the rainy season, there are no dry fields and few roadsides where one can go -- near the house, but not so near that the next breeze can carry with it an unpleasant odor -- and the cheapest and easiest - though not the most sanitary -- solution is the open latrine. The excrement that accumulates beneath the latrine is not protected from flies, birds or other vermin; it may be covered by floodwater during the wet season when the water surrounding the hillock is also used for bathing and pot washing.

A majority in both villages, however, use the fields and bushes as their defecating grounds. They follow a common pattern: women rise before the men in the early morning dark, to go to a field or grove carrying a bodna (water jar specifically for transporting water used for washing the buttocks after defecation). This way, women preserve their modesty, as niether the men of the family notice them going out, nor can they be seen by strange men.

Men rise after the women and, since they are free to move more than women are, may go further away from the house to pass stool. (5) Preferred places for defecation are empty fields and roadsides. Both men and women avoid defecating -- and thereby defiling -- any field with standing crops.

This is often the only time that women defecate during the day. When it is light, they risk being seen by strangers if they stray too far from the house to defecate. At the same time, no one wants to soil the ground nearby the house. This need to retain a woman's modesty is an important incentive for building latrines -- in fact, women are the major users of some latrines. (6) In most cases, women do not have access to a latrine, and so they train themselves not to have any bowel movements during the day. Women have been known to skip lunch in order to avoid having a bowel movement. (7)

For urinating during the day, a woman's most discreet opportunity presents itself while she bathes in pond or river. Standing in the water, she can urinate without anyone noticing. (8) After bathing, both men and women complete the ritual by rinsing the mouth. No distinction is usually made between water used for bathing and that used for mouth rinsing. Considering that pond water contains run-off from whatever is on the side of the pond -- including cow and possibly human faeces -- the dangers of this practice are obvious.

Men have more opportunities if they need to pass stool or urinate during the day. Since most men spend the days outside the house compound, they have their choice of any protected grove for defecating, and any open roadside for urinating. If he defecates outside the house, a man will probably not have a bodna at hand, and will go to the nearest water source afterwards to wash his buttocks. The only customary restriction on a man urinating is that he squat and turn his back to whatever activity is going on. Men face walls or stand in corners to urinate, but face away from as many people as possible.

Children, especially babies, usually pee or defecate wherever they are, no matter whether inside or outside the house compound. Babies are allowed to pee on the floor and the moisture is usually left to dry up by itself. But if a child -- or a chicken, for that matter -- defecates on the house floor or in the courtyard, a handful of ash is thrown over it before being scooped up with a leaf or twig and thrown away. Childrens' urine is not considered particularly harmful. A baby sitting on a mud floor may not be moved even t ough it has urinated on the spot, dampening the toys it was playing with or -- in the case of puffed rice -- eating.

Some habits help spread disease, while other help curb its spread. (9) People scrupulously avoid using their left hands to eat, since the left hand is used to clean the buttocks. Though women use both hands to cut vegetables and prepare food, they use only the right hand after food has been cooked. People also avoid touching their feet with their hands, and if they do they use only the left hand. They also avoid putting their feet near food, or touching anyone else with their feet. As mentioned above, people avoid defecating in fields where crops are growing, and human faeces are not traditionally used as fertilizer.

Water and Sanitary Latrines

Water sources in Bangladesh villages are limited to rivers, ponds and tubewells. Water is king in Bangladesh -- floods, rain and drought arrive on their own schedule, with little that humans can do, or are doing, to control them. In the rainy season there is too much water, and the water

[illegible]
are still very few villages where every family has access to a tubewell. In the winter, people suffer from lack of water, both for their fields and for their own purposes -- washing, cooking and bathing.

Village M has only three public tubewells (and one private one) for 80 families, one ringwell and no river or pond. Women must therefore carry water long distances to their homes for all purposes, or else carry their pots and dishes and clothes to the closest tubewell. Water is less of a problem in Village S, although water for cooking and drinking must be carried by the women into their houses inheavy water jars.

In general, tubewell water is reserved for drinking water, in most villages. Ponds and rivers -- where water can be obtained without having to pump -- are used for washing clothes and pots and for personal hygiene. In places where water is generally less available, like Village M, people usually use less water for washing themselves. Women who must carry water to their houses for all purposes, will natrually be reluctant to use it up quickly. It is easier to do the wash and bathe in the river ~~or pond or at~~ the tubewell or ringwell itself. Pond water is considered particularly pleasant. It leaves a good smell in clothes, and is said to get them clean -- probably because pond water is mostly 'soft' run-off, without the mineral content that tubewell water might have.

The government's Department of Public Health Engineering, is trying to sell sanitary water-seal latrines for the subsidized price of 150 taka for slab and rings. ([illegible]) Although the programme has been going on since 1977, they have only managed to sell 150,000 to date. There are two major reasons for this: first, that 150 taka (a subsidy of 250 taka) plus the carrying charges and construction expenses needed to install a water seal latrine, are still beyond the means of most villagers. The same money can be better used, in their eyes, on any number of purchases -- chickens, cows, goats, sarees, etc. -- whereas building a latrine has no monetary benefit(although it does have high status value). ([illegible])

Secondly, a water seal latrine is inconvenient to flush. People will be reluctant to go to the trouble of carrying two buckets of water to flush the toilet under any circumstances, and even more so if the water source is far away. Women are afraid to be seen entering the latrine, or hauling two buckets of water for obvious purposes. Yet, if a latrine is not flushed, it may become plugged or smelly, and people will prefer to defecate in the open air where the wind carries smells away.

People who have bought water-seal latrines for themselves -- either out
[illegible]

ting with a latrine pan without gooseneck (the gooseneck is replaced by a straight, sloping chute) which takes much less water to flush. Since there is no seal, however, the latrine cannot be called 'sanitary'. (14)

UNICEF has suggesting installing a latrine alongside a tubewell. Studies show that the quality of tubewell water is not affected. (15) However, as long as there reamins a shortage of tubewells, and a shortage of people to fix them when they break down, water will remain an obstacle to the success of water-seal or water-flush latrines. Although tousands of tubewell mechanics are being trained (16), they cannot yet be counted on to be vigilant in seeing that both tubewells don't remain out of service for long, and that latrines do not get plugged up.

Vietnamese Latrines : Our Experiment

Primarily to overcome the obstacle of water supply, we began experimenting with Vietnamese latrines. They call for no more water than that carried in a bodna to wash the buttocks. Three or six months after one bin is filled, it produces a load of rich compost, which can be used as fertilizer. We also thought that Vietnamese latrines would have another advantage: they do not need to be dug into the ground, and so there is no danger of contamination of ground water even during years of high flooding. They are also small, and therefore might be easier to fit on the surface of the overcrowded hillocks on which people live. Other toilets, particularly the latrines with two pits for collection of faeces, which must be dug into the ground, take up far more space. Eventually we hoped that people could overcome their aversion to using human waste on fields (17) when they saw that they could gain an income from selling vegetables, for example, grown with human fertilizer.

Before introducing the latrines into villages, however, we knew that we would have to prove that they would work. If they failed to be used correctly by our workers -- who are for the most part literate, or else have received some kind of informal education at G.K. -- then they would almost certainly fail in the villages. Gonoshasthaya Kendra has more than 200 workers, half of whom live at the project, and half of whom come from their villages daily for vocational training. The project itself is involved in health work (with a small hospital and paramedics who visit villages daily); agricultural extension work: vocational training for women in sewing, metal-smithy, carpentry, bakery, and shoe making; and a school for children of poor families.(18) About 20 or more people from other organisations usually live at the project for training.

Currently, the only sanitation programme we have in the villages consists of advice and example: paramedics tell the families they visit, school-teachers advise their students, and agricultural extension workers suggest to members of credit dooperatives to dig pit latrines. At the very least, they suggest that families use a specific place for defecation. Paramedics and school teachers also help families to begin digging pit latrines, and the school children help other families in their villages to dig them.

We realized how few families would be able to afford water-seal latrines, even at the government's subsidized price, and so we did not promote them. Also, while waiting for results of our experiments with Vietnamese latrines to come in, we did not promote any other permanent latrines.

We built our first Vietnamese latrine over five years ago. Finding that it was too big -- it took a year to fill one box -- we built the following ~~16 on a slightly smaller~~ scale. Our latrines are generally 3 feet by three feet by 6 feet (depth), with housing of bamboo poles and woven bamboo walls with tin roof and wooden door. The bins are built of brick and mortar, with Two bricks flanking the hole in the top of each bin as footrests, and other bricks to lead urine and water over the side of the bin. (Unlike the latrines in Vietnam, we do not collect or use the urine. It drains over the bin side and into the gound. (19)). The side doors, from which the compost is unloaded, are either metal or wood.

Reactions: Not Enthusiastic

Almost none of the workers was enthusiastic about using the latrines at first. Many still prefer to use a commode or latrine in ~~the-~~ a building, if they aan. They object to the smell of some latrines, and to the inconvenience of shifting forward after defecating to urinate and wash without letting water into the bin. Inevitably, people become careless and let water or urine into the bin, or forget to throw ash in before they leave, to dry the faeces and soak up odors. Two paramedics have been assigned to supervise the latrines. All health training given to our workers and visiting workers, includes a section on Vietnamese latrines. In addition , all workers taking vocational training, or who are illiterate when they arrive (guards, cooks, etc.) also learn about Vietnamese latrines in the literacy classes they must attend.

The most heavily used latrines -- those near the houses where trainees live and those behind the workshops -- are the ones most likely to smell. 50 people work in the workshops, most of whom come from their village homes in the morning and return at night. Perhaps because neither trainees nor workshop employees live permanently near the latrines, they are less careful about keeping them clean and keeping water from entering the boxes. Latrines used by one or two families are the cleanest and least smelly.

Fertilizer

We have used about 14 loads of fertilizer from our Vietnamese latrines so far. Most have been spread on our vegetable fields. No one has yet refused to work in any field where such fertilizer has been used -- although they were squeamish about unloading the first compos[illegible] our workers, from doctors down to guards, work in the fields every day. We have not made any specific tests of the fertilizer, except on one patch of tomatoes where no other fertilizer was used. The and produced big red fruits.

A few months back, we sent a sample of compost to a pathology laboratory to see if worms or their eggs could be found. We were dismayed to find out that the compost still contained a significant amount of helminths. (see Table II) However, ten minutes' cooking kills all bacteria and helminth ova Bengalis invariably cook food for at least ten minutes, so there is little danger that diseases or worms could be transmitted from the compost through cooked food. Since most people work in their fields barefoot, however, the danger remains that disease could be transmitted that way.

Research has shown that "(some) helminth ova ... may hatch out as larvae in the compost. After 3 weeks, the compost may contain significant numbers of Ascaris (roundworm) and Taenia larvae, but these subsequently die and after 7-8 weeks, 85 per cent of the Ascaris originally present, and a similar percentage of the total helminth population, will have been killed whether as eggs or as larvae."(20) Since we made no test of the helminth content of among our workers about using the compost.

Something is going awry in the composting process for one of several reasons. Since people use water to wash themselves, and are often careless about letting water enter the composting bin, the faeces may be too wet to compost properly. Wet compost will not heat up as much as dry or simply moist compost will. Possibly, the hole on the top of the bin or the door on the side are not being sealed properly, or there are leaks in the walls through which air and water can enter the bin. Since "...the precise nature of the (composting) process is uncertain... ." (21) there could be other reasons as well. We also have not had a fixed timetable for unloading compost, and it is possible that we have unloaded it too soon, before all helminths could die.

Latrines to the Villages : A Difficult Proposition

After five years of experience with Vietnamese latrines, we cannot say that they will be easy to intorduce into the villages. Although members ~~of our credit cooperatives~~ and nearby villagers who visit the center often, have asked us to help them build and try out a Vietnamese latrine, we have been reluctant to do so. There are several specific problems:

-- cost: A Vietnamese latrine is even more expensive to build than an water seal latrine: total 3,000 taka. (22) We are most interested in helping the poor villagers, who will never be able to afford thatmuch money on something which will yield so little for them.

