Basic sanitation in developing countries

SURVEY OF WATER USE IN A LOW INCOME URBAN AREA IN THE MIDDLE EAST

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SYNOPSIS

THIS paper summarises the extent of the water supply and excreta disposal facilities in developing countries and discusses the financial implications of the International Drinking Water and Sanitation Decade. Data are presented from a survey of water use in a Middle East urban area and design guidelines are suggested for optimising health benefits with water consumption rates.

INTRODUCTION

THE WATER supply and sanitation situation in developing countries is summarised in Table I in which reasonable access in urban areas is interpreted as uncontaminated water from a stand pipe within 200 m of all households. In rural areas the supply is assumed to be sufficiently close to enable the family to collect water without spending a disproportionate amount of their time in so doing. Adequate sanitation is defined as waterborne sewerage or some form of satisfactory household excreta disposal system. The figures in Table I can only be used as a general guide because of the difficulties of data collection and because the definition of what constitutes an urban area is not necessarily the same in each region.

The population in developing countries in 1976 was 2107 million, of which about 64 per cent were without reasonable access to safe water and 70 per cent without adequate sanitation.

The UN General Assembly has declared the 1980s to be the International Drinking Water and Sanitation Decade with a goal to provide these services to all people by 1990. This target can be put into perspective when it is realised that to achieve this aim no less than 2280 million people must be provided with water and 2390 million people with sanitation facilities, in both cases about 25 per cent being in the urban sector (Kalbermatten, 1978). The goal is equivalent to commissioning facilities for almost 650 000 people each day for the next 10 years. The prospect is daunting; even a 75 per cent success rate will still leave almost 600 million people with inadequate services. The development indicators in Table II further emphasise

TABLE I: Water Supply and Sanitation Situation in Developing Countries

REGION	Population without reasonable access to safe water[1]					
	URBAN		RURAL		TOTAL	
	×10⁶	% TOTAL URBAN	×10⁶	% TOTAL RURAL	×10⁶	% TOTAL
Africa	10	32	135	89	145	79
Latin America and the Caribbean	33	21	89	75	122	45
Eastern Mediterranean	10	15	138	82	148	63
Southeast Asia	74	47	632	91	706	83
Western Pacific	10	26	59	79	69	61
Europe[2]	7	29	23	55	30	45
Total	144	31	1076	86	1220	71
Population without access to adequate sanitation[3]	145	25	1190	85	1335	67

1. From WHO (1973); data relate to 1970
2. Algeria, Morocco, Turkey.
3. From Pacey (1978); data relate to 1975.

TABLE II: Basic Development Indicators (World Bank, 1978)

INDICATOR	DEVELOPING COUNTRIES LIC	MIC	TOTAL	CSOE	CPE	IC
Mean GNP (US$/head 1976)	150	750	—	6310	2280	6200
Population (×10⁶ 1976)	1212	895	2107	12.2	1197	681
(×10⁶ estimate 2000)	2000	1500	3500	—	—	—
Life expectancy at birth (1975)	44	58	—	—	70	72
Crude birth rate (per 1000)	47	40	—	—	—	—
Crude death rate (per 1000)	20	12	—	—	—	—
Infant Mortality (per 1000 live births)	122	46	—	—	—	15

LIC = Low Income Country (1976 GNP <US$250/head)
MIC = Middle Income Country (1976 GNP>US$250/head)
CSOE = Capital Surplus Oil Exporters (Kuwait, Libya, Oman, Qatar, Saudia Arabia, UAE)
CPE = Centrally Planned Economies (including China)
IC = Industrialised Countries (Europe excluding Greece, Portugal, Spain, Turkey which are all classed as MIC)

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the lower quality of life in developing regions and also illustrate the large economic disparity that exists between countries with adequate sanitation facilities and those for which the UN target has been designed.

WATER AND DISEASE

A RELATIONSHIP between water and certain diseases has long been accepted but it is only recently that the relationship has been formalised by reclassifying water-related diseases into categories which link diseases directly with water. The reclassification by Bradley (1974) is based on the transmission mechanism and is conveniently grouped into waterborne, water-washed, water-based and water-related insect vector diseases. A fifth category, that of diseases of defective sanitation, although not necessarily related to water use, is an important component of public health and sanitation facilities in developing countries.

