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Emptying On-Site Excreta Disposal Systems in Developing Countries: An Evaluation of the Problems

In the spring of 1981, the International Reference Centre for Waste Disposal initiated a project in order to evaluate the problems related to emptying pits in developing countries. Field studies on existing emptying devices and on pit latrine contents were conducted in Dar es Salaam (Tanzania) and Gaborone (Botswana). Emptying devices used successfully for many years in the Far East were evaluated during an extensive journey to Japan, China, the Republic of Korea and Thailand.

The following article represents an extensive summary of several reports prepared by **Peter M. Hawkins**, *consultant to the IRCWD for this project. A full report with the numerical data will be published by the International Reference Centre for Waste Disposal. Comments, suggestions and information concerning this subject are welcome. Requests for a copy of the full report or further information should be addressed to IRCWD.*

Introduction

With the increased activity in the field of excreta disposal promoted by the UN Water and Sanitation Decade, it is intended that substantial progress will have been made in the provision of sanitation for at least 1500 million people who at present have totally inadequate facilities. Most of these people live in the periurban and rural areas of the developing countries and have household incomes of less than US $ 500 per year. They are not only unable to afford piped sewerage, it may also be technically inappropriate for them. The need therefore exists to use alternative, well-proven technologies which, if properly designed, will safely dispose of excreta on site, while being both socially acceptable and affordable to the householder. The on-site excreta disposal technologies appropriate for most developing countries are the Ventilated Improved Pit Latrine (VIP) and the Pour Flush Waterseal Latrine (PF).

These latrines are best designed in such a way that when their pits are full, the superstructure can be moved to a new site, or a second pit used while the contents of the first are left to decompose into harmless and inoffensive material. In some cases, however, it may be necessary to empty a pit containing fresh, hence pathogen-laden excreta. This is likely to occur if the householder cannot afford to dismantle the superstructure and re-erect it elsewhere, if only one single pit is available due to financial limitations, or if there is insufficient space on the plot to accommodate a second pit. These constraints are common in fringe and urban low-income areas. In this context, even small to medium sized towns must be counted as urban areas if they have locally high population densities.

The scale of the pit-emptying problem is therefore very large, and it will be even larger in future since many cities and towns in developing countries are embarking on major latrine-building programmes. Most of these programmes of urban excreta disposal provision are currently proceeding without a sufficient technical basis for the removal technology. In particular, removal is rarely considered as imposing any limitations or adaptations on the overall system chosen.

The IRCWD-study presented in this paper was initiated in 1981 with the aim to examine the problems on four levels, namely:

- the pit contents: their composition, physical properties and accumulation rate,
- the technology: currently available and used removal technologies, their shortcomings and possible further development,
- management: case studies of currently operating removal services,
- planning: the mutual consequences of removal technology and latrine design.

There is little published literature relevant to this study which is based mainly on the results of field investigations. These were carried out in two quite widely differing African cities (Dar es Salaam, Tanzania and Gaborone, Botswana) and in one or two cities in each of Taiwan, Japan, South Korea and Thailand. Between them they represent most of the types of urban excreta disposal technology currently being advocated, and a range of physical and socio-economic conditions. No doubt, further areas could usefully have been included in the study, but it was felt that at this stage, further effort would be best directed towards practical developments, before a second round of evaluation.

Latrine systems and their emptying requirements

Table 1 shows the basic types of latrine and compatible collection systems and the fate of excreta and sullage when each is used.

Table 1.
Latrine and collection system types

Latrine system	Collection system	Fate of: Liquids	Solids	Sullage
Pit latrine	Build new latrine	1	1	1,2
Emptyable pit latrine	Manual (bucket, scoop) Vacuum truck	1,3	3	1,2
Vault latrine	Manual Vacuum truck	3	3	2
Bucket latrine	Manual	3	3	2
Septic tank	Manual Vacuum truck	1,2,3	3	1,2
Sewerage	Pipeline + water	3	3	3

Key: 1 - remains in or seeps into ground
2 - dispersed on surface to seepage or water body
3 - removed

The liquid fraction of the excreta includes urine, anal cleansing water and some of the water associated with faeces. The solid fraction is the remainder of the faeces, solid anal cleansing materials (paper, stones, corn cobs, etc), absorbent materials used by menstruating women and a surprising variety of rubbish. Sullage is the domestic wastewater from washing, bathing, food preparation etc. and can have quite a high organic (particularly fat) content.