-- compost production: the latrines might seem more rewarding for the village/farmer if they produced a load of compost more often. Even the latrines behind our workshops or beside the houses where trainees live yield a load of compost at most every four months. If a single family uses the latrine, a year can pass before any compost can be used. Although the compost is the Vietnamese latrin's biggest potential 'selling point' among villagers with less understanding of health and sanitation, compost alone may not convince people to adopt the latrines. If more people used one latrine, so that it would fill quickly, and the compost was used on a field from which all those people could gather vegetables, the benefits of the compost might be easier for the users to see. That kind of collective action is, however, extremely difficult to organize -- if not impossible in the current social, political and economic climate.

--compost for the poor: If the compost can be controlled or used by the poor only, perhaps it could be a source of income and some kind of power for them. We do not want to repeat the mistakes of people who have introduced bio-gas plants, which are more often than not taken over by rich and middle farmers who can provide enough gobar (cow manure) or roganize enough human wastes to produce natural gas. (22) For this reason, we would like to work with the poor farmers who are members of our credit cooperatives, in order to introduce Vietnamese latrines. Apart from the difficulty of organizing maintenance for a latrine used by a few such families, most of the families do not live near each other, making communal latrines an almost impracticable proposition.

--maintenance: if it were ever possible to construct Vietnamese latrines for each family in a village, the problem of maintenance would still remain. It takes a good deal of supervision to keep our own Vietnamese latrines running properly, despite our relatively educated workers. Follow-up would have to be organized, though how long it would have to continue is another quewtion. In general, latrines that have been purchased by the users are well kept up, and so if Vietnamese latrines could be less expensive, perhaps maintenance would be less of a problem.

Conclusion: Mobilization and Systemic Change.

In order for any sanitation programme to be successful, a whole community must be mobilized. The public health impact of latrines does not begin to show up until a large number of houses in a given area have access to them. (23) The Chinese and Vietnamese sanitation programmes have attained a degree of success in part because they have involved almost all houses in the community.

More importantly, however, health and sanitation measures will not have any meaning for people until they can be fed, housed and clothed. Until villagers in Bangladesh can afford to feed themselves, they will not consider spending money on a latrine particularly important. When they do make enough money, they must be mobilized. Best of all would be a change in the socio-economic system which would not only allow all people to have the basic necessities of life, but would integrate health, income generation, etc. in one system.

That kind of change does not look probable in the near future, in Bangladesh. In the meantime, we can test some technical solutions to problems. The Vietnamese latrine still has many problems associated with it: could it be constructed more cheaply? how should education about how to use it and follow-up to make sure it is maintained, be organized? can the bins be constructed so that the compost heats to a higher temperature and

Initiatives will have to come from top leadership, as well as from N.G.O.'s like Gonoshasthaya Kendra. In China and Vietnam, sanitation was made official policy, and a whole movement was started around the theme 'Stop the Faecal Peril,' in Vietnam. (24) "In China, sanitation was made inot a matter of social prestige and patriotic duty." (25)

Visitors to Vietnam (from western countries) reportedly claim that Vietnamese latrines are not working as well there as is claimed by the government. (26) Bangladesh sanitary engineers should check on this allegation, and perfect the latrine technically. But the rest of the effort -- that is, the use of the latrines -- is entirely up to the people, calling for mobilization, supervision, etc. Above all, however, it calls for a unified approach to development, treating sanitation as only one facet of health care measures which include income generation and education. Only then will any sanitation efforts bear fruit in Bangladesh. In the end, the problem is not an engineering one, but a question of manpower and political wisdom, and lots of dedicated work.

TABLE I

SOCIO-ECONOMIC INDICATORS AND SANITATION IN TWO BANGLADESH VILLAGES.

FACTORS:	VILLAGE S	VILLAGE M
No. families	total 55	total 80
landholding per family:		
landless (0-1 bigha*)	18	45
1-3 bighas	12	18
3-6 bighas	6	13
6-9 bighas	9	1
9 + bighas	11	3
housing:material of roofing		
tinshed	35 (63.63%)	14 (17.5%)
chapra (partly tin, partly thatch)	10 (18½78%)	38 (47.5%)
thatched	9 (16%)	26 (32.5%)
nil	1	2
latrine: cement (sanitary)	1	-
tin walled	9	2
bamboo	16	15
none	30 (53.73%)	63 (78.75%)
tubewells:	6 (2 are private)	4 (one is privat
other water sources:	one river beside the village one ring well(open top) no ponds	one ring well no river no pond

* one bigha = approx. 1/3 acre

TABLE II
HELMINTH OVA AND LARVAE FOUND IN VIETNAMESE LATRINE COMPOST, SEPT. 1982

1. Direct examination and concentration techniques revealed:

Ova. of A. Lumbrocoides N 60/gram of sample

Ova of T. Truchuri N 4/gram of sample

Larvae of hookworm N 1/gram of sample

2. Microbiological culture at 25° and 37° C for 48 hours on suitable media revealed few colonies of:

Escherichia coli (non-pathogenic strain)

Pseudomonas - (saprophytic strain)

Klebsiella [illegible]

Notes:

1. Rahman, Habibur, "Village Sanitation". photostat - no date, no publication title. (Mr. Habibur Rahman works for the Department of Public Health Engineering, Dhaka.)

2. Skoda, John D. Mendis, J. Bertrand, and Chia, Michael, "The impact of sanitation in Bangladesh," pp. 33-34, and "Data on Excreta Disposal," pp. 1-4, (Table 1.1), in Pacey, Arnold, ed. <u>Sanitation in Developing Countries</u> John Wiley & Sons, New York, 1978.

3. Curtis, Donald, "Values of Latrine Users and Administrators," pp. 170-176, ibid.

4. E.G. Wagner and J.N. Lanoix, "Excreta Disposal for Rural Areas and Small Communities," <u>WHO Monograph Series,</u> No. 39, Geneva, 1958, p. 22.

5. This is the same pattern as in West Bengal, see Kochar, Vijay, "Culture and Hygiene in Rural West Bengal," p176-184, esp. 180, in Pacey, <u>Sanitation...</u> .

6. Preliminary findings of an evaluation of test project of various latrines, ~~in Chittagong,~~ carried out by the Department of Public Health Engineering, Bangladesh. unpublished photostat, 1982. Not for quotation until official report is published, in 1983.

7. . This has been observed by authors. Women also consider using the same toilet as men something to be avoided, which should be taken into consideration when latrines are introduced to a community.

8. see Kochar, in Pacey, <u>Sanitation...</u>

9. see Kochar, in Pacey, <u>Sanitation...</u>; Many of the sanitation habits he describes are shared by people in Bangladesh. Other habits he mentions which are shared include: people build their houses away from bamboo groves, which are thought to give off 'bad wind'. This is probably in fact the case, since they are used as defecating grounds, in Bangladesh as well as in West Bengal.

10. It has been shown that the incidence of water-borne as well as other diseases, falls when more water is available -- regardless of the quality of the water. Chowdhury, Zafrullah. "Basic Service Delivery in "Underdeveloping Countries": A View from Gonoshasthaya Kendra." United Nations Economic and Social Council, E/ICEF/ASIA/9, 4 May 1977. p. 30.

2. Notes.

11. personal communication from Habibur Rahman, D.P.H.E., Dhaka.

12. see. preliminary findings of evaluation of test project, D.P.H.E., 1982. Not for publication until final report is published. It was reported that people who received Vietnamese latrines for the evaluation test kept them clean for the most part, and seemed pleased that they had been awarded the most expensive latrines on trial. They were also the poorest families in the study.

13. ibid. Reportedly, most water-seal latrines in the project -- all of which had been purchased by their users before the project began, were in use, though all had smell and flie problems and most gossenecks were broken.

14, Personal communication from Habibur Rahman, D.P.H.E., Dhaka.

15. Gibbs, Ken, "About Pumps and Privies - Keep them Together," mimeograph, UNICEF, Dhaka, Bangladesh, 11 August 1980. This study showed that tube-well water was more easily contaminated by priming the well with unclean water, and by touching the spout with dirty hands.

16. "Water and Sanitation for All?", Earthscan Press Briefing Document, no. [illegible]. p.

17. Briscoe, John, "Labour and Organic Resources in the Indian Sub-Continent," pp. 186-191, in Pacey, Sanitation.... see pg. 189.

18, see Progress Report No. 7, Gonoshasthaya Kendra, August 1980.

19. McMichael, Joan K., "The Bouble Septic Bin in Vietnam,", pp. 110-114, in Pacey, Sanitation.

20. ibid, p.112.

21. Conference Working Groups, "The Need for Research on Composting Latrines," in Pacey ~~et-al~~ Sanitation..., pp. 119-122. see.pl. 121

22. Breakdown of expenses involved in building one Vietnamese latrine:

bricks: 825 pc @ tk. 1200/1000	=	990
cement - 1 1/2 bag @ 115 / bag	=	172
rod - 50 lbs @ 6.25 / lb.	=	157
bamboo fencing - 150 squ ft. @ .89 / sq. ft.	=	134
C.I. sheet tin - 3 pg @ 150 / pc.	=	450
wood - 4.05 cft. @ 150 / cft.	=	607
iron pin & wire -	=	25
wages	=	400
total		2900 taka.

3. Notes

23. see Briscoe, in Pacey, Sanitation
24. see Earthscan bulletin, pb. 85,
25. see Earthscan bulletin, pg. 79.
26. personal communication

VIETNAM's SANITATION SYSTEM

Krisno Nimpuno

The Vietnamese toilet is of interest for several reasons. It is probably the only system which was successfully applied on a national scale in a developing country. This was possible because of its simplicity in construction and use. The system made significant contribution to the environmental care and agriculture in Vietnam by recycling human excreta as fertilizer. Its significance for public health care is also very considerable. The Vietnamese method of excreta disposal is most remarkable since it follows completely different principles of pathogene destruction and mineralisation of organic matter compared to systems used elsewhere.

The great difficulty in public sanitation encountered throughout the third world certainly justifies some attention for the succesful Vietnamese methods, especially since the system is unique in its applicability in flood prone areas, as well as in places without piped water supply.

The few publications about the Vietnamese Toilet so far available in the west have been limited to short descriptions of the construction and use of the toilet but little information has been available about the actual process performance.

In this article we would therefore like to concentrate on these aspects.

Anaerobic Composting

The system is characterized by in situ treatment of excreta, separation of urine and feaces, anaerobic composting and family size units.

The Vietnamese Toilet is a double vault system or a discontinuous toilet. There are two tanks: One is used as a privy, while the other has been closed and is used for composting the faecal matter.

The Vietnamese Toilet requires that faeces and urine are deposited in different containers. After each use of the toilet some ashes or lime is thrown on the fresh excreta to absorb humidity and to eliminate the smell. Toilet paper can be dropped into the vault. The lid is carefully replaced on the opening after each use. When the tank is full, the material is levelled off with a stick and all is covered with an extra layer of ashes.The opening is then closed hermetically with mortar and marked with the date to assure a sufficient treatment time.

In the Vietnamese Toilet organic matter decomposes in two phases: as long as the toilet is in use there is ample oxigen available. Since the faeces are always sprinkled with ashes the pile remains porous and aerated and the process is aerobic. After the vault is closed the oxigen is rapidly exhausted and the process turns anaerobic. The Institute of Hygiene and Epidimiology in Hanoi monitored the development regularly and analysed the various processes involved in this type of toilet. Since food tradition and living conditions vary and there are different constructions methods in the various regions, the institute established a number of field stations for such analyses.

The Process.

The Vietnamese Toilet has been developed as a part of the preventive health work of the National Institute of Hygiene and Epidimiology. The Institute started in 1956 to study old and new methods for the collection, transport and treatment of human excreta and its use in agriculture. Data about the qualities and composition of human excreta were collected:

Table 1

Human excreta composition

Annual excreta quantities per person:		ca 500 Kg
Containing:	1.07 % N	
	5.7 % Organic matter	
	1.3 % Inorganic matter	
	0.26 % P_2O_5	
	0.22 % K_2O	

It was noted that human excreta is rich in organic material in comparison with excreta of domestic animals.