Almost half the number of deaths in developing countries occur in children under five, the most common cause being diarrhoeal diseases. In Asia, Africa and Latin America it is estimated that over 500 million episodes of diarrhoea occur annually among children (Freij and others, 1978). The link between water use and diarrhoeas is well established and it is now an accepted fact that defective water supply and sanitation are generally the principal causative agents, not only of diarrhoeas but also of other diseases including typhoid and cholera. The provision of a wholesome water supply eliminates waterborne diseases; the provision of an adequate quantity of water, not necessarily of the same high quality as the drinking supply, significantly reduces the incidence of water-washed diseases, particularly diarrhoeas, dysenteries, skin diseases, trachoma, etc.

Despite the general acceptance of the beneficial aspects of improved water supply and sanitation on public health, few data are available to quantify the improved health benefits. The results that are available suggest that improving both water supply and excreta disposal is more effective and less expensive, particularly in the long term, than immunization (World Bank, 1976). Unless there is evidence that immunization would prove more effective for certain high risk groups, the control of enteric and diarrhoeal disease can often be more effectively achieved by improvements in sanitation facilities, with the added advantages that more diseases are covered and other social and economic benefits accrue (Cvjetanovic, 1978).

The data in Table II clearly demonstrate that the infant mortality rate falls dramatically as the general living standards improve; the provision of an adequate water supply is an integral part of rising living standards.

Although the provision of water results in a significant improvement in community health, above a certain rate of water use the marginal health benefits from further increases in water use are relatively small. Unfortunately data are lacking on the water use which could be used as a target for optimising water supply facilities in developing nations.

A study carried out by Freij and others (1978) in Addis Ababa resulted in the tentative conclusion that a substantial reduction would occur in the rate of gastroenteritis if all households were provided with a private latrine and sufficient water to ensure a use of at least 10l/head.d. In this particular survey area the water consumption ranged from 1.7 to 120 l/head d (median 11.4) with 10 per cent of the households having in-house taps, 65 per cent sharing taps and 25 per cent relying on public stand pipes. Only 16 per cent of the households had a private means of excreta disposal, generally a pit latrine; the remainder shared or used public facilities. Children under the age of two suffered from diarrhoeal disease for 2 months per year.

In Bangladesh the effect of water use on dysentery was studied by Rahman (1978) in a rural area with a population density of 5 persons/ha. Excreta disposal was by household pit latrines fitted with water-sealed squat plates. The relationship between water use and the incidence of dysentery was as follows:—

Water use (l/head.d)	Dysentery Attack Rate (% population/year) Clinical	Positive Shigella
≤20	31	5.4
21-29	23	3.9
≥30	19	2.8

A number of surveys such as that by Van Zijl (1966) have shown similar beneficial effects of water supply and sanitation on dysentery or diarrhoea diseases. White and others (1972) found that the incidence of diarrhoea in East Africa was six times higher in houses served by stand pipes than in houses with piped supply. Data reported by Bannaga and Pickford (1978) for an urban area in Sudan show that for a 6-month period the relationship between illness and water use was represented by:—

$$d = \frac{237.5}{w} + 2.57 \qquad (1)$$

where d = days illness in 6 months
w = water use (l/head.d)

The survey included houses with piped supply (95 to 242 l/head d) and houses relying on stand pipes or vendors (14 to 68 l/head d range). The authors concluded that there was little improvement in health standards when water use exceeded 60 l/head d; at this rate the average number of days illness was 6.5/6 months, compared to 8.5 and 5.5 d/6 months at 40 and 80 l/head d respectively.

It would appear from the work carried out to date that the provision of say 40 to 50 l/head d would be a reasonable target to aim for in order to optimise the health benefits from increased investment in water supply facilities, together with a reliable method of excreta disposal.

WATER USE PATTERNS

THERE ARE wide variations in water consumption rates depending as much upon social customs as upon the cost of buying water and its availability. The rate shown in Table III for Papua New Guinea represents a minimum water use; in this particular case the diet of the people surveyed had a high proportion of sugar cane and a very low salt content. It is unusual for the water use to be less than 5 l/head d regardless of the cost or distance to the supply, since for most societies this quantity is approaching the minimum necessary to sustain life.