There are three ways in which these three major components can leave the house plot: by subsurface seepage into the soil and thence sooner or later into shallow aquifers; on the ground followed by a combination of evaporation, seepage and flow in surface drains and other water bodies; and by technological means which can be broadly divided into manual methods employing buckets and scoops, mechanical pumping, usually by vacuum trucks, and sewers.

As far as emptying is concerned, there are in principle only two major types of latrine systems: those (pits) which allow some of the liquids to be disposed of by seepage, and those (vaults) where all the liquids and solids (but no sullage) is retained for collection. In the former case, the sludge tends to be thicker and more compacted. The remainder of the waste not assimilated by the environment has to be removed by technological intervention. Disregarding sewerage, this means manual or mechanical removal followed by cartage to a treatment, disposal or re-use facility.

Manual methods employing scoops and buckets are suitable for the more fluid type wastes, but present obvious health and aesthetic hazards to the workers involved. Thicker sludges have to be dug out, and this can involve almost total immersion in the sludge, as, for instance, by the "vyura" (frogs) of Dar es Salaam who may spend up to six hours in the pit, digging it out. Twin pit systems can overcome the unpleasantness and health hazards involved by allowing the excreta to digest and become virtually pathogen-free after two or more years' storage in the pit. This is the only method devised to date which makes manual emptying an acceptable practice.

Mechanical methods revolve at present almost entirely around the use of vacuum trucks, where atmospheric pressure forces the pit or vault contents along a hose into a tank under partial vacuum. This method of pumping is preferred because the pump does not have to come into contact with the sludge, which may contain solids capable of blocking or damaging it. Again, the thicker sludges can present problems, since the system relies on fluid behaviour by the material to be pumped. In some cases addition of water and/or manual agitation of the contents may be practised to increase fluidity.

The shortcomings of existing pit emptying services using vacuum trucks

In many Third World countries, pit emptying services using Vacuum Trucks (developed in industrialised countries) have been in operation for many years. However, most of these services have proved inefficient and unsatisfactory due to organisational as well as technical reasons. Three main shortcomings have been identified during the study.

Firstly, the physical size of the machinery can prevent adequate access to latrines. Currently available vacuum trucks are of sizes from two tonnes upwards and are too big to be able to drive into the hearts of the ancient cities of Asia or the more recent urban squatter settlements around the world, with their narrow, winding streets adapted for pedestrian traffic. Depending on sludge consistency and strength of the vacuum pumps, hoses of up to 30–70 m length can be used, but in many cities and towns a sizeable proportion of houses can be further than this from the nearest suitable roadway. Even in planned sites and services schemes, where road access is generally good, latrines are often situated at the back of the plot, creating unnecessary difficulties for collection workers.

A more fundamental problem is the absolute constraint that vacuum systems cannot handle some of the thicker, compacted sludges in old pit latrines. In a few cases this can be overcome by mixing extra water with the sludge, using a pole. The principle of vacuum systems demands fluid behaviour of the material to be removed, and an alternative concept is required for sludge not exhibiting this type of behaviour.

The third problem area is in the management of vacuum trucks. Their engines must be kept running all day, either to move the truck or to operate the vacuum pump when stationary. This causes rapid wear and makes them especially susceptible to breakdowns resulting from poor preventive maintenance. Fuel consumption is high, and vacuum trucks may be prime targets for cuts in fuel supplies if the operating agency is forced to make economies. These and other similar problems are typical of high cost, high technology equipment in poor countries, but this does not make them any less real. In addition, a very interesting behaviour of the crews has been observed in places where the fleet of available vacuum trucks is by far too small compared to the requests for emptying. Instead of trying to empty each pit as well as possible, the crews are mainly concerned to serve as many houses per day as possible. This behaviour can easily be explained by the fact that a houseowner is only served by the crews if he or she is willing to pay a considerable amount of money to the crew directly, in addition to the official rate.