Treatment should therefore not only be useful from the health point of view that is effective in pathogene desctruction, but also for agriculture reasons: achieving a satisfactory mineralization and conservation of the valuable organic matter. One of the first methods propagated in Vietnam was aerobic composting of human excreta with agricultural waste in windrows on a floor of rammed earth or concrete.

The windrows were covered with a thatch and mud layer of ca. 20cm. Temperatures of 70°C could thus be reached and the process was completed after three weeks. But all the known disadvantages of windrow composting were experienced: transport and handling of fresh excreta, fly breeding and very disturbing odours. It was therefore soon decided to try anaerobic composting methods. An interesting development at this stage was the research on the antibiotic effect of carbon rich material added to the excreta. Household refuse, agricultural waste and leaves were studied. Two types of leaves, Rhizo-hora micronata and Aegiceras- were chosen because of their iodine content, while the leaves of the Melia Azadarach were tested because of their antibiotic properties. The results were encouraging and in later developed composting methods these leaves were used. The first experiments with anaerobic composting were executed in pits of 150 - 200 cm depth, where alternating layers of excreta and carbon rich material were buried under a cover of straw and mud. The institute found that after four weeks a satisfactory level of pathogene destruction could be reached. It was also found that a 10% additive of lime or superphosphate would reduce this time to ten days. The positive results of nitrification and pathogene destruction in anaerobic composting ecouraged the Institute to attempt composting directly in the toilets in order to avoid the handling of fresh excreta. A multidisciplinary team in the National Institute of Hygiene and Epidimiology under Dr Nguyen Dang Duc then set out to develop the Vietnamese Toilet. The first publications about their work appeared in the series Vietnamese Studies. The toilets were first called "Double Septic Tanks" later the name "Double Septic Bin" was used. In this article we simply use the name "The Vietnamese Toilet". A major question was whether composting of very small quantities of faeces such as produced by one family would be feasible, in view of the problem of odours and of heat loss which retards the composting and changes the character of the process. It took time to solve these problems. An interesting additional requirement was to develop a toilet which would satisfy the peasants timing for applying fertiliser to the fields. The use of human excreta in agriculture is so general in Vietnam that farmers often proved unwilling to wait for the treatment if it would interupt the agriculture cycle. The decisive factors for determining the dimensions of the toilet were therefore the minimum composting time possible and the volume of excreta produced during the same time by an average family.

These two factors would assure the peasant the shortest possible cycle to make a safe compost available. The attention of the institute turned therefore to the choice of suitable carbon rich material to shorten the cycle. The final product is naturally determined by the composition of the excreta itself and it was noticed that the composting process developed better with a dry than with a humid mixture. It is essential to avoid flooding of the vault, but it is not easy in a hot climate. Moisture content should either be reduced by adding moisture absorbing material or by separating urine from the mixture. This last step proved to be effective. It was also found that fly control would be easier in a dry mixture. Seperate urine treatment was not considered very risky from the health point of view. For the volume of the vault it would mean a reduction by 90%. The seperation of urine from faeces has much effect on the composting process. Firstly great quantities of water are avoided: urine has a moisture of 93 - 96% (see Gotaas 2). In this way the faeces can be composted without arrangements for drainage or ventilation. The quantities of nitrogen and potasium (as K_2O) are approximately equal in faeces and urine as excreted per person per day. The quantity of calcium (as CaO) Phosphorus (as P_2O_5) and carbon in urine are respectively only 50%, 25% and 10% of those discharged in the faeces. It is worthwhile to recover these materials as well.

Table 2
Excreta composition
(Calculated from Gotaas' figures).
Dry weight in grams per person per day

	Faeces	Urine
N	6.75 - 16.9	7.5 - 13.3
P(P_2O_5)	4.05 - 14.58	1.25- 3.5
Potassium (as K_2O)	1.35 - 10.75	1.5 - 3.15
Carbon	54.00 -148.5	5.5 - 11.9
Ca (as CaO)	5.4 - 14.5	2.25- 4.2

Urine handling

Urine is seperated from the main treatment tank to simplify the composting process. The large quantities of fluids are handled seperately, and the acidity and nitrogen content in the composting pile is reduced significantly. Consequently much smaller amounts of carbon rich material are needed to reach the C/N ratio required for composting. But what are the health aspects of it? The higher temperature which now can be reached in the composting vault promotes the pasteurisation effect of the composting process and makes it therefore more efficient. The urine itself however has to be treated as well. The original method is simply to drain the urine into a water filled jar outside the toilet building. The one to four dillution reduces the smell and the mixture is used to water the garden. In later designs a special receptable filled with lime and ashes receives all the urine. In this arrangement no flies or odours are detectable even if the receptable lacks a cover. There are few diseases which

can be transmitted through urine: bilharzia,typhoid and leptospirosis.* [15]
It can therefore be argued that the health risks related to urine are insignificant compared to those caused by faeces. The Vietnamese hold that urine, after absorbation and retention in lime or ashes, safely can be used as fertilizer. There are, however, no data vailable to substantiate this claim.
Further experiments were thus based on urine seperation and on studies of effects of carbon additives. Since the aim was to develop a toilet with composting in situ, it was necessary to know the effects of the additives both during the time the toilet was used and during the composting period. Household refuse, powdered earth, leaves and straw belonged to the examined materials. Although the results were encouraging, a shorter composting time than two months could not be achieved with these and the search for better additives continued. Powder lime, quick lime and kitchen ashes were found to given good results. These additives would increase the composting temperature, improve fly control and reduce odours of the toilet in use. The general availability of kitchen ashes to rural household was an important consideration: it would increase the acceptibility of the toilet.

Since only faeces would require a lengthy treatment process the reduction of the quantities make a great difference. Dr Nguyen Dang Duc calculates that the annual quantities of faeces per person amount to 48 Kg, whereas the figure for urine is 438 Kg. In other words only 10% of the excreta has to be composted. The treatment of the other 90% is much easier.
In comparison with the 48Kg which have to be treated per person annualy in the Vietnamese method it is interesting to note that the annual quantity of waste water per person in North America is 800 times as much: 40.000 Kg/an. The five gallon flush multiplies the treatment enormously.
The Vietnamese emphasize that adding ashes is essential for the process. Gotaas argues, while discussing aerobic composting, that great quantities of ashes should be avoided during the composting to prevent the loss of nitrogen. The Vietnamese at the other hand hold that anaerobic composting in closed containers retains many of the gasses which in an open process are lost. Ammonia for example dissolves in the water suspended in the pile and is useful as fertilizer as NH_4CL, $(NH_4)SO_4$ and $(NH_4)_3PO_4$. Ashes do absorb many of the aromatic gasses. The concentrations of NH_3 and SH_2 measured in the vault were only 0,007 mg/l respectively. After three weeks composting no traces of these gasses could be found anymore. The effect of ashes and other additives on pathogene destruction was tested in relation to Shigella, Salmonella, Vibro cholera, ascaris and many other pathogenes.

* Personal communication from Dr R. Faechem.

Table 3
Additives and pathogene destruction
Anaerobic composting

Destruction in days

Pathogenes:	1	2	3	4	5	6	7	*)Additives
E Coli	62	60	35	56	20	0.34	21	
Sh Shigae	12	10	10	9	8	0.7	7	
S Typhi Vi	24	15	12	12	12	0.4	14	
Vibri Chol	9	8	3	7	7	0.24	1	

*)Key:
1 = excreta only
2 = powdered earth
3 = Melia Azadarach
4 = Household refuse
5 = Powder lime
6 = Quick lime
7 = Kitchen ashes

The effect of the additives is noticable. Kitchen ashes show about the same values as powder lime and are everywhere in the rural areas available. Ashes also have a marked reducing effect on the occurence of flies. The temperatures in the vault during the aerobic period is a few degrees above the toilet room itself. The humidity is also slightly higher in the vault. After closing the vault hermetically the temperature rises dramatically: in five days from 30°C to 45°C peaking after twenty days at 52°C-60°C and then slowly dropping off after 45 days to the original temperature again. The method used to measure temperatures is to mount waterfilled glass tubes through the construction into the pile. During the composting period thermometers are introduced into the tubes to take the temperature of the surrounding material.

The ministry of Public Works [16] informed us about the test results concerning pathogene survival and gave some details on bacteria and parasites. Salmonella, Salmonella typhi, Para A & B, Shigella, Flexner and Sonnei were absent from the test of the compost. Special attention was given to Escherichia Coli, a very resistant pathogene.

Table 4

Survival of Escherichia Coli

Total before composting	11 110 000	un.
After one week	1 110 000	un.
After four weeks	100	un.
After 6 - 7 weeks	traces	

Of the common parasites ascaris was studied carefully because of its high resistance. The effect of the composting process on the survival of intestinal parasites is of great importance since about 70% of the population were reported in 1958 to be Lumbricoides Ascaris Carriers, 35% were carriers of Duodenalis Ankylestema. Samples from the third and fourth composting weeks showed a high occurance of Ankylestema Larvae and a 35% reduction of the eggs. The larvae do not survive the seventh and eight weeks. Of the remaining eggs 50% can no longer develop into larvae. The Vietnamese sources conclude that a total of 85% of the parasite eggs are destroyed after an eight week composting period. The destruction of parasite eggs is closely related to the type of additive used for the composting. If lime, phosphate or kitchen ashes are used 50% of the Ascaris Lumbricoides eggs - the most resistant parasites - degenerate, while all the larvae are destroyed.

Dr Nguyen Dang Duc informed us that the general application of the Vietnamese toilet must be credited with the sharp reduction in the occurance of intestinal diseases as demonstrated in the table below.

Table 5

Incidende of intestinal diseases

Bacteria and parasites causing intestinal diseases	Incidence 1958	Incidence 1978
Shigella disentry	12 - 13%	1,2 - 1,7%
Salmonella	6 - 7%	0,1 - 0,6%
Coli GEI	4,5-12%	1,2 - 1,8%
Ascaris Lumbricoides	60 - 80%	15 -35 %
Trichocephalus	40 - 45%	10 -12 %
Ankylostoma Duodenalis	20 - 25%	10 -15 %

Mineralisation of organic material can be determined in different ways and is used to indicate the stabilisation of the decayed excreta. The different methods do not give compatible results and there are no general methods to compare mineralisation of composting and water borne excreta treatments. In the last disposal method Biological Oxigen Demand (BOD) is used to indicate the remaining decay activity. In composting volatile soil tests indicate the same. In Vietnam the mineralisation of the organic material is measured by determining the protein and nitrate content. Measuring biological activity can also be done by determining CO_2 production. We were allowed to take a sample from one of the Vietnamese toilets, which one week later in Bangkok was analysed by Dr Thanh of the Asian Institute of Technology. A part of the sample was dissolved in water and then the BOD_5 was determined to be 4,364 mg/l. The rest of the sample was used in a volatile soil test and the residue content was found to be 10,5%. The Institute of Hygiene reported the following results:

Table 6
Proteins and nitrates in the compost

	Proteins gr/100 gr compost	Nitrates gr/100gr compost
before composting	1.102	0.011
After 4 hours	0.395	0.210
After 8 hours	0.020	0.446

The nitrification is reportedly most effective during the fourth week of composting and a six week composting period is recommended in view of the agricultural use as a minimum period.
The Institute of Hygiene gives the following chemical processes to describe the composting in the Vietnamese Toilet.

1. Glucose

aerobic: $C_6H_{12}O_6 = C_4H_9OH + 2CO_2 + H_2O$

anaerobic: $C_4H_9OH+H_2O = 3CH_4 + CO_2 + H_2O$ CH_4/CO_2 ratio = 1:1

total: $3CH_4 + 3CO_2 + 2H_2O$ + 8,500 $Kcal/Nm_3$

2. Protein

aerobic: $CO(NH)_2 + CH_2NH_2COOH = CO_2 + NH_3 + H_2S + H_2O$
ureum amino acid
$CO(NH_2)_2 + H_2O = CO_2 + NH_3$

anaerobic: $4CH_2NH_2COOH + 2H_2O = CO_2 + 4NH_3 + 3CH_4$ CH_4/CO_2 ratio = 3:1
+ 6,375 $Kcal/Nm_3$

3. Lipids

aerobic: $C_3H_5\ CH_3(CH_2)_{16}COOH + 3\ H_2O = C_3H_5(OH)_3 + 3CH_3(CH_2)_{16}COOH$
glycerine stearine acid

anaerobic: $44C_3H_5(OH)_3 + 2H_2O = 7\ CH_4 + CO_2$

$12CH_3(CH_2)_{16}COOH + 3\ H_2O = 52\ CH_4 + 20\ CO_2$

total : $59CH_4 + 25\ CO_2 + 5{,}970\ Kcal/Nm_3$

CH_4/CO_2 ratio = 2.36:1

The implementation of the sanitation system.