The data in Table III for developed countries represent actual water use; wastage or leakage from distribution mains are in addition. The use of a flush toilet and sewerage system in the developed regions is an important contributor to water consumption, approximately 33 per cent of the total water use being accounted for by toilet flushing. Work being carried out by the Building Research Establishment in the UK into ways

Table III: Breakdown of Water Use in Developed and Developing Countries

COMPONENT	DEVELOPED COUNTRIES (l/head d) UK[1]	Belgium[2]	West Germany[2]	USA[3]	DEVELOPING COUNTRIES[4] (l/head d) Lesotho	Papua New Guinea	Uganda (Lango)	Uganda (Kigezi)
Drinking	29	4	16	15	8.1	0.54	3.4	0.5
Kitchen (Cooking, dishwashing)		11				0.07	2.3	5.9
Toilet	37	42	30	80	0	0	0	0
Personal Washing	28	38	42	50	2.7	0	11.9	1.6
Laundry	13	11	30	38	4.0	0		
Miscellaneous	3	22	—	6	3.2	0.07	0.4	0
Sum	110	128	118	189	18	0.68	18	8

1. From Rump (1979)
2. From Males (1975)
3. From Ligman and others (1974)
4. Data for rural areas from Feachem and others (1978)

Table IV: Water Consumption in Developing Countries

STAND PIPES REGION	l/head d	SINGLE TAP CONNECTIONS REGION	l/head d
1. Urban Areas --	30	Guatemala[1]	60*
India (Calcutta)			
Turkey (Istanbul)[1]	15	Paraguay (Asuncion)[1]	28-49
Venezuela[1]	15	Pakistan[1]	16*
Uganda (Kampala)[1]	14	India (Calcutta)[1]	90
Pakistan	20	West Africa[3]	70
Egypt	14	East Africa[4]	30
2. Urban Peripheries[2]—			
Upper Volta	5-6,5	Pakistan	60
Gabon (Libreville)	7	General[5]	40-60
(Port Gentil)	10		
(Lambarene)	2		
Cameroon	7-8,5		
3. Rural Areas[1]—			
Bolivia	10		
Kenya	7		
Nigeria	25		
Sudan	13		
Tanzania	15		

*automatic taps

1. World Bank (1974)
2. WHO/IRC (1975)
3. Lauria and others (1978)
4. White and others (1972)
5. Dietrich and Henderson (1963)

of economising on water use suggests that present domestic consumption in the UK could be reduced by 45 per cent without any reduction in hygiene level or change in the user behaviour pattern (Rump 1979).

If this is the case domestic water use in the UK would fall upon implementation to 60 l/head d.

Typical water use data for developing regions are shown in Table IV. Although numerous surveys have been carried out it is suspected that in many cases the rates have been overestimated, possibly because design or production data have been used rather than true consumption (World Bank, 1976).

For single-tap connections a figure of 100 l/head d is often regarded as an average use but this is unlikely when it is realised that even in the UK the real consumption in multi-tap connections is of the same order of magnitude. Lauria and others (1978), for example, found that in a West African city those houses with a piped supply used about 70 l/head d. Dietrich and Henderson (1963) recommend a design standard of 40 to 60 l/head d for single-tap connections, the higher figure including an allowance for waste. When a community has been accustomed to using small quantities of water from a stand pipe it does not necessarily follow that the provision of a single-tap connection will result in an immediate increase in water consumption to levels approaching those of the developed countries.

The water use from stand pipes is influenced to some extent by the carry distance. In East Africa White and others (1972) found that when the carry distance in urban areas exceeded 45m consumption was at a minimum of about 15 l/head d and was little affected by increases in distance. In the West African city surveyed by Lauria and others (1978) the population relying on stand pipes or vendors used less than 10 l/head d. When the carry distance exceeds 1.5 km consumption may fall to 5 l/head d or less (World Bank, 1976).