Pit contents

In order to determine what kind of material has to be handled by an appropriate pit emptying device, the content of pits and vaults in Tanzania, Gaborone, Taiwan, Japan, South Korea and Thailand were analysed for its properties.

Distribution

As excreta is stored in a pit or vault it tends to separate into different layers. In the most general case there are three layers, but depending on circumstances one or two may be absent. The three layers are, from top down:

- floating scum
- liquid
- sludge/sediment.

For a well-drained or "dry" pit latrine there is no liquid layer and therefore also no floating scum layer.

When liquids are retained in the vault or pit, a scum layer is possible. Its formation appears to be related to at least two factors: the use of paper for anal cleansing, and the number of users of the latrine. When paper is used for anal cleansing there is nearly always a floating scum layer, usually 100 mm — 200 mm thick, which may give the appearance of being very solid. If pressed with a pole, it flexes considerably before the pole breaks through to the liquid below. However, observations show that it is possible to break up such a scum layer with a little persistence, and mix it in with the underlying liquid to a consistency allowing easy removal by vacuum truck. Large balls of paper may cause blockages, but these are relatively easily cleared.

In areas where water is used for anal cleansing, scum is less common, and, when it occurs, usually in a thinner layer (50 mm — 100 mm) and with a softer consistency. Scum samples taken in Thailand had a moisture content around 85% and did not need to be broken up prior to removal by vacuum truck. Data from a survey of 192 pit latrines in Dar es Salaam showed that latrines with large numbers of users are more often completely covered with a scum layer. Strictly speaking, it is probably the number of users per unit cross-sectional area of the pit which determines scum formation. This means that in practice nearly all vault type latrines are scum-covered because of their relatively small size.

The formation of a sediment below the liquid layer appears to be a much slower process. Observation of regularly emptied vaults suggests that it takes about 6 months before an appreciable sludge layer starts to build up. This is probably related to the digestion process, fresher excreta floating as scum due to the entrained gases produced during the early phase of decomposition, and sinking when digestion has proceeded to a certain degree. This is borne out by analyses which show non-volatile solids comprising 12% — 23% of total solids in scum samples, but 30% — 50% or more in sludge. However, once a sludge layer is laid down, its composition and properties are broadly similar to those of sludges from "dry" pits at a similar stage of digestion.

Sludge composition

As stated previously, any scum layer can easily be mixed with the underlying liquid to form a fluid presenting no handling problems. It is the deposited or well-drained sludge layer which proves to be the most difficult to move. The sludge has therefore been studied in more detail.

Sludge composition was measured in Dar es Salaam, Gaborone and Bangkok, whilst in the other countries visited, so little sludge was found that no measurements where made, and published figures for the average composition of nightsoil are presented. Average and extreme values of water content, NVS (as % of total solids) and density are presented in Table 2.

Table 2.
Sludge composition and density

Country	% water		NVS %		Density kg/dm^3		Source
	mean	range	mean	range	mean	range	
Japan	97	97-98	40	30-50	-	-	Magara et al. 1980
Taiwan	97	96-98	41	19-87	1.01	-	Camp, Dresser, McKee 1970
S. Korea	95	94-96	29	24-34	1.02	-	Dept. of Preventive Health, 1978
Thailand	86	81-89	40	12-84	1.04	0.97-1.13	Measured
Botswana	68	43-91	59	37-76	1.27	1.03-1.43	"
Tanzania	46	26-74	42	23-59	1.45	1.11-1.75	"

In addition to these basic components, many latrines contain a certain amount of rubbish, the nature of which reflects the users' lifestyle. In practice, however, the rubbish causes few problems when pits are being emptied, any blockages being relatively quickly and easily cleared. When vacuum trucks are used, it is the bulk flow properties of the sludge which cause problems.

