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Sewage Disposal in Developing Countries

A SURVEY OF METHODS

Dr. Krisno Nimpuno

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INTRODUCTION

This report addresses itself to the problem of excreta disposal in the Less Developed Countries (LDC's) and discusses criteria specially relevant to these countries.

Prominent among the motives behind our effort is our doubt about the justification of the use of water in sewage disposal. It is not only because of the wastefulness of using a precious commodity for transport, but also because of the insufficient environmental effect of these systems. The particular danger of pathogene accumulation in soil and potable water has not been considered adequately in physical planning in the LDC's. The combination of a superficial treatment of sewage and irregular pressure level in the water supply system as exists in most cities in the LDC's lead inevitably to a regular and dangerous combination. We believe that the high mortality in the cities of the LDC's partly can be explained by the penetration of contaminated effluent into the water supply system.

It is our hope that this report will contribute to a renewed debate on urban infrastructures and that alternative systems will be accepted which will not only be safer but also more economical than the systems developed in the rich world.

Dr. Krisno Nimpuno

EXCRETA DISPOSAL IN LESS DEVELOPED COUNTRIES

INTRODUCTION

The rapid demographic changes which we can witness all over the world today have great consequences for physical planning. Urbanisation in the Less Developed Countries (LDC)has developed suddenly and explosively with annual urban growth of 7-10%. For the poor countries it has proved to be extremely difficult to plan the urban development and provide the growing cities with elementary infrastructural services. As a result large unplanned residential areas have sprung up, often without road network, water and drainage system. The absence of a proper waste disposal system is no doubt a very serious threat for the future of these areas and it has proved to be extremely difficult to amend the deficiencies afterwards.

The existing waste disposal systems have been developed in and for the industrialized countries and aim at achieving a good environmental and physiological hygiene standard by two main steps:

(a) a reduction of organical matter or BOD (biochemical oxygen demand) in order to limit water pollution and to avoid insect breeding.
(b) a reduction and control of pathogenes.

In LDC it is above all this last factor which is of importance to public health. A major cause for the high child mortality, which is over a hundred times higher in the LDC cities than in the cities of the industrialized countries, is infection carried by excreta. Excreta disposal is, therefore, a matter of great priority. But there are many obstacles to the general application of modern sewage treatment techniques in the LDC, especially because of its costs. Even in its most primitive form - aqua privy or septic tank - it is not in proportion to the investment potential. In Tanzania such a system costs at least \$300/per household, thereas a family has in average only \$900 at its disposal to spend on housing. (1)

But it is not only for economic reasons that these methods do not offer a solution. It is almost inconceivable to dig a complete system of drainage pipes into an existing, unplanned residential area. And this is the case in many places. Another major factor is the scarcity of water which will hamper the development of an urban waterborne excreta disposal system. And apart from the feasibility of a general application of a waterborne system one should remember the very limited purification effects of the existing

(1) Building Research Unit, Dar Es Salaam, 1973

sewage systems. A spetic tank can reduce the BOD concentrations but its effluent is still very pathogenic and virulent and is then just infiltrated into the ground, The system leads, therefore, to a rapid pollution of the ground water which in many cases is used for human consumption as well.

Waterborne sewage systems are, therefore, a luxurious solution which for the LDC is risky, uneconomical and unattainable. By using a watercloset the user converts 1.5 litres of pathogenic matter into 40-50 litres equally pathogenic sewage water which the exising sewage systems do not sterilize effectively. Within 48 hours the flushing water has the same bacteriological concentrations as the original excreta deposition. It is against this background that will be attempted to identify solutions for LDC aiming at a reduction of infection risk from faeces and treatment of BOD material without using water as a transporter. The system should be applicable in existing residential areas at acceptable costs, simple to operate and to construct.

CRITERIA FOR EXCRETA DISPOSAL IN LDC'S

The provision of excreta disposal is listed by the WHO among the first steps to be taken towards assuring a safe environment and a good public health.(2) "There is a direct as well as an indirect relationship between the disposal of excreta and the state of health of the polution".(3) The direct hazard related to the spreading of excreta transmitted diseases including cholera, typhoid, bilharziasis, diarrhoea, enteritis and hookworm. The indirect threat is caused by the decomposition of excreta into simple, stable molecules. The decomposition constitutes an active chemical environment, which can be conductive for the multiplication of bacteria, parasites and insects and can extract large quantities of oxygen from recipient water. The decomposition time of the organic matter can vary from a few days to one year depending on the conditions.

There are two general criteria for any excreta disposal system:

1. Destruction of pathogenes.
2. Safe decomposition of organic matter.

But these two criteria should be elaborated and different authors have attempted to formulate specific criteria in a comprehensive way.

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(2) WHO Expert Committee on Environmental Sanitation of 1954.

(3) Wagner & Lanoix WHO monograph No. 39.

The Swedish Road and Water Board published a booklet in 1962: "Sma avloppsanlaggningar", which mentioned the criteria:

- Excreta should not contaminate the environment.

- Excreta should not be deposited in water because of its pathogenity and because of the oxygen depletion and increased plant growth it promotes.

In a Danish discussion paper of 1972 some criteria are mentioned in relation to urban areas in Africa, among other. (4)

Ecological criteria:
The system must not upset the ecological balance of the environment.

Health criteria:
The wastes must be collected, stored, transported and treated in such a way that pathogenes cannot be spread.

Operational criteria:
The system must not for its day to day functioning require any skills not normally found among the users.

In the literature it is generally agreed that excreta disposals should satisfy the seven requirements formulated by Ehlers and Steel which were adapted by the WHO (monograph 39) study of Wagner & Lanoix.

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 adaption."

We find these criteria simple and concise. It could be added that the type of construction and not only the costs of it determines the long term success of a system because maintenance is a common bottleneck in Africa.

For application in urban areas some of these criteria should be applied with great care because a great population density increases the pollution effect. In the towns of the Third World there is above all a need for an excreta disposal system which can be applied in existing areas. The extreme high infrastructural costs of the western urban sewage systems is prohibitive for poor countries. The massive piping network cannot be superimposed in existing high density areas, especially if it concerns unplanned communities.

SPECIAL CONSIDERATIONS FOR LDC'S

In Less Developed Countries some special requirements are needed over and above general criteria of the WHO. The general population has here often still a low 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 great investments in sewage disposal systems are impossible here and 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 LDC's.

OPERATION

The daily operation should require minimal educational and technical instructions and should be limited to the development of an instruction 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. In Europe it takes at approximately 10% of the total housing investment to build the sewage system.

To exceed this percentage in LDC's could place an unacceptable burden on the people and there are some indications that a substantial excess of this limit leads to omission of sewage facilities altogether by the individual houseowner. Such systems become, therefore, self-defeating.

> The construction costs hould not exceed 10% of the total house investment.

CONSTRUCTION

It is equally important that the maintenance requirements are low and that the construction will need mainly local materials and can be executed by semiskilled 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 dillute and transport
> the excreta should, if possible, be avoided.

URBAN ADAPTABILITY

Sewage systems are not only needed in future residential areas, but as the great majority of the urban dwellers in the LDC's do not have direct access to satisfactory excreta disposal systems it is at least as important to require that disposal systems are developed which can solve such urban sanitation problems.

> Application should also be possible
> in existing high density areas.

CRITERIA FOR EXCRETA DISPOSAL SYSTEMS IN LDC'S

The five special criteria for LDC's should replace WHO criteria No. 1 which just states that a simple and inexpensive construction is needed.When the list then is put together the criteria for LDC's is 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 dillute and transport excreta should, if possible, be avoided.
11. Application in existing high density areas should be possible.

It should be noted that the first seven requirements are applicable in all LDC's. In some special cases the cost requirements can be omitted. In view of the existence of waterborne sewage systems in some places it might be justified to adapt to the situation and the water requirements can then be omitted. Finally, in rural situations as well for new urban residential developments the adaptability requirement be dropped.

Summing up, the composting process appears to be the most promising system for LDC's especially since the climatological factors are very conductive to the process in the tropics, and because the system can be installed in individual, existing buildings. Lime treatment can also offer attractive solutions in LDC's and water saving flushers are in all cases recommendable. In some cases water is required by local regulations - Nairobi by-laws prescribe waterborne systems. The Gobar or methane process presents itself as a very attractive solution for those places where water is available for sewage purposes. The methane gas is very valuable and can be used to replace oil as the main form of energy. A further development and application of non-water borne systems seem to be the right policy for LDC's even if many practical and psychological implementation problems remain to be solved.

EXCRETA TREATMENT PROCESSES

As we have seen before there are two different processes involved in sewage treatment:

- a reduction of organic matter (BOD Reduction)
- pathogene destruction (sterilization)

In most waterborne systems sterilization is limited and the treatment mainly concerns BOD reduction. The treated water or effluent is relatively free from organic matter but still contains virulent disease carriers. Sterilization is sometimes achieved by chlorination of the effluent but it is quite common that the effluent without treatment leaves the plant. Waterborne excreta can be treated in a variety of ways but the most important process is microbiological action. There are two main types of biological decomposition: firstly, the aerobic, where the bacteria use oxygen to break down the large, organic molecules. The process can be swift but is only effective if sufficient oxygen is available in the water. Secondly, the anaerobic decomposition, where micro-organisms break down the organic matter into gas and stable, simple molecules which can be separated as floating flocks or as sediment. The anaerobic process produces very disagreeable odours and if it occurs under uncontrolled circumstances it causes serious environmental problems. In this process carbon, the main component, is finally reduced in the form of CH_4.

The aerobic process does not have this disadvantage and it is therefore the more common treatment. There are a great many methods to stimulate the aerobic decomposition - usually based on the intensive exposure of the sewage to oxygen and the carbon will here be bound in the form of CO_2. A classification of processes is given in the box below.