The ministry of health of Vietnam is through its Institute for Hygiene and Epidimiology responsible for the implementation of its rural sanitation system. The Institute works through its network of provincial stations and through the health centres of the ministry of health in the villages.

The sanitation programme was launched as part of a broader public health programme promoting the establishment of a protected well, a bathroom and improved latrine for each household. The programme has developed into one of the most successful public health efforts anywhere and deserves international attention. The health centres are well organised and work with carefull planning methods. The health centre always has a map of the village with each house indicated and numbered. The number corresponds with the number of the health file of the family, which contains medical records as well as the environmental health conditions of the house and plot. The construction and conditions of wells, bathrooms and toilets are carefully recorded here. A typical health centre is staffed by an assistant physician (medical assistant), a nurse, a midwife, a pharmacy assistant, two home visitors and two traditional medicine practitioners. These health workers live in the village and are responsible for the development of the village public health programme. The plans are drafted at the district level and supervised from there.
The programmes include the construction of sanitary facilities, the cultivation and processing of medical herbs for drugs, health education, family planning, preventive health care, inclusive vaccination programmes and curative out - patient services.
The district authorities train the health centre staff and provide them with information and propaganda material such as posters, demonstration models and leaflets. Much of the propaganda work is brought in the form of theatre performances. There are annual competitions between the health centres at the

provincial and national level concerning performance the implementation of the public health programme. The health centre organizes the population through its Red Cross Society which has a family health worker in each household.[17] It is a very fine developed mobilisation network which highly promotes the contact possibilities with the population. The family health workers receive regular health information and have some rudimentary health education.
They act as family nurse and are trained to enlist more qualified health workers as soon as the problem cannot safely be handled by them. The family health worker sends the family members to the centre for vaccination, constructs and maintains the well, bathroom and toilet and tends the family medical herb garden, holds the first aid box.

The Vietnamese public health system is based on a successful mobilisation of the population and on a careful definition of the roles which the various actors in the public health delivery system have to play from the national and provincial institutes to the family health worker.
The very rapid implementation of the national health programmes testifies to the effectiveness of the Vietnamese public health system and its remarkable successes can serve as an instructive example to other countries.

The construction.
The Vietnamese Toilet is in its present design and construction a low cost solution. The toilet was developed as a part of the rural health work and the whole effort was therefore geared towards bringing sanitation within reach of the poorest peasants. In the villages there is no problem to site the toilet building, as is the case in the urban and sub urban areas. The construction is therefore an independant building.
The construction material used now varies from place to place according to the local building tradition and the availability of construction material. Most common are burned brick constructions with the floors made in concrete. Plastered adobe constructions are used in some areas, whereas even plastered bamboo constructions can be found.

Many areas in Vietnam have a very high ground water table and inundations are there common. It is in such areas necessary to build the whole toilet construction well above the surrounding ground. The floor of the vaults should be at least 20 cm over ground level. The vaults measure 70 x 70 cm with a height of 60 - 70 cm. There are therefore three or four steps leading up to the toilet door. The vaults have each a 25 x 30 cm opening to extract the compost located in the back or front walls of the construction. These are closed with bricks and mortar after emptying the vault. The vaults are not ventilated, since ashes deposited on the excreta sufficiently absorb odours.

The slab over the two vaults forms the squatting plate and the floor of the toilet and has two openings with foot supports of which one has been sealed and the other has a lit. A urine drain in the slab leads to a urine tank. In many areas Health Cebtre Workshops prefabricate and distribute latrine slabs.
In summary one can give the advantages of the Vietnamese Toilet as its simplicity, its efficient pathogene destruction, the good mineralisation of organic matter, its safe use and handling, the absence of odours and polution, its low costs, the rich yield of fertilizer and its applicability in flood prone areas. The system can still be perfected, especially in its treatment of urine, but by and large all performance criteria for waste disposal systems are satisfied by it. The Vietnamese Toilet can be applied under difficult circumstances where other sanitation systems fail.

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IMPLEMENTATION ASPECT IN HUMAN WASTE MANAGEMENT THE INDONESIAN EXPERIENCE

PRESENTED AT

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ON

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FOR LOW INCOME SETTLEMENTS
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DIRECTORATE FOR URBAN DEVELOPMENT
MINISTRY OF HOME AFFAIRS OF
REPUBLIC OF INDONESIA

IMPLEMENTATION ASPECT IN
HUMAN WASTE MANAGEMENT
THE INDONESIAN EXPERIENCE

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I. INTRODUCTION

This paper is prepared in the context of an Internatio nal Seminar on Human Waste Management for low income settlement held in Bangkok, Thailand from 16 to 22 January 1983, and is adjusted to the following objec - tives of the Seminar :

- To exchange information of the ways to manage human waste in the urban areas ;
- To discuss and find a pattern and a system of human waste management both technically and administratively, and to improve community participation especially in the Asian cities.

This paper will thus provide more information on the problem of human waste management related to Kampung Improvement Programme currently underway in Indonesia.

Environmental sanitation in Indonesia has since World War II been deteriorating;human waste disposal, waste disposal and drainage.
During the Japanese occupation and the war for independence, most of the available facilities were neglected and no additional facilities were constructed. After the independence environental sanitation has not been fully taken into account for many reasons.

1). The limited funds of both the Government and the community, whereas many problems have to be solved; such as rehabilitation of damages left by the war and disorders, lack of food and clothings and unemployment.

2). Increasing urbanization due to disorders in the rural areas, the desire to continue education and to find better jobs. Those people bring with them to the cities their way of village-life, such as throwing waste at will in ditches and gutters or everywhere on empty places and defecating in ditches which very often are completely dry without any water or almost dry.

They come flocking to the city's kampungs or they set up new kampungs of their own without planning and facilities for waste disposal, garbage dump , waste water drainage and rain water channels.

3). Lack of government apparatuses both in quantity and quality. During the Japanese occupation period and during the colonial time the leading agencies were accupied or led by Japanese and Dutch officials. After the struggle for independence there had been serious gaps becouse most of the officials left the country. The consequence was that many unqualified and unskilled people come in their places. Most of those newcomers directly held the leading posts although they did not understand or did not fully understand what their tasks actually were. As to environmental sanitation, it is consequently been neglected. Additional facilities and infrastructures are very limited. The consequence is that the enviornmental health conditions becomes worse or remains unchanged. The first step to cope with this problem is to encourage the community to settle their own problems. Approaching them is thus a very important factor and is the first effort done with a well - panned strategy and simple pattern, clear and easy to understand.

To encourage people to handle waste, waste water, rain water etc. in the best possible way, it is first of all necessary to make them understand the dangers improper disposal systems can create. Then they should know the best way to throw waste. If they are not able individually or collectively - to do so, the Government should help them although they themselves have to pay part of or the entire costs that might be needed.

To make people understand the importance of a proper system of waste disposal, waste-water and rain -water outlets etc., the Government should give them the necessary extension/information and even models on this matter.

This provision of extension / information and models should be properly planned and given priorities and people should be taught how to handle the matter in the best possible way with the available funds and manpower. This is important in that the fund and personnel the Government has for this purpose is relatively too small compared with the huge work to be implemented.

For human waste disposal - if it is no more possible to use septic tank, " cubluk " and pits in the house garden - the Government should assist by constructing public facilities like MCK (Facilities for people to take bath, to wash clothes and to defecate) or urban sewerage, the Government should assist by constructing general or public sewerages from the houses to outside the environment.
Cost for such activities carried out by the Government can partly or wholly be paid by the community who are the sources of the waste and rubbish and who want to dispose waste and rain water. This can be in the form of fees collected by the Government or organized and supervised by the Government.
Starting 1967 the Government the progressivley created disposal system in various fields based on priorities. This has been successful. Food self-sufficient programme has been achieved, and Indonesia is now an exporter of ready-made dresses and clothes whereas in infrastructural development significant progress has been made, and this success has been facilitating development in the other sectors.

Fund accumulated from this successful development can now be put aside for other sectors not covered in the first and second Five Years Development Plans, including environmental sanitation through proper waste , sewerage and waste water disposal systems.

The fund has been gradually been increasing, but funds that can be made available etc still relatively too small compareb with the work to be implemented. In Addition, people lack awareness and understanding so that their participation in solving the problem of environmental sanitation is too limited. This is the reason why the problem of environmental sanitation cannot be coped with nationally so far. This should be solved in progressive stages.

This progressive handling provides the opportunity to gradually develop the needed menpower. This is important in that the shortage of skilled personnel has been seriously felt.

To achieve maximal sufficiency and effectiveness from investment made in environmental sanitation and health, it is necessary to decide priorities both among the sub sectors - waste disposal, drainage, sewerage and waste water disposal - and the other components.

The Department of Home Affairs is the agency which is directly responsible for developing and supervising all development sectors in the country including environmental development and rehabilitation. The physical implementation is carried out by the respective regional government which is directly supervised by the Department of Public Works and the non - physical components by the Technical Departments concerned.

II. THE BACKGROUND

The condition of settlement areas in general and those in the urban areas in particular does not meet people's requirements and of proper life. Environmental facilities to secure environmental health such as hospitals, health centres, water supply, sewerage and waste water disposal, roads, etc., are quite scarce. This situation has led to the creation of very thickly populated residential areas/kampungs which do not meet health requirements and socio - cultural life patterns, which in turn lead to critical urban situation.

1. To develop environmental facilities and to provide basic services for the community.
2. To encourage and develop the participation of the community by increasing the income and productivities of the kampungs.
3. To develop kampung environmental system by arranging and ordering the bothers of plots and their legal status.

There have been programmes for improvement of living conditions and residential environment in some big cities. These efforts, however, are still too restricted compared with the big problems to solve. Funds that should be made available by the Central Government, and the ablity of local personnel are too limited, and these programmes have to be implemented under this restricted condition and ability of the Municipal Governments and the Community. So these efforts can only be enjoyed by the community after a long period. The Government is quite aware of this limitation. The Government therefore will try to accelerate Kampung Improvement Programme so that the community can enjoy it. The Central Government will mobilize other sources for this purpose. Financial sources like APBS (National Budget), APBD (Regional Budget), INPRES (Presidential Instruction) Programmes and foreign aid will be used to implement this programme.

Consequently, city development and the rapid increase of population create complex problems which need to be coped with, among the problems are :

- housing
- waste disposal
- shallowing channels
- waste water and rain water draining system

- water pollution by industrial waste and sewerage disposal, which endangeres urban drink water supply system.
- electricity
- security
- lack of understanding and awareness on the part of the urban community of the importance of healthy life environment.
- the limited development ability of the low-income urban community.
- the limited ability of the Regional/local Governments to develop and build facilities due to lack of fund.

The unrestrainable urbanization has in the meantime created slums where environmental health, for example waste water and sewerage disposal system, MCK (bathing, washing and discharging) ficilities do not meet health requirements and which eventually couse environmental pollution.

In addition, the industries found in big cities pay less attention to proper waste-water disposal systems which lead to water pollution.
In the urban areas, for example, kampungs are built at will neglecting environmental health. This is attributed to the premature development of the cities concerned due to rapid urbanization.
In the rural areas, in the meantime, such a problem is due to the inability of the local people and their lack of knowledge and understanding of what a healtthy environment would mean. This is reflected in the scarcity of infrastructures and environmental facilities.

In the cities, kampung people - who generally come from the rural areas - apear to be not able to maintain and take care of their environment, besides supporting elements of urban environment differ from those of the rural areas.

This difference demands higher requirements which can only be met with better environmental health infra structures and with certain technical requirements which they can not provide.