As shown in Table 2, the density of sludge can be as high as 1.75 kg/dm^3, which obviously greatly increases the static head against which any emptying device has to work. In the case of a large vehicle emptying a deep pit, the difference in level from the base of the pit to the top of the tanker may be up to 7 m. With a density of 1.75 this would generate a static head of 1.2 bar, rendering any vacuum-based emptying system useless.

Sludge flow properties

The dynamic properties of the sludge may cause further difficulties once the static head is overcome. Sludge generally exhibits a yield stress, shear thinning behaviour and a degree of thixotropy. All these phenomena have the same practical implication: starting the sludge moving is the most difficult part of the operation, but once it is in a fluid state it can quite easily be kept moving.

The addition of small quantities of water can also have a dramatic effect on sludge fluidity. Two effects are involved: simple dilution, and thixotropy. Tests with sludges from different pits with water contents of 83% and 64% have shown that the addition of an extra 2% of water can reduce resistance to flow 30 – 300 fold, respectively. This effect is probably due more to thixotropy than to dilution.

Another factor of great importance in determining the properties of the sludge is the compaction which occurs over time as it is stored in the pit. This compaction is due partly to pressure from the pit contents overlying the sludge, and partly to the continuous leaching of liquids down through the sludge, washing out soluble digestion products and leaving a matrix of inorganic matter and less easily degraded organic material such as fibre. In the African samples it was observed that a significant amount of sand and soil particles were also to be found, washed in from above and also from the surrounding soil during times of falling water table.

The results of this process can be seen most clearly in the rise of yield stress, density and solids content with time. The overall tendency appears to be for most of the compaction to take place during the first year or so of storage. In addition the measurements showed that the presence or absence of free water in the pit does not correlate with the sludge properties, and that compaction proceeds at an equal pace in both "wet" and "dry" pits.

Sludge accumulation

The sludge accumulation rate was found to be between 7 and 17 (average 12) kg of dry matter per person per year. Thus for the compacted pit latrine sludges of Dar es Salaam and Gaborone with typical moisture contents of 50% – 60% this represents around 25–30 litres of wet sludge per person per year. In Bangkok, with a typical moisture content around 85% this comes to around 80 litres, and in Japan and Taiwan, with nightsoil of 97% water content, to 400 litres per person annually.

Implications for pit emptying

In summary then, it is apparent that the major pit emptying problems are associated with the sludge layer that starts to be deposited after about 6 months' storage. The longer it is stored and the more water that is allowed to leach out of it, the more stiff and resistant to flow it becomes. Organic content too tends to decrease over time because of digestion, and this again reduces fluidity. The mixing in of small quantities of extra water can greatly increase sludge fluidity, mainly because it is thixotropic and reduces its viscosity after the shearing necessary to mix in the water.

Considering this analysis, various possible options for pit emptying would appear feasible:

a) Use vaults or small pits of limited leaching capacity to maintain water content and provide less than one year's storage capacity, thus yielding a fluid material which is easily pumped out.

b) Use pits of more than one year's capacity and fluidise the sludge deposited by some device to apply shear, mixing it with water already present as a separate layer or, in well-drained pits, with additional water.

c) Use pits of more than one year's capacity and remove the sludge as a solid material. The simplest way of doing this is probably by adopting twin pits and desludging manually. For single pits, a solids handling device would be required.

Currently available pit emptying technology

Because access to the sludge is very often only through the (small) drop-hole, and the latrine itself may well be inaccessible, the use of a flexible pipe to convey the sludge from the pit to the removal container appears the most attractive option for a pit emptying device. Accepting this constraint, there are four major options currently available:
- vacuum trucks
- helical rotor pumps
- diaphragm pumps
- air drag systems

In the longer term, solids handling technologies such as bucket or screw conveyors might be developed for pit emptying purposes, but currently available devices of these types are too heavy and bulky for this application.

The first three systems are only effective on liquid wastes and wet sludges which have not been stored long enough to become compacted. Manufacturers of these types of equipment recommend a minimum moisture content of around 80% if sludges are to be effectively shifted. Thicker sludges can be moved by a "gulping" technique, but this is slow and laborious. With these technologies, therefore, there is a need for concurrent use of some fluidising device when handling thick, relatively dry, compacted sludge.