CLASSIFICATION OF PROCESSES

EXCRETA TREATMENTS

- 1 Dry and semi-dry processes
  - 11 Incineration
  - 12 Composting
    - 121 Non-pasteurization
    - 122 Pasteurization
      - 1221 With process heat
      - 1222 With added heat
- 2 Wet processes
  - 21 BOD-reduction
    - 211 Sedimentation
    - 212 Aerobic
    - 213 Anaerobic
    - 214 Precipitation
      - 2141 Floculation
      - 2142 Coagulation
  - 22 Chemical sterilization
  - 23 Filtration
  - 24 Infiltration
  - 25 Pasteurization

For alternative classification systems see:

Wagner and Lavoix - WHO monograph 39
Nimpuno and Regnell - Excreta Disposal Systems in the Less Developed Countries
Rybczynski and Ortega - Stop the Five Gallon Flush

CLASSIFICATION OF WASTE DISPOSAL SYSTEMS

- INFILTRATION
  Pit latrine
  Bore hole latrine
  Overhang latrine
  Cesspool

- SLUDGE SEPARATION
  Methane toilet
  Aqua privy
  Septic tank
  Oxidation pond
  Sewage plant

- DIRECT REMOVAL
  Bucket toilet
  Chemical toilet
  Freeze toilet
  Packing toilet
  Recirculating chemical toilet

- MECHANICAL REMOVAL
  Vacuum truck
  Chemical privy
  Waterborne network
  Vacuum network

- DESTRUCTION
  Incinerating toilet

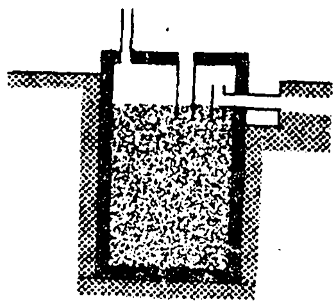
- DECOMPOSITION
  Composting toilet
  Mouldering toilet
  Algae digester

EXISTING METHODS IN LESS DEVELOPED COUNTRIES (LDC'S)

In the cities of the LDC's one can usually notice that those who can afford it will acquire water closets. It is obviously a privileged minority because so few have piped water connections inside the house - e.g. in Dar es Salaam, only 18.7% of all households. A central sewage system is very rare - in East Africa the usual sewerage treatment installation is a separate septic tank for each building. In very large institutions, such as schools or hospitals the construction of oxidation ponds has occurred lately. In some other countries e.g. Zaire and Botswana - the aqua privy has become the common solution. These solutions produce a still pathogenic and virulent effluent, which can constitute serious infection risks. The effluent from all these treatment installations is infiltrated or led into nearby streams. Ground water pollution from the effluent from septic tanks, aqua privies and oxidation ponds is one of the serious disadvantages of the waterborne system. Penetration of groundwater into the water system is very common in LDC due to the irregular water pressure in the over burdened urban water supply systems. In Dar es Salaam, among others, almost weekly such pollution can be noticed.

AQUA PRIVY

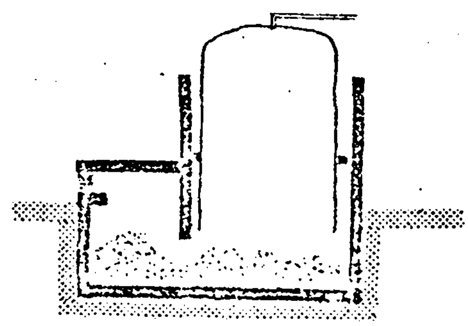
little water needed - anaerobic decomposition; sludge and effluent; still dangerous



Only a few installations receive indeed the minimum of maintenance required for an effective operation of the plant. Many oxidation ponds and septic tanks get completely clogged with sludge without anybody feeling the need for emptying the installation. And in the cases that the sludge is pumped out, it can quite generally be seen that it is dumped at any convenient place nearby.

METHANE TOILET

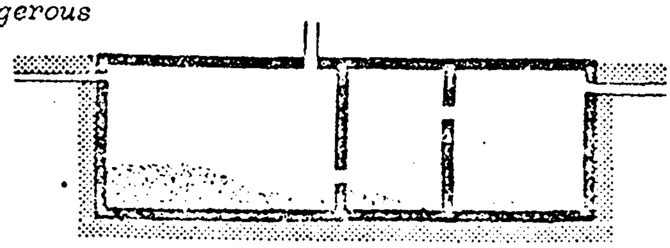
little water needed - anaerobic decomposition; sludge and effluent still dangerous; valuable gas production



The production of methane gas through an anaerobic decomposition is the method which recently has been sponsored by the Indian government. The Gobar gas method, as it also is called, which absorbs animal excreta as well, uses the same process as the aqua privy with similar sludge and effluent as final products. The sludge and effluent are still virulent and require additional treatment. In most cases, however, no such treatment takes place.

SEPTIC TANK

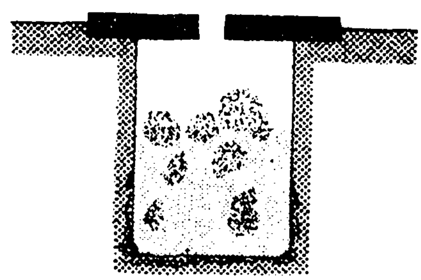
much water needed - anaerobic decomposition; sludge and effluent; still dangerous



In WHO monograph no. 60 Gloyna describes the survival possibilities of pathogenes in the effluent of oxidation ponds and stresses the risks involved in waterborne systems: *The removal of BOD without regard to the destruction of disease causing agents is inadequate. At least now it is very recognized that pathogenic matter must be destroyed.* He also points out that insect breeding easily occurs in sewage systems and recommends regular insecticide spraying. This requires, however, careful maintenance operations which can be difficult to ensure in LDC. Waterborne systems destroy great quantities of water which in some dry countries has a great economic effect. Water transport is expensive, often over 60% of the local installation costs, whereas the pipelines sometimes would require considerable demolition work in existing areas.

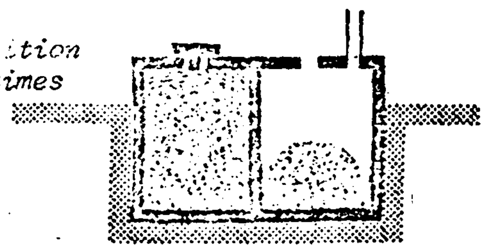
PIT LATRINE

slow but effective decomposition; bad odours and not insect proof; no water used, but pit contaminates ground water.



It is therefore easy to see that the expensive waterborne installations constructed in the cities do not produce the desired effect. For the majority of the town dwellers the absence of water connections do not allow for any waterborne sewage system. The usual solution is then the pit latrine. This is also generally the case in the country. Although it is a very primitive construction it has environmental and hygienic advantages. The infection is limited because all excreta are without any dilution concentrated in one place, where, by microbiological action, it will achieve complete decomposition and after a long interval even reach elimination of the pathogenes. Disadvantages are possible pollution of the ground water, risk for insect breeding and smell. Pit latrines often reach the gound water level and the anaerobic decomposition produces evil smelling gases.

VIETNAMESE DOUBLE SEPTIC TANK - effective decomposition through composting; sometimes anaerobic conditions and smells



The risk of total clogging of the pit walls and as a result standing acid water in the pit is common in laterite soils. To counteract the clogging effect, the reduction of the pit diameter to 15-60 cm has successfully been applied. This variant is known as the <u>borehole latrine</u>. Composting of household wastes and human excreta has been common in some Asian countries. The names <u>double vault latrine</u>, <u>composting latrine</u> are used. North Vietnam has applied a variant: the <u>double septic tank</u> as the solution for the rural areas. The composting method decomposes the organic material together with cellulosa fibres under a sharp increase of temperature which virtually eliminates helminth, virus and bacteria by pasteurization. The final compost is a safe and agricultural fertilizer.

NEW METHODS FROM INDUSTRIALIZED COUNTRIES

Great developments have taken place in sewage treatment techniques in industrialized countries during recent years. The concern for the human environment has led to the wish to reduce BOD and phosphorus emissions more effectively. The new technical equipment has increased the capital investment explosively with centrifuges, pumps, filters and biological decomposition towers. The interesting point is that the bulk of these investments do not aim at excreta destruction, but at the purification of the transport water. At the same time, no equal development in the field sludge reduction can be detected. Almost universal argument is reached that the existing sludge treatment methods are unsatisfactory. In this respect, with the above in mind, it becomes clear that billions could be saved if excreta treatment could take place without preceeding water dilution. It can therefore be proposed that much can be gained by avoiding waterborne systems. That also means that the modern sewage systems do offer very little which readily can be applied in underdeveloped areas.

As part of the general effort to reduce pollution and economize with the natural resources, new interest has awakened in the industrialized countries for alternative excreta disposal systems. Many of these do not seem to be very suitable for remote areas because of the complicated and expensive technological processes involved, but a few of these might offer attractive alternatives.

There is one recent development which has yielded highly interesting solutions for remote areas, e.g. the excreta disposal solutions for recreational activities. Here we are confronted with some characteristics which are similar to certain conditions in remote areas: small rural units, absence of electricity, low density, etc. The new developments include the following types:

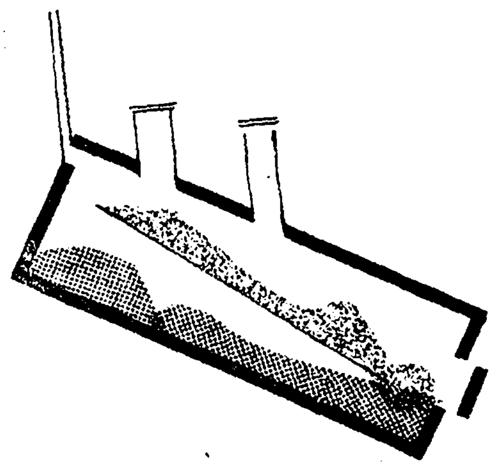
(a) incinerators
(b) dry systems
(c) water saving flushers
(d) composting and mouldering toilets

Incinerators are expensive to buy and to operate and difficult to maintain. A serious drawback is the pollution effect incineration causes.