The relationship between carry distance and stand pipe provision has been defined by Lauria and others (1978) to be as follows:—

$$R = 56\sqrt{A/N} \qquad (2)$$

where R = radius of circular area served (m)
A = area served (ha)
N = number of stand pipes

Tentative standards proposed by World Bank (1974) suggest that the water consumption from a stand pipe should be 20 l/head d (40 l/head d if wastage is included), with a maximum carry distance of 200 m and no more than 180 persons/stand pipe. If these constraints are substituted in equation (2) it appears that a population density of 15 persons/ha must not be exceeded. If the maximum carry distance is reduced to 45 m, below which the consumption is more likely to be at least 20 l/head d, the use of equation (2) suggests a population density of 300 persons/ha, a more realistic figure for urban areas.

In most urban areas in developing countries the proposed standards are rarely achieved. In Dacca, for example, the most densely populated area contains about 4 300 persons/ha with 620 people using each stand pipe which only operates for a few hours each day. In the bustees in the urban peripheries where covered dwelling area is of the order of 5.5m²/family, a stand pipe generally serves from 60 to 120 persons.

Because of the wide variation in water use it is advisable to carry out a sample survey to determine reliable data and if time and resources permit to initiate a demonstration project so that design information can be obtained for future water supply upgrading programmes. The advantages of a demonstration project are many, not least that the communities' acceptance of improved water supply and sanitation facilities can be tested and modifications made to further schemes as necessary.

WATER USE SURVEY

A SAMPLE SURVEY was carried out at the beginning of 1979 in an urban area in a Middle East city in order to check actual consumption figures for use in the design of a demonstration urban rehabilitation project. The country ranks at the lower end of the Middle Income Country classification in Table II with a mean infant mortality of about 100/1000 live births. Almost 25 per cent of all children die before reaching five years of age, primarily from dysentery and diarrhoeal diseases which account for 50 to 70 per cent of all deaths. It is considered that the main disease transmission routes in the urban areas are from exposed excreta, refuse and flies. The lack of an adequate quantity of water results in the high incidence of water-washed diseases, including trachoma which is generally found in unhygienic, arid, dusty areas.

The survey area had a population density of about 1000 persons/ha with one quarter of the families living in a single room. Although 60 per cent of the population was served by a sewerage network only 10 per cent had a water flush system and almost half had no water supply to the house. Those households with no sewer connection relied on seepage trenches.

The water consumption data are summarised in Table V. The mean water use was 17.5 l/head d, excluding household G and excluding water used for the weekly laundry. In general terms the amount of water used for washing clothes (about 16.4 l/head) was equivalent to the mean water consumption on non-laundry days. The total mean water consumption was 22 l/head d. There did not appear to be any correlation between water use and carry distance for those households 70 m or more from the stand pipe. The highest consumption, 36 l/head d excluding laundry use, was recorded for household G which was 200 m from the stand pipe but which preferred to purchase water from a neighbour with a house connection, at a carry distance of about 30 m. It is interesting to note that in this case the cost of the water from the neighbour was almost eight times greater than the tariff being charged by the Water Supply Authority for an in-house supply, although the tariff was too low to provide a realistic return to the Supply Authority.

All households used a similar container for carrying water, a metal drum 320 mm diameter and 250 mm high with a full volume of 20 litres. The effective volume arriving at the house was about 18 litres primarily because of the need to maintain some freeboard during carrying.

The mean water consumption of 17.5 l/head d is similar to that of 15 l/head d recorded by White and others (1972), who also reported that the consumption did not increase until the carry distance was less than 45 m.

A survey of water use in a building housing five families, each provided with a multi-tap supply, showed the mean consumption to be 86 l/head d.

The households served by seepage trenches invariably discharged only sewage to the trenches, sullage being tipped into the streets, which were not paved. The bulk of the water used was tipped as sullage; only a small proportion was used for anal cleaning and discharged to the trenches.

Where buildings of more than two storeys were served by trenches the families on the upper floors tended to discharge both sewage and sullage, which invariably resulted in frequent trench overflowing and crude sewage standing in the yards and street. Because of the high water table the trenches were emptied by tanker at approximately monthly intervals. The cost represented about 2.5 to 5.0 per cent of the household income, and was lower for tankers pulled by donkeys than for tanker trucks.