The last-mentioned system, air drag, does not rely on the sludge being fluid, as the fluid flowing in the collection hose is a high velocity air stream which entrains solids or liquids and deposits them in the removal container when the air stream enters and slows down.

Vacuum trucks

By far the most widespread of these four systems in use for pit emptying is the vacuum truck. The main problem with these is engine wear, since the engine runs under load throughout the working day, either hauling the tanker or driving the pump. Some models are fitted with an auxiliary engine to power the pump, but this merely spreads the same maintenance requirement over two engines.

There are two generic types of sliding vane vacuum pump, and these do show significant differences. Most European and North American manufacturers make high-speed pumps with fabric-reinforced resin vanes lubricated by a total loss drip-feed system. This reduces capital cost and is effective in the countries of manufacture where maintenance is efficient and spare vanes and bearings are easily obtained and stocked. In developing countries, however, spares and maintenance are perennial headaches, while capital costs are often met, wholly or partially, by foreign assistance. Even where this is not so, a municipal capital budget is more likely to receive central government support than the recurrent budget. This makes the other (more expensive) type of vacuum pump, manufactured primarily in Japan, much more attractive. Rotational speeds are generally lower, increasing pump lifetime, and the vanes are made of thick steel plate which does not wear or shatter in the same way as resin. In addition, the lubrication system is enclosed, with oil circulating from a reservoir. This allows a much higher lubrication rate than is affordable with a total loss system and hence more reliability.

Other fluid pumping equipment

Helical rotor (also known as progressive cavity or "Mono") pumps and diaphragm pumps are both capable of handling only liquid sludge and, additionally, the sludge must pass through the pump. This calls for more rugged (and expensive) construction than for vacuum pumps and for some device to prevent rigid solid debris from damaging the elastomeric casing (of a helical rotor pump) or diaphragm.

The diaphragm pump has one advantage in as much as it is the only one under consideration which can easily be hand-powered. It also has a minimum of moving parts: check valves, the linkages in the reciprocating mechanism and the diaphragm itself. A hand-powered unit would obviously have a much lower capacity than a motor-powered one and would thus really only be suitable for small pits and vaults where the time spent pumping is relatively small compared with setting up and removing the equipment. However, in small towns with ready supplies of cheap labour, hand-operated diaphragm pumps used in conjunction with vaults of a few hundred litres capacity would be a cheap and simple option. Field trials would indicate the range of sludge conditions over which they would be suitable.

Sludge fluidisation

All the devices discussed thus far would require some ancillary equipment or operation to fluidise thicker, more compacted sludges if they are to be shifted. Vacuum trucks can perform a certain degree of fluidisation without ancillary equipment, provided the hose can be forced down into the sludge, which may not always be possible. Various techniques have been recorded in investigations by the World Bank in U.S.A. and Haiti. These involve switching the vacuum pump into pressure mode and pumping air or water (possibly previously removed from the same pit) into the sludge from below. If the sludge is thin enough to enable the hose to be pushed through it, then the limited pressure available will probably be sufficient to achieve effective mixing. In any case, high pressure would cause erosion of the pit walls and probably also excessive splashing (observed in trials with sewer jetting equipment operating at 100 bar). Sludge of this intermediate consistency can also be fluidised by mixing with a pole (if the pit is not too large) or even removed directly (but slowly) by a "gulping" procedure whereby the hose is pressed into the sludge to enclose a small quantity and then lifted clear until the sludge is removed up the hose along with some entrained air.

However, in very well-drained or mature pits, it is impossible to push the hose through the sludge. In this case, a mechanical, rather than hydraulic, fluidisation technique would be required. No such devices have been field tested, and this is an important area for development. A device along the lines of a vibrating concrete poker has been suggested as a possible solution. The only commercially available equipment for this purpose encountered during the study was a caged propeller, rather large to be lowered into a typical pit and probably not capable of mixing really compacted sludges in any case.