Some systems modify the transport system only by retarding the actual decomposition: deep freezing, packing and chemical toilets belong to this group which has very limited interest without special treatment facilities provided simultaneously..

Water saving flushers can easily be connected to the existing waterborne solutions in LDC (oxidation ponds, septic tanks, etc.). A special type is the Vacuum toilet/Electrolux which does not use conventional treatment but applies a massive lime dosage to precipitate and sterlize BOD matter. This technique might also offer a suitable solution for small communities. The most interesting solution, however, has taken place in the field of composting and mouldering. Composting has been introduced as a suitable solution to isolated cottages.

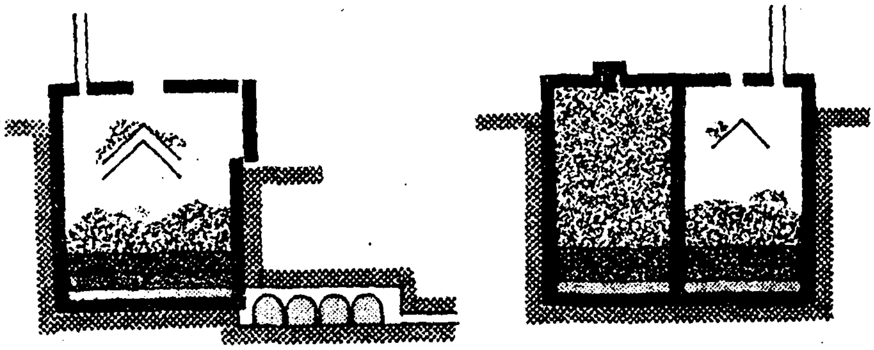
SWEDISH MOULDERING TOILET
slow aerobic decomposition; at low temperatures risk for anaerobic conditions; in humid climate yields manure.



In these systems the excreta is decomposed by a massive oxygen supply. In some cases this takes place after mixing the excreta with household wastes. In the last case very high temperatures can be reached (60-80°C). This special biochemical process varies with the temperature and the C/N ratio (carbon/nitrogen content). In certain types it is difficult to achieve any pasteurization due to the cooling effect of the circulated air, then a long term storage of the mouldering matter or mull is necessary.

An uncertain factor with the mouldering latrines is the humidity control in the chambers. In Scandinavia, it has proved to be a success because a rapid evaporation can be achieved by accelerated ventilation, so that no anaerobic decomposition and evil odours occur. In the humid tropical zone this is not possible.

An attempt to control humidity has been made in the Biopot which has a chemical drainage filter.



side section *front section*

BIOPOT
complete decomposition and pasteurization through high temperature composting; chemical filter controls humidity even in humid tropical climate; yields valuable manure.

PACKING TOILETS

A recent development of the bucket toilet is of some interest: the Packing Toilet (e.g. Pacto 203 from Sweden).

In this system the fresh excreta are collected in a plastic tube and sealed every time after using the toilet. The long "sausage" tube is collected in a sub-floor container and the fresh excreta are not exposed anymore and are safe in handling. No decomposition takes place and each load of 40 bags is to be taken elsewhere for treatment. The design is quite simple and rugged and is widely used at Swedish construction sites. Professional maintenance is occasionally necessary though.

The advantage of the system is the high standard of hygiene for the user and the safe handling and transport of the untreated material. In arctic areas the system could be applied for scattered communities linked up with a central treatment facility which can be operated during the summer months.

CHEMICAL TOILETS

Chemical toilets have found a wide application for remote areas and in transport systems. The chemicals prevent decomposition and odours so that excreta can be stored until treatment can be arranged.

In summer houses, boats, buses and aeroplanes chemical toilets have become quite accepted. There are, however, considerable environmental disadvantages connected with these systems. Some chemicals are dangerous and can easily cause allergic skin reactions. The decomposition delaying effect will make later treatment very difficult and can destabilize the process in treatment plants and the chemicals can themselves cause considerable pollution problems. For remote areas with difficult communications the system is definitely not recommended.

SCANDINAVIAN EXPERIENCES WITH MOULDERING SYSTEMS

Environmental protection laws have forced a wide search for alternative sewage solutions in Norway and Sweden in the past five years. It is especially for the recreational facilities that adequate solutions are wanted. In many mountain cabins no running water is available and soaking pits have been banned in recent years.

The mouldering toilet systems have especially come into focus and at a certain time as many as fifty commercial systems were available. Many systems proved unworkable and at this moment about two dozen brands are still on the market.

In 1975 twenty-two types were tested at the Norwegian Agriculture College for the Norwegian Consumer Council. The project studied especially the process development and the microbiologist responsible for the project, Mr. Guttormsen, tested the survival rates of several pathogenes like sabmonella baccilli and polio virus.

The original mouldering system - Rikard Lindstrom's Mulltrum from 1938 - now marketed under the brand Clivus, was not made available for testing. All the other commercial systems are more or less developments of the original Mulltrum, which has the disadvantage of being very large and costly.

The mouldering system is a dry composting of the excreta over a long period at room temperatures. In some cases, the excreta are mixed with household wastes, other systems, just evaporate excess fluids and reduce the excreta through microbiological action under aerobic conditions.

One of the greatest problems is humidity control. Failure will create anaerobic conditions, retards decomposition and causes very disturbing odours. Excessive evaporation dries out the excreta, without proper BOD reduction.

In attempts to reduce the size of installation, various services have been used to facilitate a rapid decomposition. Many systems have a temperature control system, many have used mechanical ventilation to control humidity and some have stirring devices which aim at a thorough aeration of the excreta pile. Three of the compact systems which would not require any sub-floor structures functioned in respect to the mouldering process: Bio-loo, Mullbanken and Mulltoa, but proved to be very sensitive for overloading and serve a maximum of four persons.

These systems all have electrical heating, ventilation and mechanical stirring arms. The best system proved to be the Bio-loo which also has a special pasteurization device and a vertical pile turner. It is, however, very doubtful whether any compact system can function in a larger scale application.

THE MOULDERING PROCESS

Mouldering of excreta was first used in the late thirties in Sweden by Rikard Lindström, the inventor of the Clivus-Multrum toilet. Later more than twenty toilet systems were developed using the mouldering process. The process has attracted attention because it safely decomposes excreta in or under the toilet without the use of water and therefore avoids the negative environmental effects that the waterborne systems have. If used well, a mouldering toilet is free from odour and the decomposed material is a safe fertilizer.

Mouldering toilets found wide application in Scandinavia for summer cottages when a safe disposal of excreta became mandatory. Because of the pathogenic character of the effluent, septic tanks are not accepted in Sweden and the mouldering process offers an alternative especially in remote areas. The mouldering process is based on a dry oxidation of the organic matter which is exposed to a thorough and continuous supply of oxygen and very gradually breaks down into simple and stable molecules. The process can take from six weeks to one year to complete, depending on temperature, humidity and oxygen supply.

The chemical processes involved are largely the same as those in aerobic decomposition in water where dissolved oxygen is surrounding all organic particles and rapidly reacts with them. In the mouldering process the oxygen does not as easily reach all particles and it takes, therefore, a longer time to complete the reactions.

When the material is relatively dry or surrounded by oxygen rich fluids, the decomposition will bind carbon in the odourless form. In oxygen poor fluids, however, CH_4 will be produced and disagreeable methane odours develop. Relatively little fluids are needed to create such anaerobic conditions and the offensive odours of bucket latrines are caused by decomposition of urine and anaerobic conditions in the pile which result in the release of ammonia and methane.

This is not very agreeable and one of the reasons why water flushed toilets are much preferred is that the rapid submersion and transport of excreta in this system prevents the occurrence of odours. Mouldering toilets can be odourless but only if the fluids are removed before anaerobic conditions can take place.

In dry climates this can be achieved by a thorough ventilation of the excreta tank, sometimes combined with a regular turning of the pile.

In very humid climates such as Vietnam and the coastal areas of Tansania, other methods of fluid control are necessary. Where the air is already so humid that ventilation cannot carry the excess fluids away and ventilation does, therefore, not give the desired effects, anaerobic conditions can occur, decomposition can become ineffective and bad odours are released. This seems often to happen with the Vietnamese Double Septic Tank which therefore has found application in rural areas only.

The author has attempted to control humidity in such conditions by a drainage system under the mouldering compartment which would be effective for tropical humid areas. This system, the Biopot, combines the advantages of mouldering and composting.

In the conventional mouldering systems humidity also poses a problem, especially when an abnormally large number of people suddenly use the toilet, such as during parties. This Saturday Night Party effect can drown the system, stop the mouldering, create anaerobic conditions and flood the compost tray where the dry final product is to accumulate. Small, compact mouldering toilets, without a subfloor tank, are, in fact, all likely to be sensitive in this respect. The attempts to match fluid input with forced ventilation are seldom completely reliable. It is difficult to make sure that the fluids are sufficiently exposed to the ventilation air. At the other hand, it is not easy to regulate ventilation so as to prevent dehydration of parts of the mass. This can occur even while part of other parts of the pile still contain excess fluids. Overventilation is bad because dehydration stops the chemical process.

In some systems a certain absorbtion of fluids takes place when putting household wastes and paper into the tank. The materials will then be composted and a temperature increase will be generated by the chemical reactions.

Mouldering does not take place under the freezing point and in cold climates the systems therefore need a heating and insulation system around the toilet and tank to keep the reactions up and around the chimney to prevent the freezing of the vapours and clogging of the channels.

From all this is should be clear that the mouldering process by no means is as trouble - and maintenance - free as many believe. It is especially the maintenance which should be considered when installing a mouldering toilet because other than in waterborne systems where the excreta are stored outside the house, in mouldering toilets all the wastes are inside the dwelling or in a space in direct connection with it. Malfunctioning of the system is therefore intolerable.