The general conclusions which could be drawn from an inspection of the excreta disposal facilities are that in-house water supply should not be provided without sewerage; sewers should preferably not be provided for houses served by stand pipes (particularly where the

TABLE V: Survey of Water Use in an Urban Area Served by Stand Pipes

	HOUSEHOLD						
ITEM	A	B	C	D	E	F	G
Family size	10	10	5	7	5	6	4
Distance from stand pipe (m)	70	90	130	140	160	160	200
Mean trips/d (excluding washday)	12,5	7	4	6,5	6	8,5	8
Additional trips on washday	12,5	—	3	2	7,5	—	4
Water use excluding washday (l/head d)	22,5	12,6	14,4	16,7	21,6	—	36
Washday use (l/head)	22,5	—	10,8	5,1	27	—	18
Total mean water use including washday (l/head d)	25,7	—	15,9	17,4	25,5	25,5	38,6

Household G purchases water from a neighbour (distance 30m) rather than use the stand pipe.

carry distance exceeds say 30 m), and seepage trenches are generally acceptable for excreta disposal provided that sullage is disposed of separately and the buildings are not higher than two storeys. Sullage disposal to the ground can be acceptable provided that the soil is permeable, land is available and ponding does not occur. Although the pathogenic content of sullage is thought to be much lower than sewage, unless the sullage contains water from washing soiled clothes, the health risk of sullage tipping is more likely to arise from the creation of a wet area which might encourage indiscriminate defecation or mosquito breeding (Feachem and others, 1978).

FINANCIAL IMPLICATIONS

THE INTERNATIONAL Drinking Water and Sanitation Decade target represents a considerable financial investment. According to Kalbermatten (1978) typical capital costs are as follows:—

Water Supply	
Urban areas (mixed house connection and stand pipes)	= £25-75/head
Rural areas — piped systems	= £15-25
— handpump well	= £2.5-5
Waterborne sewerage	
Urban areas	= £50-200
Other excreta disposal systems	= £15

If the target is to be met the capital investment required could be of the order of £40 000 M and £100 000 M for water supply and excreta disposal respectively, say £14 000 M each year for the next decade. On the basis of the indicators in Table II this annual investment is equivalent to 3.3 per cent of the total 1976 GNP of the developing countries, or 0.65 per cent of the 1976 GNP of the Industrialised Countries and Capital Surplus Oil Exporters. The magnitude of this investment makes the UN goal seem optimistic, even if cheaper forms of excreta disposal are developed and adopted on a wide scale.

It is generally found that households in developing countries can afford to pay charges for water supply and waste disposal provided that the total cost does not exceed from 3 to 5 per cent of the total family income. For low cost site and services schemes water supply and waterborne sewerage costs usually represent 20 to 30 per cent and 40 to 50 per cent respectively of the total on-site infrastructure plot costs (World Bank, 1974). Since families in developing countries can rarely afford to spend more than 20 per cent of the household income on housing and associated water supply and excreta disposal facilities, it is apparent that the financial constraints on improving these essential services are onerous.

CONCLUSIONS

THE PROVISION of adequate water and excreta disposal facilities for everyone will bring about a substantial improvement in the level of public health, far more than if a similar level of investment were to be spent in the formal health sector. In order even to attempt to meet the UN target, water supply and excreta disposal designs must be optimised to serve the greatest number of people at the least cost.

In the absence of local information it can be assumed for preliminary planning purposes that the optimum increase in health benefits occurs at a water use of 40 to 50 l/head d, a consumption which should be achieved from stand pipes in urban areas if the carry distance does not exceed 30 m. For a single-tap house supply the consumption is likely to be from 50 to 100 l/head d, probably around 70 l/head d for low income families. If site conditions permit, the disposal of sullage to gardens, unpaved yards or streets may be satisfactory, at least as an interim solution. Excreta disposal systems which do not rely on sewers can therefore be smaller and will probably function more efficiently for longer. Although in many densely populated urban areas in developing countries the expensive waterborne sewerage system may be the only viable solution, particularly where houses are provided with a piped water supply, alternative excreta disposal systems should not be dismissed lightly, since in many cases they represent the only means whereby the level of public health can be improved within the existing severe financial constraints.

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