Expansion of urban territories which does not match the flows of urbanization and rapid population growth coupled with the difficulty to promote the status of the city in line with the given standard criteria, the urban areas have rapidly become tight and pressed , the city administration becomes busier due the limited funds and apparatuses, and these all create separate difficulties.

Below is a table showing the speed of population growth in 50 municipalities in Indonesia.

Year 1980	City	Number of population in 1980.	Year 1971	Number of population in 1971.
01	Jakarta	6.503.449	01	4.579.303
02	Surabaya	2.027.913	02	1.556.255
03	Bandung	1.462.637	03	1.200.000
04	Medan	1.378.955	05	635.562
05	Semarang	1.026.671	04	646.590
06	Palembang	787.187	06	582.961
07	Ujung Pandang	709.038	07	434.766
08	Malang	511.780	08	422.428
09	Padang	480.922	14	196.339
10	Surakarta	469.888	09	414.285
11	Yogyakarta	398.727	10	341.629
12	Banjarmasin	381.286	11	281.673
13	Pontianak	304.778	12	217.555
14	Tanjung Karang	284.275	13	198.986
15	Balikpapan	280.675	22	137.340
16	Samarinda	264.718	21	137.782
17	Bogor	247.409	15	195.873
18	Jambi	230.373	19	158.559
19	Cirebon	223.776	17	178.529
20	Kediri	221.830	16	178.865
21	Menado	217.159	18	170.181
22	Ambon	208.898	31	79.636
23	Pekanbaru	186.262	20	145.030
24	Madiun	150.562	23	136.147
25	Pematang Siantar	150.376	24	129.232
26	Pekalongan	132.558	25	111.201
27	Tegal	131.728	27	105.752
28	Magelang	123.484	26	110.308
29	Sukabumi	109.994	28	96.242
30	Probolinggo	100.296	30	82.008
31	Gorontalo	97.628	29	82.320
32	Pasuruan	95.864	32	75.266
33	Tebing Tinggi	92.087	46	30.314
34	Pangkal Pinang	90.096	33	74.733
35	Pare - Pare	86.450	34	72.538
36	Salatiga	85.849	35	69.831
37	Payakumbuh	78.836	37	63.388
38	Blitar	78.503	36	67.856
39	Binjai	76.464	40	59.882
40	Banda Aceh	72.090	41	53.668
41	Bukittinggi	70.771	38	63.132
42	Mojokerto	68.849	39	60.013
43	Bengkulu	64.783	44	31.866
44	Palangka Raya	60.447	47	27.132
45	Sibolga	59.897	42	42.223
46	Tanjung Balai	41.894	43	33.604
47	Padang Pandang	34.517	45	30.711
48	Solok	31.724	48	24.771
49	Sabang	23.821	49	17.625
50	Sawah Lunto	13.561	50	12.427

III. GOVERNMENT POLICY AND PROGRAMME

The national policy for promoting environmental development or what is know as Kampung Improvement Programme, has been stated in the General Guideline of State Policy (GBHN) and in Repelita III (3rd Five Year Development Plan) which among others states :

1. The integrated and well - planned construction of people's housing, clean water facilities and the development of environmental health will be adjusted to city and regional planning, population policy, financing and crediting systems, expansion of working opportunities, technological development and other socio - economic pilicies.
2. The role of the community in the development of people's housing and environmental facilities that meets the given requirements will constantly be promoted effectively and more house will be built in a healthier environment and at prices within the reach of the common people.
3. The construction of people's housing, clean water facilitie and the development of environmental health will be stepped up progressively and given priorities to assist the low - income population.
4. Kampung improvement in urban residential areas will be further promoted and spread to small cities and towns.

Urban residential development or popularly known as Kampung Improvement has provided valuable experieces for various parties that handle planning, implementation , and evaluation and monitoring, and for the community in general who have enjoyed the outcomes of development programmes.

In this context the institutional aspects of Kampung Improvement Programme related to the following, should firstly be described :

a. preparatory and planning processes

b. the administration of development implementation and financing patterns.

c. implementation in the field

d. utilization, preservation and maintenance programmes

e. programme for further development and improvement of the community's initiatives.

f. other activities supporting the entire process of kampung improvement.

To place the problem in its real proportion it seems to be necessary to study the link and relationships between kampung improvement programme and the current system of administration.
This is important because the direct target of kampung improvement programme is the economically weak community. Thus this involves the interest of the largest part of the urban people who really want improvement to their settlements in general in a marginal situation and condition.

As a consequence of Article 18 of the Constitution of 1945, which is specified in GBHN, the Government is obliged to implement the principles of decentralization and deconcentration and to assist in running the regional administration.

a. Decentralization

The regional government is fully authorized and respon sible for the regional administrative affairs in the context of the implementation of the principles of de centratization.

In this case initiatives are fully left to the Regions, both those related to policy making, palnning, imple - mentation and financing, and all these are to be imple mented by the regional agencies and services themsel- ves.

b. Deconcentration.

Because not all administrative affairs can - according to the principles of decentralization - be delegated to the reagions, various administrative affairs in the Regions on the basis of deconcentration. Administra- tive matters or affairs delegated by the Government to the regional authority on the basis of deconcentration, remain the responsibility of the Central Government both those related to planning, implementation and fi nancing. The executing elemnts are vertical agencies co-ordinated by the Area Head in his capacity as a Cen tral Government apparatus. Policy for the implementa - tion of deconcentration however, remains fully in the hand of the Central Government.

c. Co-administration.

It has been stated earlier that not all of the adminis trative affairs can be delegated to the Regional Govern ment to become fully its own regional affairs. So,some administrative affairs remain the affairs of the Cen - tral Government. However, it is by no means an easy task for the Central Government to carry out the whole admi nistrative affairs in the regions which - basesd on the principles of deconcentration - are still its responsi bility. This is especially dua to the limited ability of the Central Government's apparatuses in the regions. Also, seen from efficiency and effectiveness, it is not justifiable and really correct if all matters or af - fairs of the Central Government are carried out by its agencies in the Regions in that this requires person - nel and huge costs. Besides, viewing the natura of the affairs, many of them are difficult to carry out pro perly without the participatoin of the Regional Govern ment concerned.

We can thus conclude that :

a. Decentratization is the execution of administration in the regions based on the following :

- planning by the regions themselves
- financing by the regions themselves
- implementation by the Regional agencies or servi ces themselves.

b. Deconcentration is the execution of administrati- on in the regions based on the following :

- planning by the Central Government
- financing by the Central Government
- implementation by the Central Government' agen- cies/services in the regions - vertical agencies.

c. Supporting task/assignment is the execution of ad ministration in the regions based on the following:

- planning by the Central Government
- financing by the Central Government
- implementation by the Regional agencies (non ver cal agencies).

Studying or reviewing the above mentioned principles of governing is important and useful in that the ins titutional aspects of the implementation of kampung improvement is very much influenced by one or more of the three principles.

As to human waste management in settlements of low-income peolpe in Indonesia, the target is the same as that of kampung Improvement Programme and its implementation in the urban areas is partly linked with the implementation of kampung Improvement Programme. Below is the development of the process of Kampung Improvement Programme in Indonesia.:

- started by the Dutch Government in the beginning of the 1930s.
- ceased due to World War II, War for Independence and internal disorders and rebellions.
- in the 1950s, the Government and the community could not start its implementation. Efforts were focused on rehabilitation after the war.
- in the 1960s the community started kampung improvement programme in several cities, although limited to some aspects only, especially footpaths.
- in the 1st Five Years Development Plan (Repelita I) the initiative of the communities in several cities were supported by the Regional Goverments.
- in Pelita II, the Central Goverment started supporting by allocating additional fund from foreign aids to accelerate Kampung Improvement Programme in Jakarta and Surabaya.
- in Pelita III the Central Government increases aids for the Regional Governments by :
  - continuting efforts to get foreign financial aids
  - allocating pioneering funds particularly for small cities and towns.

- Two kinds of standard financing of Kampung Improvement Programme have come up :

  = emergency standard for pioneering Kampung Improvement Programme (KIP) with a construction cost of 2.8 mi llion rupiahs per hectare ; pure National Budget or foregin loan by the Central Government.

  = Minimum standard of 6 million rupiahs per hectare ; 50 % allocated from the National Budget and 50 % from the Regional Budge (District and Provincial Boudget).

Programme Components.

1. Consisting of :

   - footpaths
   - area roads
   - waste water disposal
   - MCK (bathing, washing and dischaging) facilities
   - cleans water supply
   - garbage / rubbish
   - elementary schools

   The physical components have been implemented trougth the National Budget, Regional Budget and community self- help and loans from the World Bank, Asian Development Bank and bilateral co-operation (see list of activities).

2. Non-physical components :

   - improvement of health services
   - improvement of education facilities
   - social services
   - community development.

   These non-physical components have been implemented by the technical Departements concerned and seven cities have been selected :

- Surabaya
- Yogyakarta
- Ujung Pandang
- Cirebon
- Medan
- Bandung
- Semarang

in the context of co-operation with UNICEF for aids and special guidance for the implementation of the above mentioned programme components.

IV. SOME OBSERVATION ON THE RESULTS OF A CASE STUDY ON THE USE OF MCK FACILITIES AND FAMILY LATRINES.

As we all understand human waste management, particu - larly in the low-income people's settelements, is partly linked with Kampung Improvement Programme in the urban areas. Facilities for human waste disposal take the form of MCK (public latrines) and family latrines, and multiple latrine. MCK fasilities area built by the govern ment thought Kampung Improvement Programme and the com munities themselves. Family latrines are provided by the Government thought the Departement of Health and Inpres Projects (Projects based on Presidential Instruction while multiple latrines are currently at a trial stage (pilot project) in several big cities in Indonesia, thought a Programme of the Departement of Helath.

Below is a case study on the use of MCK within KIP areas, where MCK constitutes a sufficiently afficient means for further development. Viewing that the most difficult hin derance is the provision of land in thickly populated areas, this case study was implementaded in 4 small cities and towns near Jakarta : Bogor, Tangerang, Bekasi and Ci rebon.

Based on interviews and analyses the following are con cluded :

1. MCK have been used in different ways. There are people who consider MCK a very important facility,but in another location people in other location think it best just for washing clothes.

2. Apart from functioning as latrine, MCK functions more as a place for talking a bath and washing clothes , and the most important tehnical weakness is the bad system of waste water disposal.

Some people complain of the bad smell of the waste water, but other people consider the system as being improper.

3. In addition to the size of the MCK, people also complain about the place of entrance, the way septic tank is lo cated and some serious constructional errors. However, lack of understanding and attention to the correct way of using MCK has made the situation become worse and in convenient. For some other reasons people appear to be reluctant to use MCK.

As to the use of family latrine we can refer to the sta tement for the Municipal Government of Semarang, a pro - vincial capital city of about 364.81 sq.km., with a popu lation of 1,034,175 people. This city has got sufficien-tly big allocation of Kampung Improvement Programme in - cluding MCK components, both throught loan provided by the World Bank and the National as well as Regional Bud gets.
By the end of 1981 only 53.3 % of the entire population of the city used newly built latrines. The rest discharged in rivers, gutters, ditches, home garden etc.
This situation had caused environmental population and en-dangared people's health in general.
It is expected that by the end of 1990 80 % of the whole urban people will have used latrines and 25 % of the ru ral population should have used latrines that meet health requirements.

A. Hygienic conditions and home house sanitation :

1. Facing problems = 39,86 %
2. Facing no problems = 60,14 %.

B. Hygienic conditions and drinking water sanitation :

1. Bacteriological :

a. Meeting requirements + = 62,96 %
b. Does not meet requirements = 37,04 %.

2. Chemical :

a. Meeting requirements = 33,33 %
b. Does not meet requirements = 66,67 %.

C. Hygienic conditions and human waste disposal sanitation in the urban areas :

1. Having family latrines = 44,71 %
2. Does not have family latrines = 55,29 %.

Human waste disposal in the urban areas faces difficulties in acquiring land for the location of family lat rinees.