The commercial mouldering toilets available at the moment can be divided into two types: Multrum-type toilets, with subfloor tanks and a cycle of three to five years, and compact toilets with forced ventilation and a cycle of a few months.

The Multrum-type usually also digests household wastes and here the material slides down a ramp under continuous aeration. These toilets have a large capacity, are relatively insensitive to overloading and some can even balance humidity without mechanical ventilation. The large subfloor tank, the excavations and the problems of temperature control are negative aspects to be considered here.

The compact mouldering toilets can be accommodated within a washromm or back room without any subfloor facilities. Because of the small size of the holding tank it is difficult to keep the pile sufficiently aerated and anaerobic conditions easily occur. The system is very sensitive to flooding and overloading and humidity control by forced ventilation is always an essential part of the system. Many models have stirring devices to keep the pile aerated but mechanical problems are common and the systems are certainly not yet ready for distribution and use without supervision.

THE COMPOSTING PROCESS

The composting process in an old agricultural practice of sewage disposal or of animal excreta treatment which was developed in agriculture. It is based on the decomposition of excreta together with cellulosa containing material such as can be found in agricultural waste or in paper. A mixture of the two substances reacts under consumption of oxygen resulting in a very effective breakdown of the large organic molecules in the excreta through a series of chemical reactions which gradually break down the material in smaller and stable molecules. In favourable conditions of sufficient quantities of cellulosa and oxygen, the process generates a considerable temperature and results in a very rapid and complete decomposition. The process heat brings the temperature to 60 or even 80 degrees Celsius under a sustained period of time which therefore results in a complete pasteurization of the mixture. As a result, the final compost is completely sterilized, free of pathogenes, bacteria, helminths and virus. Compost, the final product, is a complete non-reactive material which contains all valuable elements to improve agriculture and has a considerable commercial value. Traditional composting is a rather primitive process which requires a considerable manual labour for overturning the material in order to sustain a satisfactory level of oxygen in the composting pile. The direct handling of the un-digested material is not without risks and this is one of the reasons why composting has remained a method of excreta disposal which has mainly been confined to use in agricultural enterprises. In a few countries like Holland, India and China, however, several attempts have been made during the last 50 years to find applications for the composting method especially with regard to human excreta. The results of the technical developments in Holland and in Denmark has been a reliable but very capital intensive process and it was first after the oil crisis that a greater number of countries paid attention to this process as a realistic alternative to the conventional sewage treatment processes. There are, at the moment, a great number of composting reactors, composting towers, composting digestors on the market which all have been designed to replace the conventional water-based excreta treatment methods. The Scandinavian countries have, during the last ten years, started an intensive search for alternative and more environmentally acceptable excreta disposal methods. The development of mouldering toilets is one example of this trend and the recent tests of composting installations are another example. The State Environmental Protection Agency of Sweden has conducted a series of tests in their composting research program located in the town Laxa in the centre of Sweden. It was so designed that all the municipal sludge from one town would be used in the research program and various composting methods were set up in rather large scale plants aiming at yielding general applicable experience for municipal excreta disposal through composting. In most of these tests, sludge from sewage plants is mixed with shredded household refuse and treated with oxygen and agitation in various types of reactors. The three factors central to the process of composting are:

(1) the ratio between excreta and the added cellulosa which is referred to as the C-N ratio

(2) the humidity of decomposting pile, because humidity controls the effectivity of the chemical reactions and,

(3) the availability of oxygen throughout the composting mass

It was found that all kinds of cellulosa material would be useful in such composting plans. In one series of tests ordinary shredded household refuse was used. In other tests, bark or wood wastes was equally successfully used in composting. Most of the modern composting installations have a rather complicated system aiming at imitating the traditional composting method of turning over the material. In the different composting reactors or composting digestors, the material is stirred or mixed by mechanical means. The latest developments in this field, however, have indicated that no such complicated installations are necessary. The right balance of the three factors mentioned above can be achieved without a complicated installation. The Swedish Environmental Protection Agency found that mixtures of shredded household wastes and sewage sludge or human excreta could react very effectively if a proper humidity was maintained by spraying of water and if air was forced through the pile from a system of ducts. The combination of the two factors would leave the material in a sufficient porous state so that a full aeration as well as an active chemical process throughout the pile could be achieved. The present seires of tests in Laxa have been very encouraging. An area of 200 square meters and a pile of two meters high are treated by blowing air through the mass from ducts at the bottom of the pile. A temperature of 70C^{o} was easily reached and the Swedish Environmental Agency is at this moment assuming that this particular process not only will solve the considerable municipal sewage disposal problems, but that it will help to solve the municipal household waste problem. A survey of Swedish households refuses done in 1976 showed that the normal wastes collected in the Swedish towns contain:

36% food rests
2% textile
2% kraft paper
7% carton
29% paper
5% plastics
6% metals
9% other wastes

Consequently one can see that slightly over 10% of the municipal garbage is not degradeable, the other 90% can successfully be disposed in a composing process.

COMMERCIAL TOILET SYSTEMS

Bucket latrines		
Cipax	Ojopax AB, Bredaryd	Sweden
Rastahytten	AB Trelleborgsplast, Trelleborg	Sweden
Sanitoa	Sanilaprodukter, Valbo	Sweden
TT-toaletten	Ulf Trulsson Industri AB, Tyreso	Sweden
Packing toilets		
Pacto 203	Pactosan AB, Nora stad	Sweden
Freezing toilets		
Osby Minihjartat	Osby-Pannan AB, Osby	Sweden
Te-Be	Te-Be Elprodukter AB Huskvarna	Sweden
Chemical toilets		
Perdisan		
standard minor	Racasan Ltd., Wirral	England
jetflush minor	Waterlo, Paris	France
Mobil closet	Goby, Choisy-le-Roi	France
Sanitan	Technique Agricole Modernes, Paris	France
Incinerators		
Jevasett	Edholms Verkstader, Vadstena	Sweden
Incinolet	Research Products/ Blankenship, Rexdale	Canada
Pyrolet	Clearwater Inc., Wisconsin	U.S.A.
LittleJohn	Kirby Enterprises, Winnipeg	Canada
Water-saving toilets		
Cipax	Plast AB Cipax, Bredaryd	Sweden
OJ07000	Plast AB Cipax, Bredaryd	Sweden
Classic	Electrolux, Stockholm	Sweden
Vakuum	AB Gustavsbergs Fabriker, Stockholm	Sweden
Ifo	Ifo AB, Bromolla	Sweden
Linde Aqua Magic	AB Linde International, Lindesberg	Sweden
Spolett Popular	Miljovardsprodukter AB, Partille	Sweden
Flush-o-Matic	Argus Int. Supply Ltd., Winnipeg	Canada
Double vault latrines		
Camo-Do	Camo Plast AS, Grimstad	Norway
Dosenten	Thaxelplast AS, Kristiansand	Norway
Natur-Do	Ernst Fridlund, Risoya, Stavern	Norway
NGP Hytte-Do	AS Hjem & Fasade, Oslogat 2, Benna	Norway

Mouldering latrines with electrical heating		
Biolett	Svenska Biolett, Sundsvall	Sweden
Bio-loo	AB Gustavsbergs Fabr., Stockholm	Sweden
KPS miljoklosett	KPS Miljoprodukter, Oslo	Norway
Mullbanken	Inventor Miljoprodukter AB, Ostersund	Sweden
Minimult	Deferto AB, Tanumshede	Sweden
Milltoa	Bio-Des AB, Goteborg	Sweden
Mouldering latrines without any electrical heating		
Clivus	AB Clivus, Tyreso	Sweden
Mulltrumman	Polypur AB, Stockholm	Sweden
(Mulltrumman) Kombio	KPS miljoprodukter, Oslo	Norway
Toga Hyttetoalett	Gustaf Aspelin, Okern	Norway
Toa-Throne	Adeceka, Goteborg	Sweden

DATA SHEETS

General characteristics of different systems of disposal.

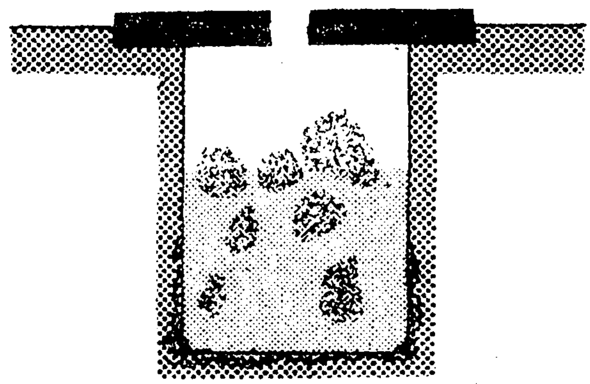
The data sheets to be used for general information only. Within each system some differences exist between different brands and types.

COMPARISON OF TOILET SYSTEMS AND CRITERIA

TYPE \ CRITERIA	Health Criteria: No handling of fresh excreta	No pathogene survival	No ground water pollution	No surface pollution	No insect breeding	No odours	Full BOD digestion	Cost Criteria: Local materials and technology	Less than 10% of housing costs	Low water consumption	Valuable by-product.
Pit Latrine	●	●		●			●	●	●	●	●
Bored-hole Latrine	●	●		●		●	●	●	●	●	●
Methane Digester	●			●	●	●	●		●	O	●
Aqua Privy or Septic Tank	●			●	●	●	●	●	●		
W.C. with Treatment Plant	●	●	O	●	●	●	●				
Bucket Toilet			●	●	O			●	●	●	
Chemical Toilet	O		●	●	●	●		●	●	●	
Freezing Toilet	●		●	●	●	●				●	
Packing Toilet	●		●	●	●	●			●	●	
Recirculating Fluid Toilet	●	O	●	●	●	●				●	
Vacuum System & Lime Stabilization	●	●	●	●	●	O	●			●	●
Incinerating Toilet	●	●	●	●	●		●			●	
Compost Toilet	●	●	O	●	O		●	●	●	●	●
Mouldering Toilet	●	●	●	●	O	●	●	●	O	●	●
Vietnamese Toilet	●	●	O	●	●		●	●	●	●	●
Biopot Toilet	●	●	●	●	●	●	●	●	●	●	●
Pack - Freeze-Compost Toilet	●	●	●	●	●	●	●				●

● Criteria Fulfilled
O Criteria Fulfilled under certain conditions

PIT LATRINE



TYPE OF PROCESS:
Anaerobic composition in a closed pit. Standing water is common due to wall clogging.