Air drag systems

Air drag systems rely on drag from a rapidly moving air stream rather than an atmospheric pressure to shift material. Thus, in addition to not requiring a fluid sludge, static head is also unimportant, and dense sludge could in theory be easily lifted. The major problem with this type of equipment is the cohesive and adhesive properties of sludge. Three types of air drag equipment were tested by the Building Research Establishment in U.K. (Carrol, R.F., 1981) on simulated sludge consisting of topsoil adjusted to 20% — 40% water content. Because of its cohesiveness, a gulping technique was required to separate chunks of sludge for entrainment, but the net result was up to five times as fast as a vacuum tanker. Build-up of sludge on the hose walls was a problem when flexible hoses were used, leading to decreased air velocity and eventually to blockage. Small quantities of water fed in near the mouth of the hose alleviated this problem.

Thus, although in principle offering the advantage of a simple one-step operation for removing compacted sludge, this type of machine would require further development to make it suitable for desludging. A serious disadvantage is the large auxiliary engine required to drive the air blower, increasing maintenance costs and probably quadrupling fuel consumption, compared with vacuum trucks. Air drag machines of a specification intermediate between most typical air drag machines and vacuum trucks are available in Japan, and possibly elsewhere, with the blower driven by a power takeoff (P.T.O.). Capital cost and fuel consumption are both still considerably higher than vacuum trucks, however.

Equipment size

Apart from reflecting differences in cost, the weight and size of pit emptying machinery are importent factors in determining suitability. Low-income urban areas are typically laid out in a haphazard manner without roadways big enough for large vehicles, and, where roadways do exist, they are often impassable in the wet season because of mud. Big, heavy machines will therefore be unsuitable in most cases. The usual capacity of European and North American vacuum tankers is 4.5 m^3 (1000 gal.) whilst Japanese tankers are commonly 1.8 m^3 with correspondingly smaller chassis. This brings in a further incidental advantage, which is that the top of such a tanker may be 1–2 m lower than a typical European model, thus reducing the necessary static head to lift the sludge.

Suitability of available technology

In conclusion, the most attractive options appear to be the Japanese-type vacuum trucks or hand-operated diaphragm pumps. The latter would definitely require field testing to develop a suitable unit specifically designed for pit emptying. The crucial technological gap is the lack of suitable equipment and techniques to fluidise thick, compacted sludge so that it can be removed by one of the recommended types of pit emptying equipment. If this turns out to be complicated or expensive, air drag machines might prove economically and technically feasible.

Case studies of currently operating services

Emptying services in eight urban areas have been investigated, covering a wide range of conditions: from the small operation in Gaborone employing one vacuum truck, to the huge one in Kawasaki, where more than two hundred are used; from the large pits of Dar es Salaam to the small vaults of Taichung. Decisions made under these various conditions may not necessarily have been the right ones, but must serve as a useful guide to service management elsewhere.

Transfer

The two services operating over the largest areas (Kawasaki and Bangkok) and with the largest workloads, both employ a transfer system. This optimises the use of vehicles, by using large tankers for long distance haulage of the sludge, but allowing the use of small, more frequently emptied tankers to pass into the densely-packed residential areas to empty latrines. In Dar es Salaam where there is no transfer system, the 4.5 m^3 tankers spend 60% of their time on the road. In Kawasaki the vacuum trucks operate in six zones, each with a central dump station where the nightsoil is stored in an underground tank prior to haulage to the treatment works in 10 m^3 vacuum trucks. In Bangkok, transfer is directly truck-to-truck, the vacuum truck being switched to pressure mode to empty its contents into a simple gravity-emptied tanker which hauls the collected waste to disposal. This latter system utilises the secondary trucks less efficiently (1.4 m^3 of secondary truck are used per 1 m^3 of primary vacuum truck, whilst in Kawasaki this is 0.8 m^3) than the transfer station system. However, the high cost of central urban land for dump stations probably more than offsets the lower costs of more efficient transfer tanker utilisation. The Bangkok transfer system may, in any case, be running below peak efficiency, since one transfer truck is nominally assigned to each vacuum truck (although in practice this is nearer one per 1.5 vacuum trucks) and spends a considerable amount of time waiting. Two-way radios might make a contribution here, enabling transfer trucks to keep usefully on the move.