Steps Taken.

a. Education/extension on home/house sanitation and the surrounding

b. Education/extension on the provision of clean water

c. The provison of aids as modification sample of family latrine namely : Multiple latrine in the Kecamatan/ Sub district of North Semarang, South Semarang, West Sema - rang and East Semarang.

the provision of this Multiple Latrine Units is supported by project aids for Settlement Environmental Sanitation ; National Budget.

D. Supervision of water used by the community and suggestions intended to protect the community from diseases. This supervision is supported by helath Installation pro project aids ; National Budget.

V. HINDERANCES AND LIMITATION AND FUTURE FEASIBLE EFFORT.

Some hinderances and limitation encountered by the exe - cutors of the programme in the context of handling and managing projects for the Provision of MCK facilities and family latrines are among others :

1. The difficulties to ecquire land for MCK/Latrine locati ons.
2. Limited funds both from the Central and the Regional Go vernments.
3. MCK built by the Government does not meet the require - ment of the users. Among others, the design, the dis - tance etc.
4. Lack of proper communication between palnners, executors and community leadres.
5. MCK and family latrines built partly with financial as-sistance by the Government and the community have not bee fully utilized.
6. The construction of MCK and Family Latrine is not syn - chronized with the provision of clean water.
7. Most of the urban people discharge in gutters, ditches, rivers and other places.
8. Lack of understanding and awareness on the part of the community as to the improtance and advantage and con - sequences of human waste discharged or thrown at will.
9. Lack of health cadres and effort to produce skillful personnel for hygienic matters and sanitation.

Efforts that can be made in the future :

1. Innovation or modification is needed to construct la - trines massively.
2. The design of MCK , its size, door, and roof should conform to the Indonesia culture and sosial feeling .
3. The provision of MCK and latrine should be synchronized with the provision of clean water.
4. To have the community participate in selecting the de - sign and location, and throught a short training, inser ting actual facts in the construction of latrines.

5. Materials needed for the construction of latrines should be bougth at lower prices ; local materials.

6. To minimize costs, the participation of the community is imperative.

7. Overall observation of the local situation or the location where MCK is to be constructed.

8. The number of MCKs and latrines to be constructed should be relatively mactching the existing problems.

9. The design and construction of MCK should be as exact as possible and should not necessarily be uniform. This depends on the condition and the geograpic location.

10. In the future family latrines should be given first priority while multiple latrines and MCK respectively second and third.

VI. CONCLUSION

The low standard of living of those people living in slums and the fact that they still apply their rural habits of throwing waste at will in gutters, ditches etc., may lead to the outbreak of various diseases and create stagnant water and pools which may also be the sources of diseases like malaria and skin diseases.
In addition, slums are generally thickly populated and the layout of houses is not well - arranged. This conditions facilitates the transmission of communicable diseases.

In the effort to improve environmental quality, the Government has implemented various programmes, such as people's housing, water supply, environmental sanitation and kampung improvement.
The construction of houses both by the Government through its National Housing Programme and by Private Developers supported by the State Savings Bank includes the promotion of environmental sanitation. The rehabilitation of rural houses is in principle aimed at the same objectives. In the meantime, Kampung Improvement Programme in the Urban areas covering slums and poor settlements is intended to create healthy environment through repairing, rehabilitating and restoring road infrastructure, drainage, sewerage disposal, water supply and managing human waste disposal.
Viewing the limited ability of the Government to implement the above mentioned programmes, whereas the problems to be coped with are quite critical, the role and participation of the entire community need to be stepped up further.
Meanwhile, the Government in a larger scope has already started programmes to preserve life environment so that the next generations can inherit a better condition of ecosystem that may support their living.

These programmes require proper co-ordination and integration both at Central and Regional levels, starting from human environment to human settlement and housing.

The problem of human waste management in the urban areas, particularly in slums and poor settlements has been tackled by the Government through programmes financed by the National as well as the Regional Budgets, community self-help, foreign loan and aids provided by international agencies like UNICEF, UNEP, etc.

Technically we can thus make this conclusion :

1. To suggest that family latrine programme being the component of Kampung Improvement Programme be continued and that family latrines to be constructed should conform to the local culture, condition and aspiration.
   The fact that requests for family latrines have been increasing rapidly, and more people become aware of the difference between MCK and family latrine is indeed welcome and even wanted.
   For this reason continuing the construction of family latrines (semi-provate) is strongly recommended.

2. We should also draw a conclusion that the local situation and particularly the need for sanitation facilities differ from one kampung to the other.
   Apart from the specific need for latrines, the other functions of MCK are also required. The rapid population growth doubles the need for these facilities, and because of the differences among the kampungs as stated above, we should be careful in making general conclusions.

3. The approaches applied so far in programming and planning family latrines in the kampungs have been seccessful. Particularly the early involvement of the people, has supported this successful MCK programme.

We suggest that this direct active involvement of the local community be stepped up even further especially before the construction of MCKs.

Detailed information on the shape and number of MCKs that can be constructed should be made available before a plan is finished.

Due to misunderstanding on the idea of septic tanks and filters, not all MCKs have been optimally used. For this reason it seems to be necessary to inform the local people on the use and operation of septic tanks.

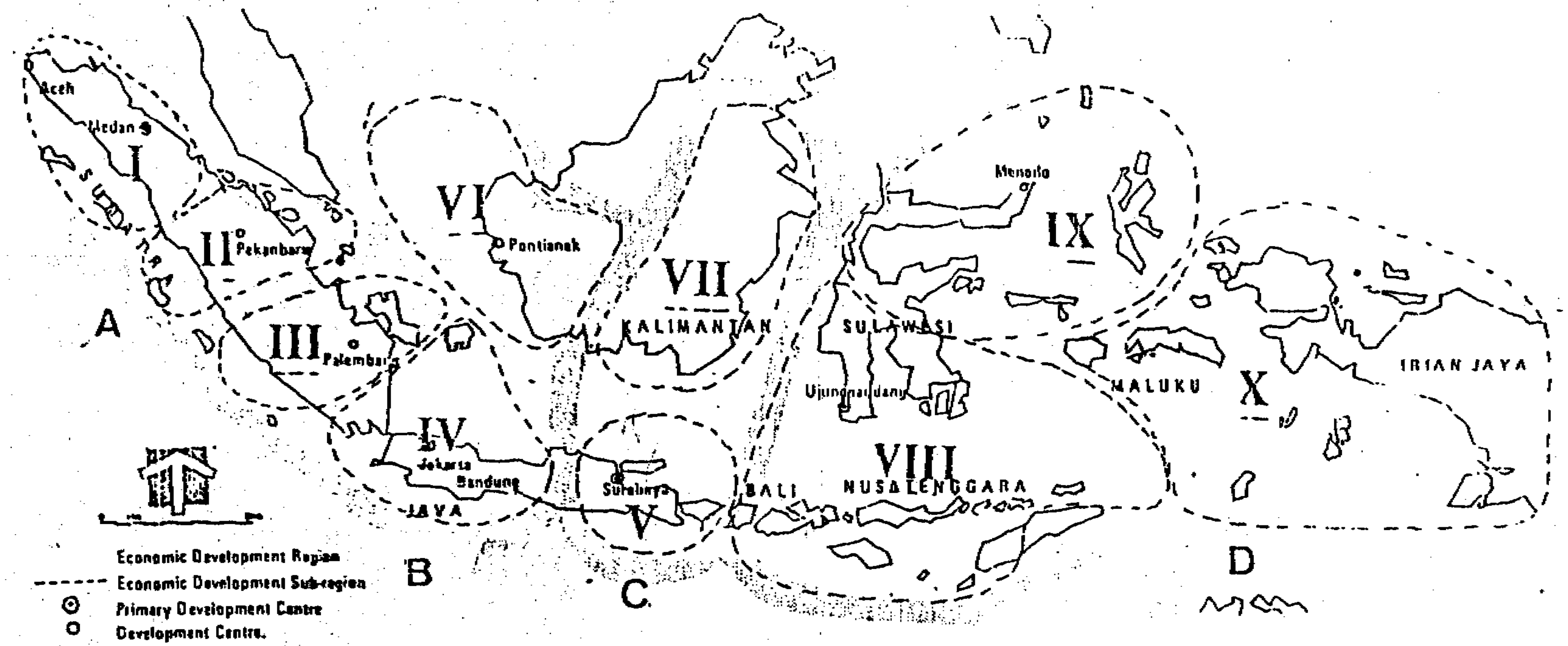
In addition, the local people (top to bottom) should be invited and encouraged to participate actively (bottom to top), particularly in selecting the lokations for MCKs. This active participation can avoid difficulties in acquiring locations for MCKs.

4. Based on some technical considerations, we should be able to distinguish between designed MCK and constructed MCK. In the opinion of the local people the waste water disposal system is not satisfactory. This is based on facts ; incomplete septic tank, misunder - standing on the difference between septic tank and soakaway or pit privy.

Fearful of possible pollution by such a septic tank of their pump wells has been the main reason for the people not to fully use MCK. MCK is considered too small. MCKs constructed a bit bigger than their original designs, are used more intensively, so we can draw a conclusion that MCKs designed so far are too small, at least for thinckly populated kampungs.

VII. ENCLOSURES

MAP [illegible] ECONOMIC DEVELOPMENT REGIONS OF INDONESIA



ECONOMIC DEVELOPMENT REGION A
Primary Centre : Medan

Economic Development Sub-region / Province

Sub-region		Province
I	:	Aceh
		North Sumatra
II	:	West Sumatra
		Riau

ECONOMIC DEVELOPMENT REGION B
Primary Centre : Jakarta

Economic Development Sub-region / Province

Sub-region		Province
III	:	Jambi
		South Sumatra
		Bengkulu
IV	:	Lampung
		P. Belitung
		DKI Jakarta
		West Java
		Central Java
		D.I. Yogyakarta
VI	:	West Kalimantan
		Kap. Natuna.

ECONOMIC DEVELOPMENT REGION C
Primary Centre : Surabaya

Economic Development Sub-region / Province

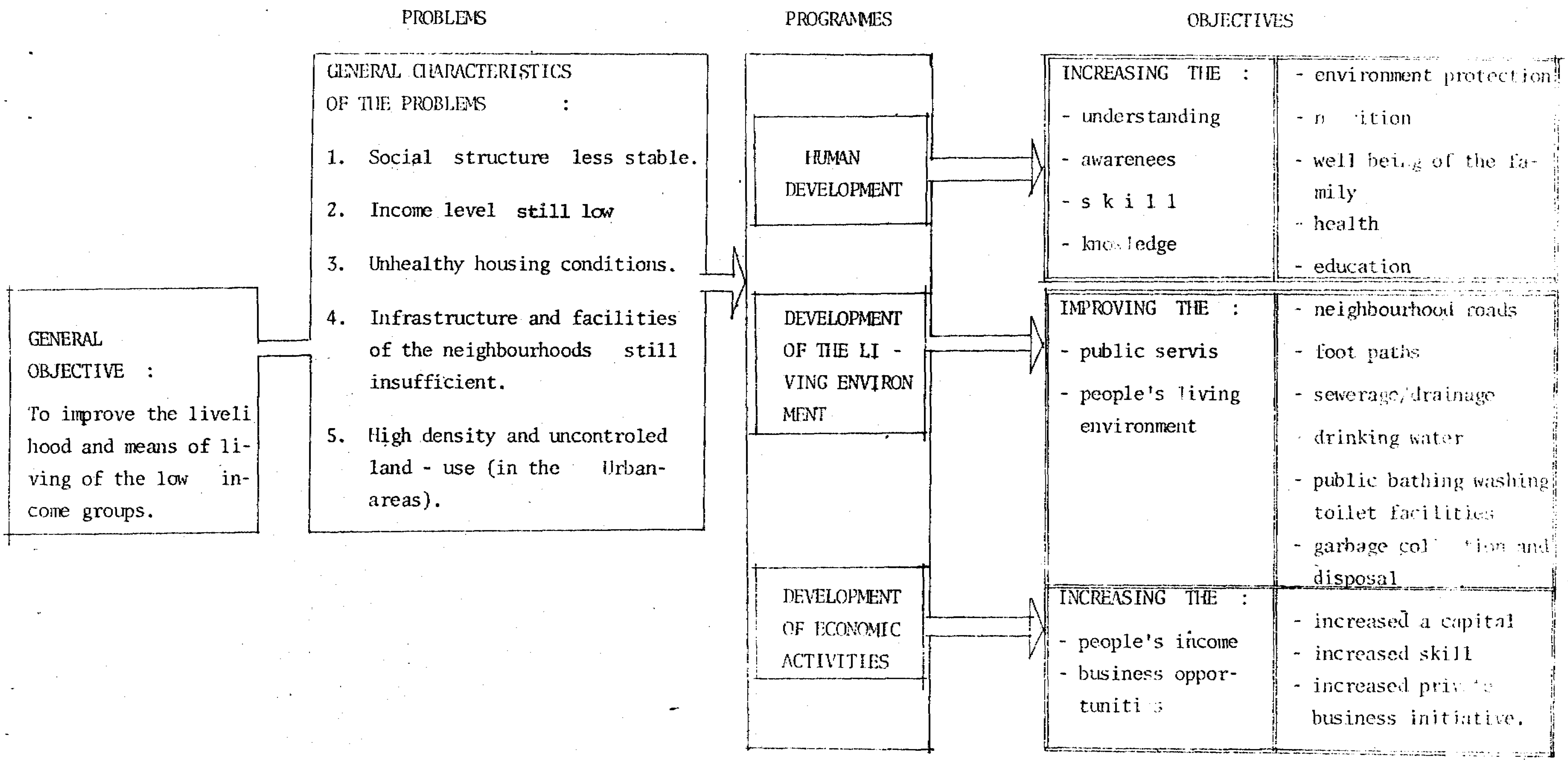
Sub-region		Province
V	:	East Java
		Bali
VII	:	East Kalimantan
		South Kalimantan
		Central Kalimantan

ECONOMIC DEVELOPMENT REGION D
Primary Centre : Ujungpandang.