DECOMPOSITION:
Complete after one year.

PATHOGENE DESTRUCTION:
Complete after one year.

HANDLING OPERATIONS:
Insect control and hygienic protection of opening required.

PERSONAL HYGIENE:
Good, especially if the slab is provided with water seal.

ENVIRONMENTAL HYGIENE:
Reasonably good. Contamination of the soil and the ground water can occur. Insect breeding can be a problem.

CAPACITY:
Depends on the size; varies from five to fifteen years.

CONSTRUCTION:
The pit privy consists of hand-dug hole in the ground, covered with a slab. The diameter and depth vary between 0.9m to 1.2m and 2.5m to 7m respectively. It can be used dry or wet. Not suitable for clayish soils.

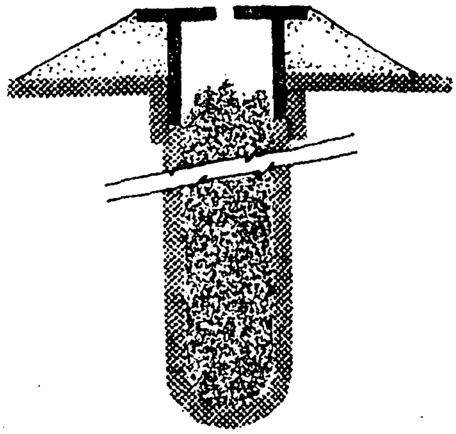
TRANSPORT:
No transport as the excreta is left in the pit and a new one will be dug out when the old pit is filled up.

SERVICE INPUT: None

ECONOMY:
Very good. It can be built by self-help and from locally available material.

ADAPTABILITY:
Can be adapted to low-density areas.

BORED-HOLE LATRINE



TYPE OF PROCESS:
Aerobic composting in a deep narrow bored hole. No standing water.

DECOMPOSITION:
Complete after one year.

PATHOGENE DESTRUCTION:
Complete after one year.

HANDLING OPERATIONS:
Insect control

PERSONAL HYGIENE:
If given proper construction i.e. if the ground water table is situated well below the squatting plate and the upper part (30-60cm) of the hole is lined the hygiene is rather good.

ENVIRONMENTAL HYGIENE:
Good. Inspection of fly breeding near opening.

CAPACITY:
Small capacity compared with the pit latrine. If used by one family of 5-6 persons the latrine will last 1½-2 years.

CONSTRUCTION:
The hole, usually 15-40cm in diameter, is bored with an earth auger. Not suitable for clayish soils. Can be constructed in a few hours.

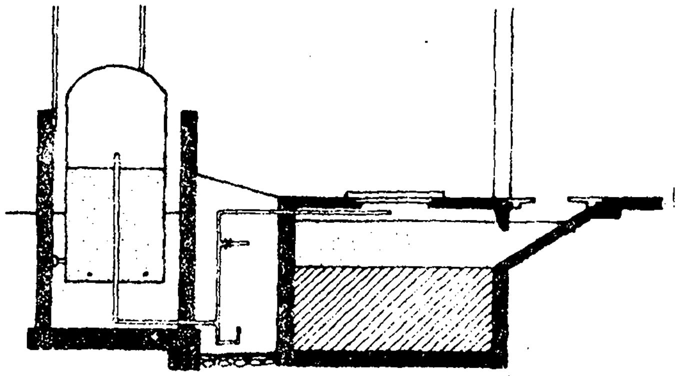
TRANSPORT:
Sometimes the well-digested material is used as fertilizer. The hole cannot be used again because of wall clogging.

SERVICE INPUT: None

ECONOMY: Cheap

ADAPTABILITY:
Adapted in dense rural areas.

METHANE GAS TOILET OR GOBAR DIGESTER



TYPE OF PROCESS:
Anaerobic digestion of waterborne excreta, reducing the organic matter in a process similar to the septic tank yields a similar sludge and effluent as well as methane gas.

DECOMPOSITION:
Anaerobic digestion, sludge maturing needed to eliminate surviving pathogenes.

PATHOGENE DESTRUCTION:
Partial during digestion, effluent needs controlled infiltration.

HANDLING OPERATIONS:
Constant inspection needed.

PERSONAL HYGIENE:
Good

ENVIRONMENTAL HYGIENE:
Good, but sludge and effluent are still offensive.

CAPACITY:
Large; the system is suitable for neighbourhoods.

CONSTRUCTION:
Bricks or concrete and pipes. Steel tank and valves.

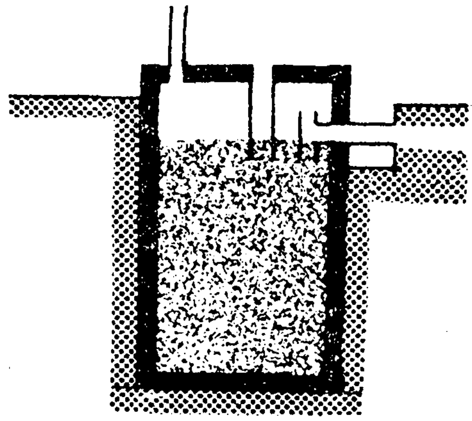
TRANSPORT:
Waterborne, similar to septic tank.

SERVICE INPUT:
Water needed.

ECONOMY:
Requires considerable initial investment, but yields valuable products: gas and fertilizer.

ADAPTABILITY:
Methane production requires a large input to be worthwhile.

AQUA PRIVY



TYPE OF PROCESS:
Anaerobic BOD-reduction, with sedimentation of sludge.

DECOMPOSITION:
The BOD-reduction is effective but the sludge can still contain undigested feceal matter.

PATHOGENE DESTRUCTION:
Limited, mainly through sedimentation into the sludge. The effluent is still offensive.

HANDLING OPERATIONS:
Simple, but sludge needs regular removal; blocking of drop pipe occurs.

PERSONAL HYGIENE:
Good.

ENVIRONMENTAL HYGIENE:
Often contaminates ground water.

CAPACITY:
Great

CONSTRUCTION:
Masoned or concrete water-tight tank, usually 1.0-1.5 m deep.

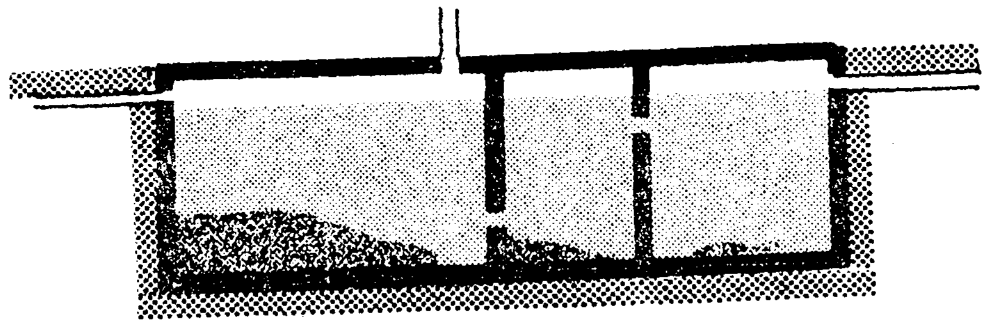
TRANSPORT:
The effluent and sludge still offensive but has to be treated and disposed. The sludge must be periodically bailed out. Effluent infiltrated in soakage.

SERVICE INPUT:
Water required for flushing.

ECONOMY:
Rather high initial cost.

ADAPTABILITY:
Accepted solution in low cost housing and in rural areas in LDC's.

SEPTIC TANK



TYPE OF PROCESS:
Anaerobic digestion. Sedimentation in two or three chambers. Regular sludge removal required.

DECOMPOSITION:
Partial, sludge still instable and virulent, requires maturing.

PATHOGENE DESTRUCTION:
Partial, sludge and effluent still virulent.

HANDLING OPERATIONS:
Monthly sludge checks, annual sludge removal. Requires each time 15-25 l of flushing water. Sludge removal to be organized.

PERSONAL HYGIENE:
Good

ENVIRONMENTAL HYGIENE:
Ground water pollution likely. Overflow occurs if not maintained properly.

CAPACITY:
Large, usually one tank for each building.

CONSTRUCTION:
Concrete or masoned underground tanks, connected to soakage or trench drain.

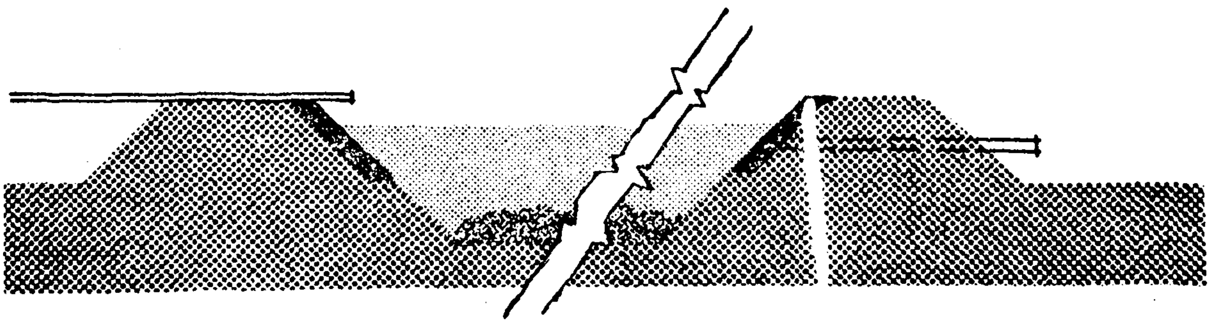
TRANSPORT:
Waterborne.

SERVICE INPUT:
Water

ECONOMY:
Medium

ADAPTABILITY:
In rural and urban situations, where ground water can be accepted.

OXIDATION POND



TYPE OF PROCESS:
Aerobic digestion in shallow lagoon and sedimentation.

DECOMPOSITION:
Partial

PATHOGENE DESTRUCTION:
Partial, mainly through sedimentation.

HANDLING OPERATIONS:
Professional maintenance required; floating sludge removal; sedimentation checks and insect control.

PERSONAL HYGIENE:
Good

ENVIRONMENTAL HYGIENE:
Sludge still requires maturing. Effluent may still contain pathogenes, esp. helminths. Insect breeding occurs, ponds attract birds and other animals.

CAPACITY:
Very great; is used for institutions or large communities.

CONSTRUCTION:
Earth dam. Stone embankments and pipes for in and outlet.

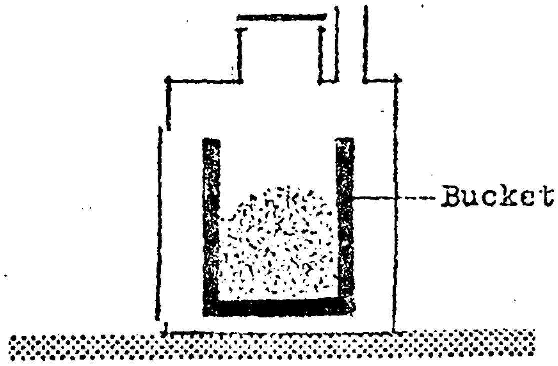
TRANSPORT:
Waterborne from water closets, great quantities of water required to ensure oxygen content.

SERVICE INPUT:
Water. In some cases pumps are needed.

ECONOMY:
A series of ponds can effectively treat sewerage from large communities. Water consumption is high, construction is costly.

ADAPTABILITY:
Requires a certain distance from dwellings. Good supply of water necessary. Requires much land.

BUCKET



TYPE OF PROCESS:
No treatment

DECOMPOSITION:
Nil

PATHOGENE DESTRUCTION:
Nil

HANDLING OPERATIONS:
The handling of fresh excreta is hazardous.

PERSONAL HYGIENE:
Poor

ENVIRONMENTAL HYGIENE:
Poor. Flies have easy access to the bucket. Spillage and leakage form a health hazard.

CAPACITY:
Depends on the size. To be emptied after 30-50 uses.

CONSTRUCTION:
Bucket, often with inside bag - in ventilated seat box. Available as portable unit, with flusher.

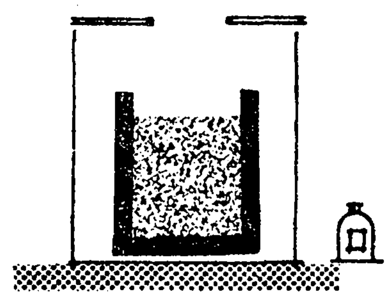
TRANSPORT:
The bucket with fresh excreta to be transported for treatment.

SERVICE INPUT:
None

ECONOMY:
A rather cheap system but handling requires great care.

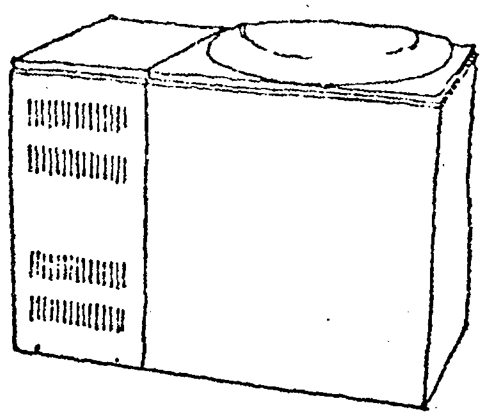
ADAPTABILITY:
Is widely used and suitable as a temporary solution.

CHEMICAL TOILET



TYPE OF PROCESS:
No decomposition. Adding of formaldehyd or similar chemicals to excreta to avoid offensive smells. The waste has to be delivered to a treatment plant.
DECOMPOSITION:
Nil
PATHOGENE DESTRUCTION:
Nil
HANDLING OPERATIONS
Simple
PERSONAL HYGIENE:
Non-odorous. The dosage and the effect of the chemicals is not controlled. Excreta still dangerous; chemicals can be harmful
ENVIRONMENTAL HYGIENE:
No destruction of waste. The chemicals retard decomposition in treatment plant.
CAPACITY:
Related to removal facilities.
CONSTRUCTION:
Bucket in seat box.
TRANSPORT:
Handling to treatment plant is hazardous.
SERVICE INPUT:
Supply of chemicals.
ECONOMY:
Rather expensive.
ADAPTABILITY:
Easily provided at any location; transport and treatment to be arranged.

FREEZE TOILET



TYPE OF PROCESS:

No treatment, storage only. Freezing to about $10^{o}C$.

DECOMPOSITION:

Nil

PATHOGENE DESTRUCTION:

Nil

HANDLING OPERATIONS:

Daily use is simple, but maintenance is vital. Separation of plastic liners and excreta is necessary at treatment plant.

PERSONAL HYGIENE:

Good as long as refrigerator works. Seat in some types heated by hot air.

ENVIRONMENTAL HYGIENE:

Bags to be delivered to treatment plant. In Sweden such delivery has proved to be difficult to arrange by private households.

CAPACITY:

Low

CONSTRUCTION:

Bucket, with plastic liner in deep freeze.

TRANSPORT:

The bag is transported for disposal. When still cold, handling is simple.

SERVICE INPUT:

Supply of liners and electricity.

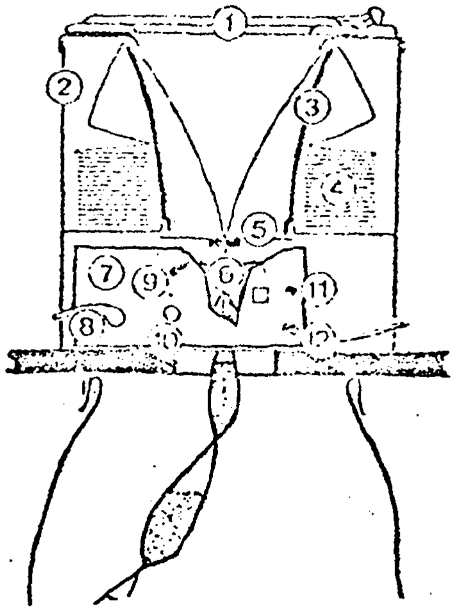
ECONOMY:

Very expensive

ADAPTABILITY:

Electricity, supervision and transport facilities are required. The limited capacity restricts its adaptability.

PACKING TOILET



TYPE OF PROCESS:
No treatment, only storage. Excreta is collected in a plastic tube and sealed after each use.

DECOMPOSITION:
Nil

PATHOGENE DESTRUCTION:
Nil

HANDLING OPERATIONS:
Simple, but requires maintenance.

PERSONAL HYGIENE:
Very good.

ENVIRONMENTAL HYGIENE:
Very good. The bags have to be cut and separated in treatment plant, requiring professional handling.

CAPACITY:
The plastic tube has a capacity of 40 bags.

CONSTRUCTION:
Strong construction of polystyrene and metal. Electric motor and sealing device.

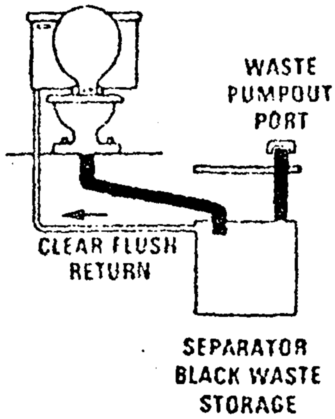
TRANSPORT:
Simple, sealed bags are hygienic.

SERVICE INPUTS:
Electricity and plastic bag supply.

ECONOMY:
Expensive, installation (Approx. $550.)

ADAPTABILITY:
Very adaptable. Separate treatment to be arranged.

RECIRCULATING FLUID TOILET



TYPE OF PROCESS:
No treatment. The fluid only transports the excreta to a holding tank and recirculates after filtration. The holding tank contents have to be treated elsewhere.

DECOMPOSITION:
Nil

PATHOGENE DESTRUCTION:
Nil

HANDLING OPERATION:
Installation needs professional maintenance.

PERSONAL HYGIENE:
Good

ENVIRONMENTAL HYGIENE:
Good, but excreta still harmful and needs treatment.

CAPACITY:
Related to removal facilities.

CONSTRUCTION:
Advanced plumbing, pumps and filters.

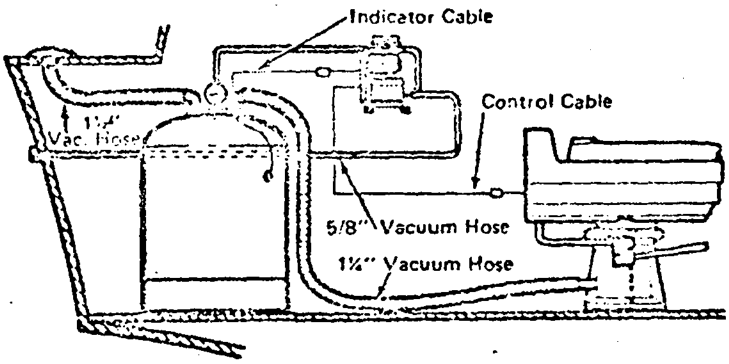
TRANSPORT:
Holding tank emptied by vacuum truck.

SERVICE INPUT:
Power, fluid renewal, no water.

ECONOMY:
Expensive installation. System as yet largely untried.