Economic Development Sub-region / Province

Sub-region		Province
VIII	:	West Nusatenggara
		East Nusatenggara
		South Sulawesi
IX	:	South East Sulawesi
IX	:	Central Sulawesi
		North Sulawesi
		North Maluku
X	:	South Maluku
		Irian Jaya.

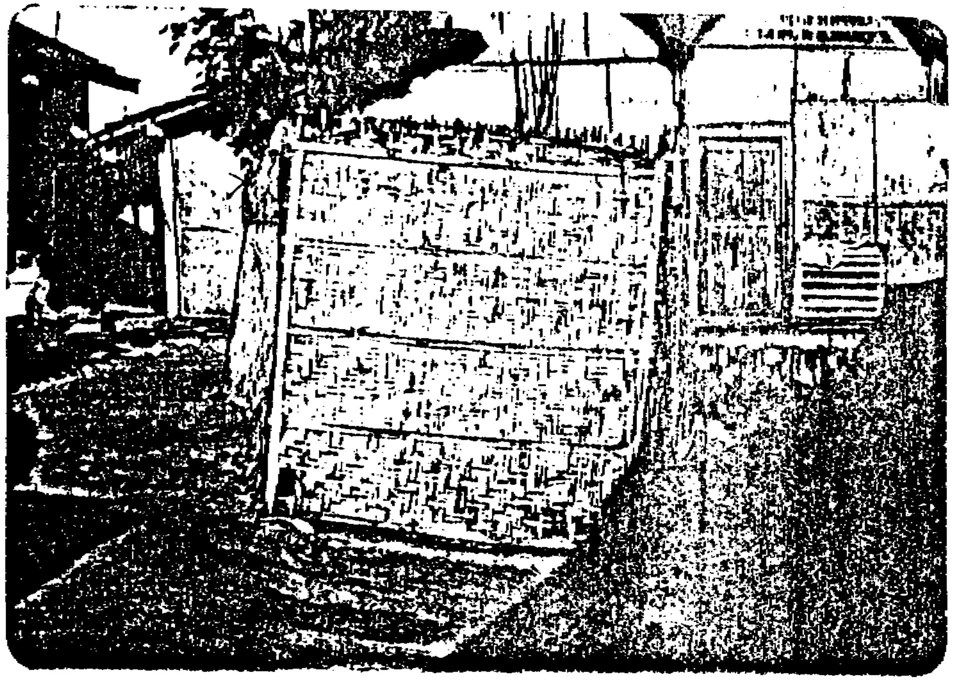
INTEGRATED KAMPONG IMPROVEMENT PROGRAMMES



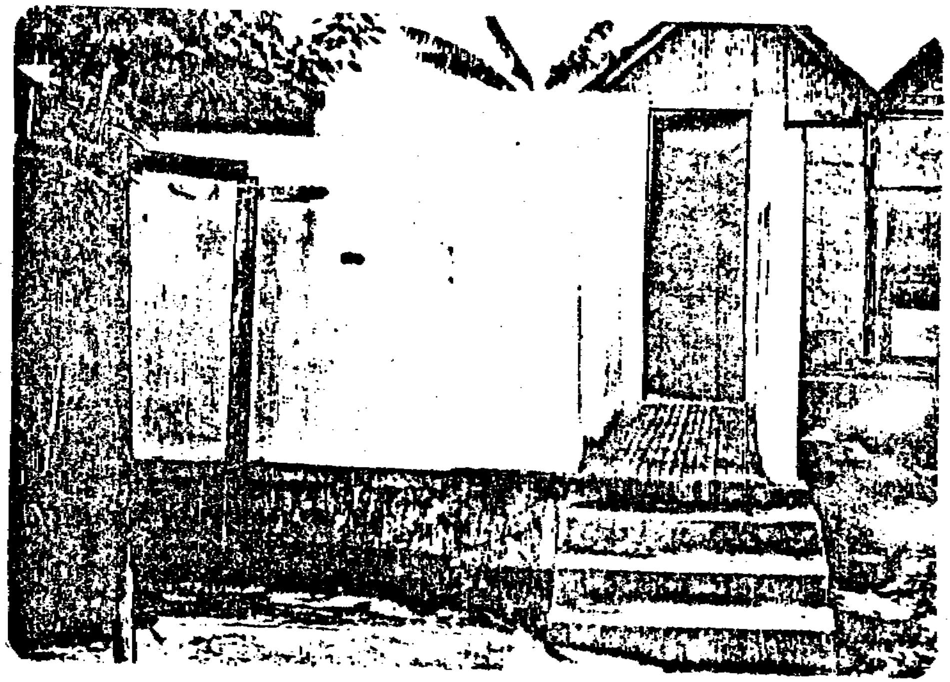
SUMMARY OF KAMPUNG IMPROVEMENT PROGRAM COMPONENTS

SURABAYA

Fiscal Year	Total Kampung	Area	Total population	Cost	Vehicular roads	Foot paths	drains	Culverts	Vehicular bridges	Foot bridges	Health Centre	Primary Schools	Health Post.	Toilet, Washing Blocks.	Water Supply/ Taps.
		(Ha)	persons	(Rp.1000)	(M').	(M').	(M').	(M')	No.	No.	No.	No.	No.	Units	(M'/Tops)
1976 / 1977	3	67	37.723	435.485	3.258	2.055	3.277	221	-	1	1	3	2	26	7274/ 60
1977 / 1978	6	125	94.851	711.943	5.431	12.935	5.553	263	6	2	2	4	-	39	14109/ 63
1978 / 1979	9	249	136.450	1.934.804	16.344	30.330	12.809	1.622	15	17	2	3	-	66	42801/172
1979 / 1980	10	185	76.900	1.837.541	6.337	24.558	4.079	1.083	7	14	-	1	-	30	26975/166
1980 / 1981	8	192	60.070	1.837.541	6.767,50	27.124	7.743	1.514	6	13	2	1	-	17	26172/135
1981 / 1982	9	1235,5	85.756	1.934.999	11.470,50	28.165,50	8.324	1.682	12	10	1	-	-	18	30625/133
Total :	45	11053,5	491.744	18.692.313	49.608	125.167,50	41.785	6.385	46	57	8	12	2	196	147956/729