ADAPTABILITY:
Suitable for many different situations.

ELECTROLUX VACUUM SYSTEM



TYPE OF PROCESS:
Lime stabilization of concentrated excreta, or treatment in conventional plant.

DECOMPOSITION:
Satisfactory precipitation.

PATHOGENE DESTRUCTION:
Effective

HANDLING OPERATIONS:
Very advanced, vulnerable.

PERSONAL HYGIENE:
Good

ENVIRONMENTAL HYGIENE:
Good

CAPACITY:
Very high; for limited settlement.

CONSTRUCTION:
Small bore piping system, pumps.

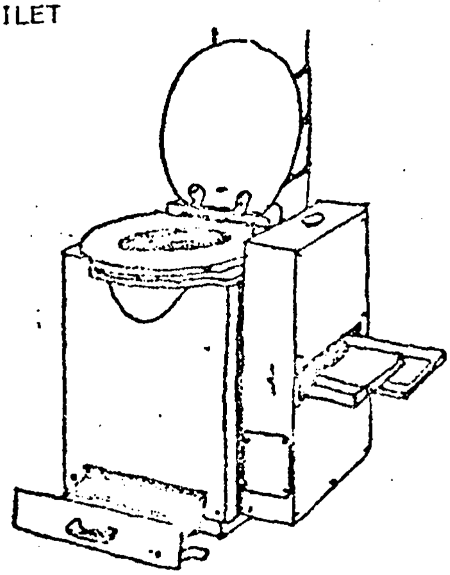
TRANSPORT:
Vacuum transport to central tank, from there sometimes to treatment plant.

SERVICE INPUT:
Power, pumps and water for vacuum transport; lime for treatment.

ECONOMY:
The installation is expensive and operational costs are high.

ADAPTABILITY:
Used in small concentrated settlement, requiring little water.

INCINERATING TOILET



TYPE OF PROCESS:
Evaporation and incineration with electrical power or gas.

DECOMPOSITION:
Complete.

PATHOGENE DESTRUCTION:
Complete

HANDLING OPERATIONS:
Requires professional maintenance.

PERSONAL HYGIENE:
Good

ENVIRONMENTAL HYGIENE:
Poor; produces very disagreeable smoke.

CAPACITY:
Low. Most models require an incineration period of about 30 minutes after each use.

CONSTRUCTION:
Metal and porcelain enamel in factory produced unit. Propane gas and electrical burner, exhaust ventilation.

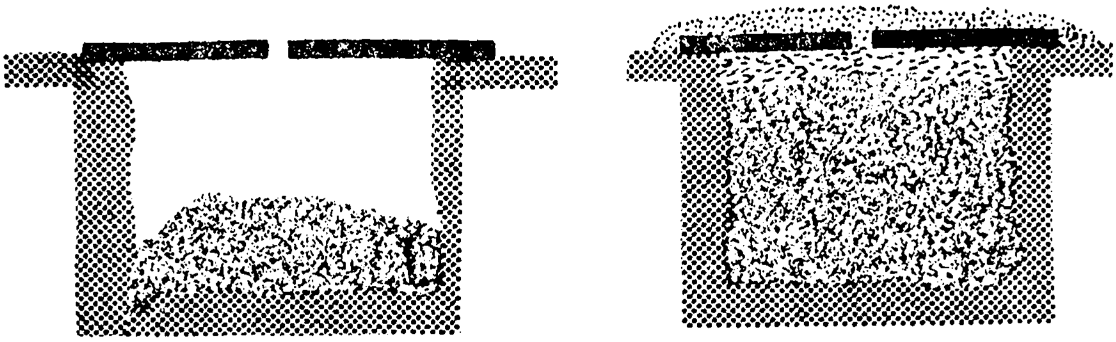
TRANSPORT:
Ashes have to be removed regularly.

SERVICE INPUT:
Electricity or gas, sometimes special paper bags or inserts.

ECONOMY:
Expensive installation and high operating costs.

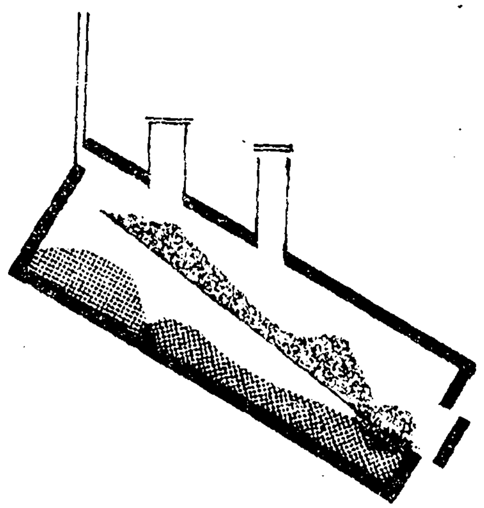
ADAPTABILITY:
About 200 meters distance to nearest house required. Air pollution is a great drawback.

COMPOST LATRINE



TYPE OF PROCESS:
The latrine consists of two similar compartments, alternatively in operation. Aerobic and anaerobic decomposition with leaves and grass cuttings.
DECOMPOSITION:
Complete
PATHOGENE DESTRUCTION:
Complete through pasteurization.
HANDLING OPERATIONS:
Overturning
PERSONAL HYGIENE:
Rather good.
ENVIRONMENTAL HYGIENE:
Often both compartments are used simultaneously thus defeating their purpose. The ground water can be polluted, offensive odours occur.
CAPACITY:
Very high.
CONSTRUCTION:
Concrete work or masonry , in some cases even unlined excavation above the ground water level.
TRANSPORT:
The final product can be used fertilizer.
SERVICE INPUT:
Leaves
ECONOMY:
Inexpensive, built by non-skilled labour and of local material.
ADAPTABILITY:
Poor. This latrine is mentioned by Wagner-Lanoix as a possible solution in rural areas and under proper conditions of operation this method will satisfy most sanitary requirements.

MOULDERING TOILET



TYPE OF PROCESS:

Aerobic composting of excreta and kitchen wastes. Air inlet at the rear by air conducts over which the composting material is carried. During the mouldering the material moves by gravity towards the rear opening. The cycle takes 2-3 years.

DECOMPOSITION:

Complete

PATHOGENE DESTRUCTION:

Satisfactory.

HANDLING OPERATIONS:

Garbage preselection.

PERSONAL HYGIENE:

Good, provided that the ventilation is working sufficiently.

ENVIRONMENTAL HYGIENE:

The compost taken from the end hatch is free from pathogenes. Insect breeding can occur.

CAPACITY:

A family with approximately five persons. Occasionally peak loads can easily be absorbed.

CONSTRUCTION:

Masonry, concrete or glass fibre reinforced polyester. Humidity control by mechanical ventilation.

TRANSPORT:

The final product is safely handled.

SERVICE INPUT:

Power for ventilator.

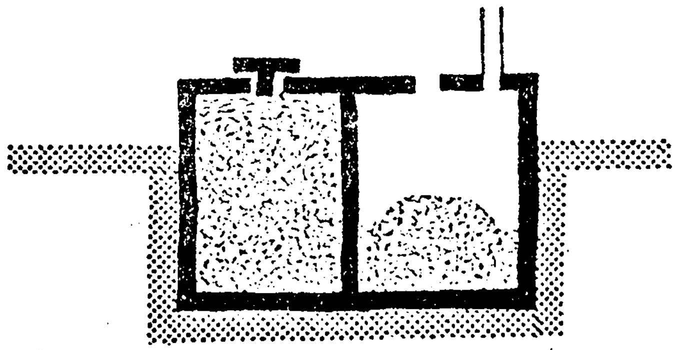
ECONOMY:

The installation requires no operational costs but the large construction volume is costly and requires in many cases considerable excavation.

ADAPTABILITY:

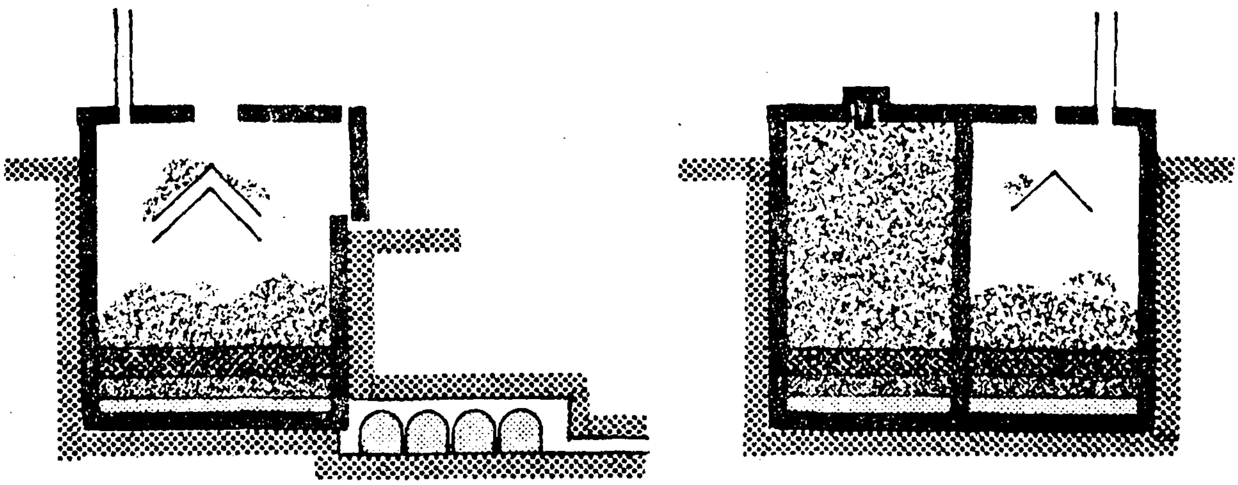
Very good.