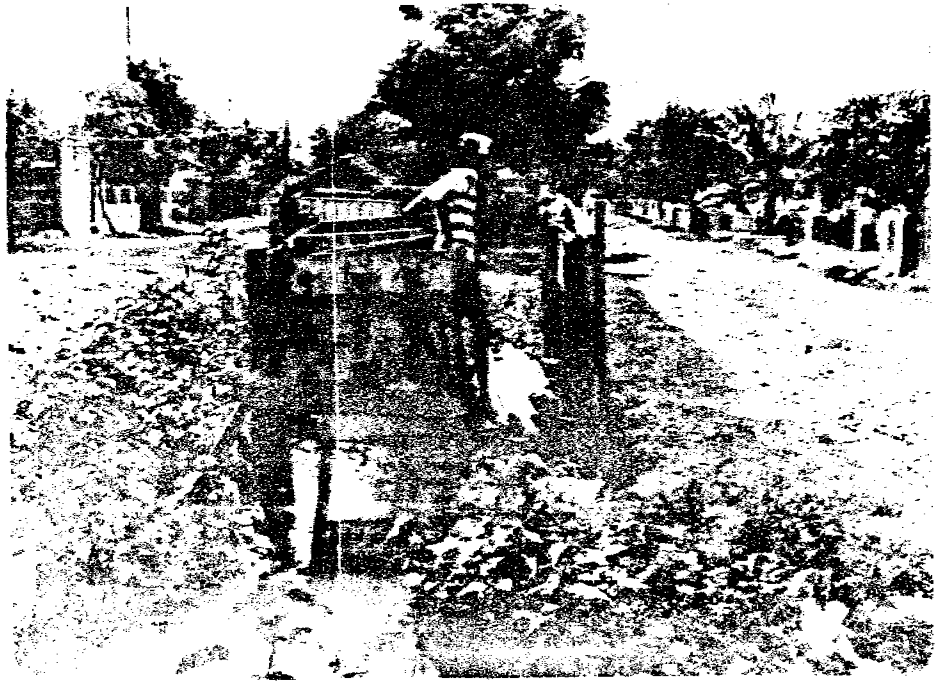
BEFORE THE IMPROVEMENT



AFTER THE IMPROVEMENT

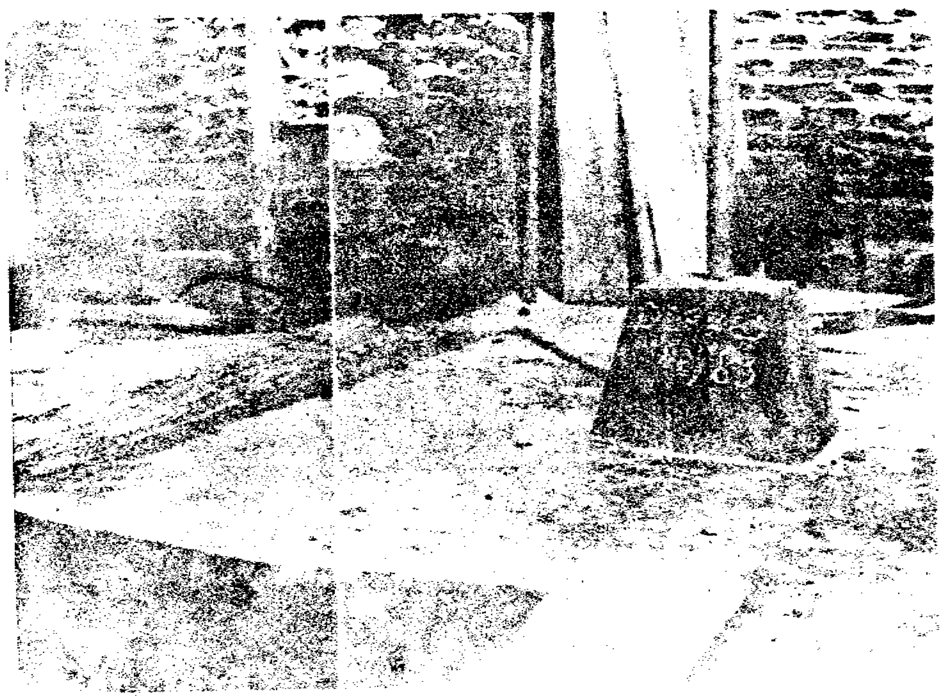
BEFORE THE IMPROVEMENT

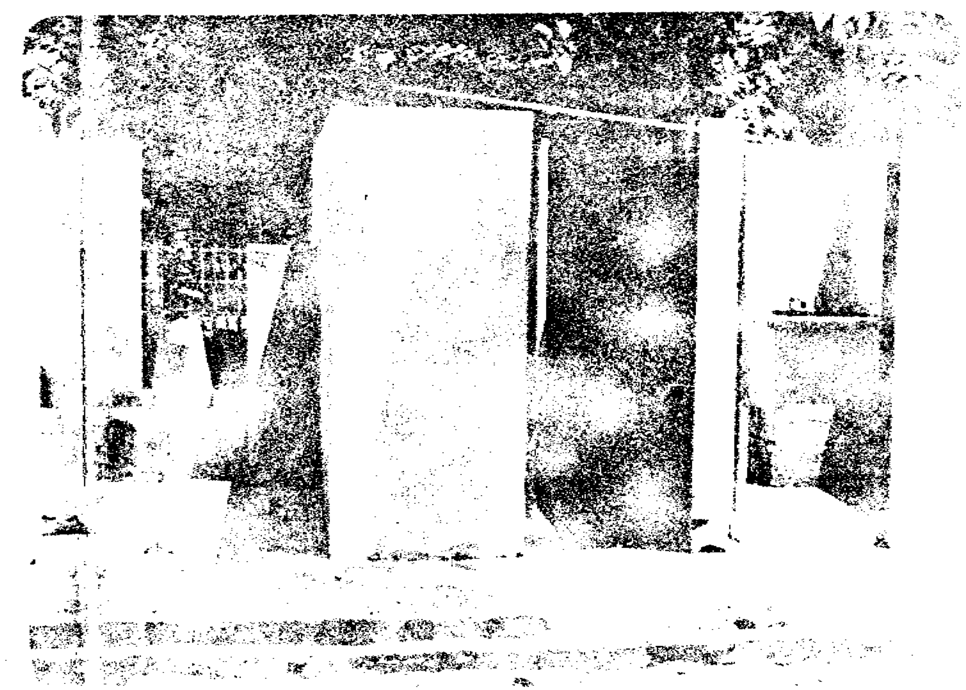
AFTER THE IMPROVEMENT



TOILETS ON THE RIVER

[illegible] ON HYGIENE & SANITATION





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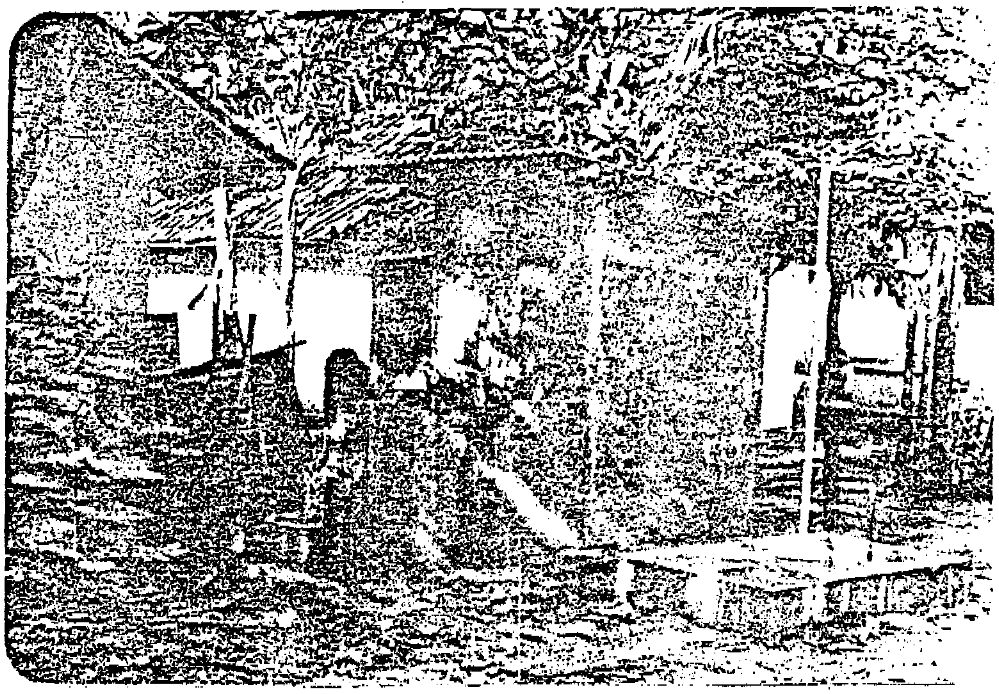

Illustration 1. At MCK's only a few people bath inside. The users have altered the wash ing areas, which are now used for bathing and washing. They do not use water from the pump for drinking since it is too close to the septic tank.

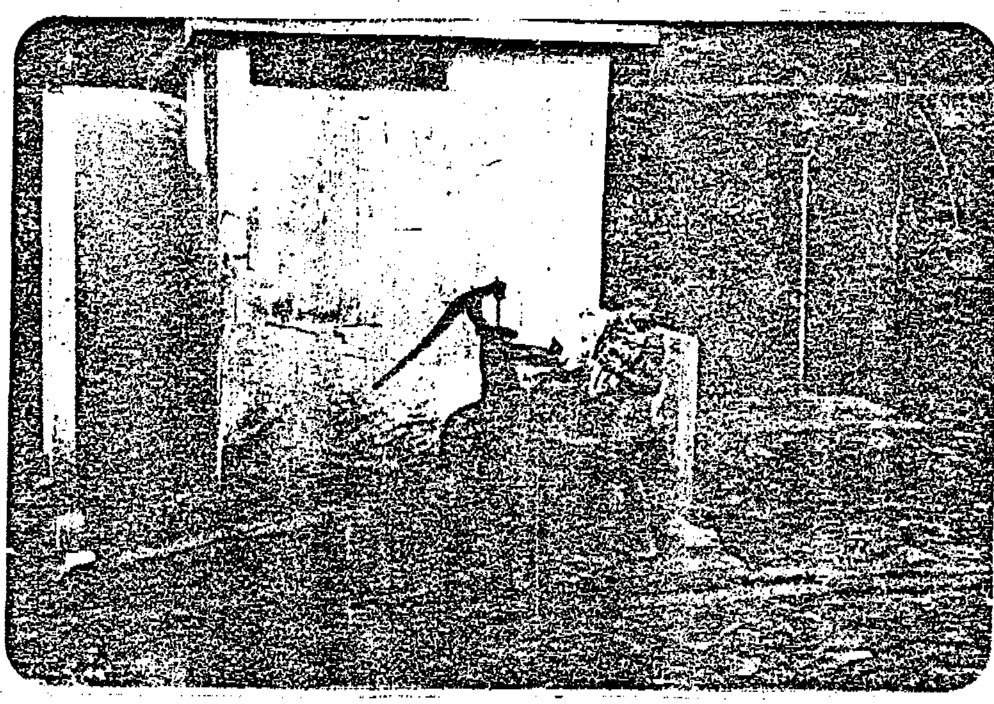

Illustration 2. Usually children bath in the washing area. Several users complained that iron pipe was used at this MCK (location 6) instead of P.V.C.

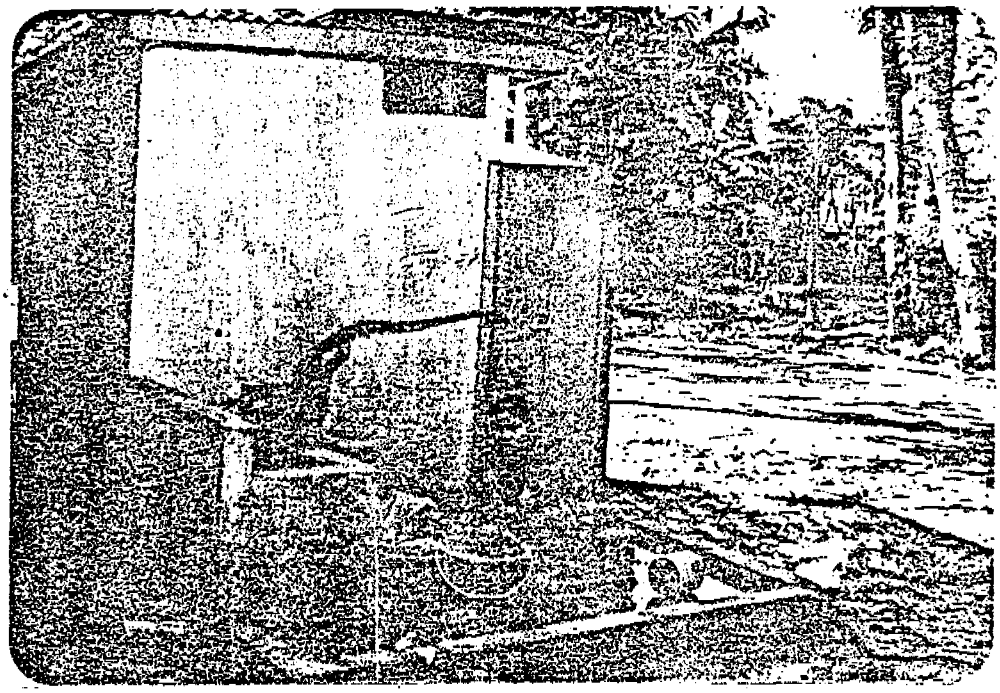

Illustration 3. Many respondents wished for a door. For the MCK at Pulo Kecil, Bekasi (near Jakarta), the users provided the door themselves with the under - standing that the facility would not be used by too many people. You can see how the users overcame the problem of the pump being placed too low to permit placing a bucket under the spout.

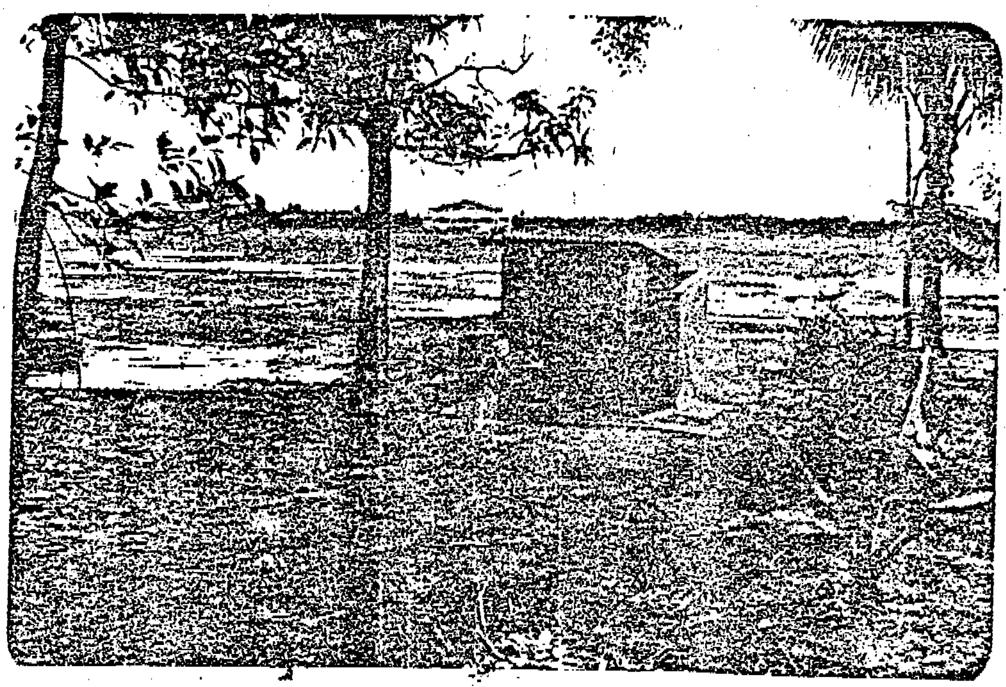

Illustration 4. Many children can be see using the MCK and playing in the washing basin. In the background can be seen swamp and rice land which once covered the entire area of Kampung Poncol, Bekasi.