VIETNAMESE DOUBLE SEPTIC TANK



TYPE OF PROCESS:
Aerobic composting. Two compartments of which one is closed after filling up and the other one is under operation. Grass and leaves are added. High composting temperatures pasteurizes pathogenes.
DECOMPOSITION:
Complete through composting and storage.
PATHOGENE DESTRUCTION:
Complete through pasteurization.
HANDLING OPERATIONS:
Fluid control to prevent anaerobic conditions, through urine separation and the additions of ashes and leaves.
PERSONAL HYGIENE:
Good
ENVIRONMENTAL HYGIENE:
Anaerobic conditions occur and give then offensive odours.
CAPACITY:
Usually one family.
CONSTRUCTION:
Masoned vaults.
TRANSPORT:
The compost is used as a safe fertilizer.
SERVICE INPUT:
Ashes.
ECONOMY:
Very good. North Vietnam (pop. 13 million) every year about 600,000 tons natural fertilizer is utilized.
ADAPTABILITY:
Not very good. Used in rural areas only.

BIOPOT



TYPE OF PROCESS:
Aerobic digestion of excreta, grass clippings and leaves. The biopot consits of two similar vaults alternatively in operation. The process will reach a high temperature, sustained long enough for pasteurization. Can be used with flushing toilets of water saving types as excessive liquids will pass through the chemical filter and will be harmless if infiltrated.

DECOMPOSITION:
Complete, even effluent is inoffensive.

PATHOGENE DESTRUCTION:
Complete

PERSONAL HYGIENE:
Very good. Dry or flush closet with reduced water consumption can be used.

ENVIRONMENTAL HYGIENE:
Very good. The manure is totally harmless.

CAPACITY:
Very high, dependent on construction size.

CONSTRUCTION:
Concrete work or masonry. Humidity control by filter.

TRANSPORT:
The final product can be collected and distributed like any fertilizer.

SERVICE INPUT:
Lime, charcoal, and sand for filter, leaves,ashes.

ECONOMY:
Inexpensive as the latrine can be built by non-skilled labour and of local material. The compost will be used as a good fertilizer.

ADAPTABILITY:
In present form not suitable for multi-story buildings but can otherwise even be placed in existing buildings.

THE BIOPOT: A MOULDERING TOILET

The shortcomings of the present sewage systems in under-developed and remote areas and in the urban areas of the Less Developed Countries (LDC's) are too obvious to be ignored.

All the systems used in urban areas are expensive. The flushing system wastes very precious water in large quantities. The pollution caused by the waterborne systems is considerable. Therefore, we feel justified in stating that waterborne sewage systems are unsuitable.

The results of our efforts is the Biopot, a system which we hope to be sufficiently flexible and effective to give and adequate answer to the most urgent urban and rural needs.

The toilet house itself can be of any type of structure. It consists of one closet which is mounted over two vaults. Only one vault is used at a time, the other vault is closed by an airtight cover. The vault in operation has a flush bowl or a drop pipe with an automatic seal, and has such dimensions that it will take a family of six people, nine to twelve months to fill it.

The Biopot is a closed system, does not contaminate the ground water, the soil or the air, and avoids the need of transporting offensive material. There are two stages of biochemical treatment involved: firstly a mouldering period, where the excreta exposed to oxygen decomposes and secondly, a composting period, which pasteurizes pathogenes and completes decomposition. Finally a chemical treatment of the effluent takes place.

As the main treatment is a composting process the additional advantage is that the bulk of the household garbage is received and treated as well. The Biopot will thus yield very concentrated and rich manure. All the organic material can be used and instead of being a costly liability becomes a valuable commodity. The system can be applied to existing neighbourhoods and the standard can vary according to the funds available.

The Biopot is a basically dry system. Although limited amounts of water may be used for flushing; there is no need for large quantities of water for the purpose of transporting the excreta. Little dilution of the raw sewage takes place and the volume which has to be treated is therefore significantly less. The system should be safe and cheap in operation.

As long as the toilet is in use ample oxygen is available inside the compartment. This ensures a rapid break down of the excreta in the same way as organic material in the open decomposes and changes into soil. The wastes will be broken down by micro-organisms in an aerobic process. The availability of alkaline material is important to neutralize the urine acids and for this reason ashes are daily to be thrown into the vault.

Paper and other household wastes will supply the cellulose which serves as a fuel in the decomposition process. When the vault is closed a further decomposition will take place and complete the process. This involves micro-organisms and will be started by filling the pit with fresh green leaves. The temperature will now rise rapidly and remain at over 60°C for a prolonged period. Although the inlet has been closed the vault remains to be ventilated to maintain aerobic conditions.

The high temperature destroys all pathogenes and the large organic molecules of the excreta successively break down into simple stable combinations, like nitrates and sulphates. It is essential that fluids are available in the deposited mass to reach such a level of humidity that the chemical process can be sustained. But is is of equal importance that excess fluids are drained away and that there is no standing water.

The biochemical process takes several months and finally when the temperature has again reached normal level a homogeneous compost remains. This material is now a completely inoffensive, odourless and dry black soil and it makes an excellent manure, rich in nitrogen and potassium.

After six months a special cover in the vault can be opened, and the then dry manure can be removed and a new cycle starts.

The filter consists of several layers of cheap material and the top part is removed and mixed with the other material at the end of the cycle, and becomes part of the manure.

A new filter is then put into its place. The upper most layer of the filter consists of leaves and coarse sand and aims at trapping the solid particles in the fluids. The next layer consists of coarse sand and charcoal and will trap the remaining organisms and particles.

The third layer consists of calcium carbonate, like for instance, a combination of crushed limestone and ashes. This layer will neutralize the acids and the passing fluids will become alkaline. The filter rests on a perforated stone slab which is a permanent part of the construction.

The neutralized fluid will have lost its smell after passing through the filter and will seep through the bottom plate into the soakage from where most will evaporate.

The fluids that pass through the disposable alkaline filter become completely harmless and finally seep into the last stage of the system. This stage will be different under various circumstances.

In areas with a low water table it can consist of a soakage trench. Then the infiltration again takes place through a limestone and sand bed. If there is a very high water table, another solution should be chosen. The fluids are collected in a tank which can be emptied if necessary.

CHARACTERISTICS

The significant differences compared with other systems are the following:

- All excreta remain in the toilet, inaccessible for insects and animals.
- No handling of offensive material takes place and no water for transport is required. It is a self-contained system which can even solve the sewage problems in existing residential areas, urban as well as rural.
- The decomposition is complete and all pathogenes and larvae are destroyed, due to the high temperature. The fluids which are infiltrated into the earch or evaporated are likewise harmless and odourless.
- The alkaline filter neutralizes the acids rendering the system environmentally safe.
- As all other organic wastes are to be deposited into the vault the whole problem of waste disposal is solved simultaneously.
- The dry manure forms a valuable material and will tend to make the system pay for itself.
- It is important that the users are aware of the nature of the system and that proper instructions are given. Field experience must therefore be gathered to develop a reliable routine for the wider introduction and adoption of the system.

APPENDIX

IMPACT OF ENVIRONMENTAL HYGIENE ON HEALTH

The connection between the incidence of waterborne diseases and the ineffectiveness of excreta disposal has been discussed in relation to Northern Manitoba by J.M. McKernan in his Project Summary of Proposed Household "Package Sewage Treatment Plant" Evaluation. We quote his arguments here in extenso:

> ...*Evidence of Need For a Broad-band, Administrative Response. It is obvious that there exists in the majority of communities in unincorporated, non-treaty Northern Manitoba a paucity of sewage handling capabilities. The perceptible effects of this insufficiency are most disturbing.*
>
> *While admittedly crude, a fairly reasonable correlation exists between the absence/inferiority of sanitation services and the incidence of waterborne diseases. If one compares data on hospital admissions for (i) the Province as a whole, (ii) the northern region, and (iii) the unorganized territories and Indian Bands, by disease types, one could develop the following table:*

TABLE 1
HOSPITAL ADMISSIONS/1000 POPULATION

	Province	*Northern Region*	*Unorganized Territories*	*Indian Bands*
Salmonella infections other than Typhoid or Paratyphoid	*.017*	*--*	*--*	*.20*
Bacillary dysentery	*.106*	*.156*	*.75*	*.40*
Food poisoning	*.03*	*.03*	*.14*	*.06*
Enteritis	*.21*	*.18*	*.89*	*.67*
Unspecified dysentery or diarrhea	*4.60*	*10.77*	*19.48*	*18.52*

As noted, these data are based solely on recorded hospital admissions. They therefore exclude non-reported cases of illness. Public Health officials indicate that the ratio of unreported:reported cases of diarrhea or dysentery can be as high as 10:1. To illustrate, an outbreak of Bacillary dysentery or Shigellosis in God's Lake in 1974 prompted a medical study that reported "....there were 60 cases of diarrhea treated at (the) time...." although there were only nine confirmed cases of the disease.

To focus more precisely on the effects of inferior waste management, one should consider the age-specific mortality of Indians vs non-Indians. One finds a higher mortality rate in Indian children than in non-Indian children; the same pattern is reflected in the 15-45 age category:

TABLE II

AGE SPECIFIC MORTALITY: MANITOBA INDIANS AND NON-INDIANS DEATHS PER THOUSAND POPULATION, 1971

Age Group	*Indian Deaths*	*Non-Indian Deaths*
	Per 100 Population	
0	*3.69*	*1.74*
15 - 45	*3.81*	*1.78*
45 - 64	*9.94*	*7.96*
65+	*32.77*	*54.69*
Total Pop.	*5.34*	*7.99*

The full significance of these data is understood when one realizes that 51% of Manitoba's Indian population are aged 15 years or less while only 27% of non-Indians fall into this category. To quote from the Interim Report of the Federal/Provincial Committee on Health in Indian and Metis Communities: "Thus the higher mortality rate, in itself of relative significance, assumes an even more serious absolute significance due to the substantial proportion of younger persons."

In conclusion, the linkages between poor sanitation and illness, between northern domicile and illness, and between being Indian and dying at any early age are admittedly tenuous.