Collection schedules

Scheduling of collections also has an important bearing on service efficiency. Regular collections on a fixed schedule reduce administrative costs and allow for optimal routing of collection journeys. This type of system can be further sophisticated, as in Taichung, by assignment of an emptying interval to each individual latrine, which takes account of different filling rates and ensures that all vaults emptied are more or less full when the tanker calls. Fixed schedules have been adopted by all services where emptying intervals are up to 6 weeks. For intervals of 3 months or more, emptying on demand is the rule. Orders may be processed by the operating authority (Dar es Salaam, Bangkok) or the trucks may travel predetermined routes, being stopped by householders needing their services as they pass (Chuncheon). In Gaborone, a combination of these two systems is used, and this probably represents the most efficient solution.

Zoning

Subdivision of the service area into zones to be served by a single tanker or group of tankers simplifies administration and makes for increased familiarity of crews with their own zones. This can be quite important in squatter areas where particular houses may be difficult to locate. Fixed schedule systems allow very accurate prediction of tanker requirements and one tanker may be assigned to each zone. Where schedules are variable, fluctuations in demand can be averaged out by increasing the size of the zones and the number of tankers in each one. In both Dar es Salaam and Bangkok, about 7 tankers are assigned to each such zone.

Performance of vacuum trucks

It should be noted that in Gaborone and Dar es Salaam a somewhat different service is being provided than in the Far Eastern cities. The large pit latrines of the two African cities are used for a considerable proportion of sullage disposal and could therefore be said to offer a higher standard of service. However, these same large pits suffer the sludge removal problems central to this study, with manual sludge removal or pit relocation accounting for a majority of ultimate solids disposal. The material being removed in all cases is thus essentially liquid with upwards of 80% moisture content. In the African cities, this is collected only from latrines with poor leaching capacity due to soil clogging or adverse soil and groundwater conditions, whilst other pits (in Dar es Salaam, 83% of the total) are not encompassed by the service. By contrast, in the Far Eastern cities, all vaults or pits are included.

The utilisation rate of the vacuum trucks has been defined as the ratio of total volume shifted annually to total tanker volume, or in effect, the number of full loads removed per tanker per year. This ranges from 500 in Sakura to 1800 in Dar es Salaam. The very low figure for Sakura probably represents the effect of competition between several private companies operating removal services in the area. The area served also comprises several rural villages near Sakura, leading to increased travel times. Excess capacity is utilised on industrial work and services in other areas. The next lowest utilisation rate is found in Kawasaki, at 1000 per year. This may in part be due to higher labour costs in Japan, which make efficiency of manpower utilisation relatively more important than efficient hardware utilisation, compared with the other countries where vehicle utilisation rates range from 1300 to 1800 per year. This is a realistic measure of the performance that can be expected of vacuum trucks in developing countries.

Manpower productivity ranges from 255 litres per man hour in Taichung to 486 in Kawasaki. These figures should be interpreted with caution, since most services operate on the basis of daily assignments for each truck, and if the work is completed before the end of the official working day, the trucks do not rush back to the depot for further assignments. It is therefore likely that the higher figures, around 450 litres per man hour, represent the true potential productivity of vacuum truck workers.

Mutual consequences of removal technology and latrine design

Many urban areas have established traditions of latrine construction and use, and any pit emptying service must clearly adapt itself to the requirements of the particular latrine technology used. This will entail the removal of liquid material and, in some cases, compacted sludge as well. The kinds of technological developments needed to deal with this latter problem are discussed earlier in this article.

Nevertheless, current estimates indicate that only about a quarter or, at most, a third, of all developing country urban residents have access to a latrine of any kind. Against this background, substantial efforts are being made, particularly during the U.N. Water and Sanitation Decade, to provide excreta disposal facilities on a mass scale for the people as yet unserved. When planning the large projects involved, the overall system of excreta deposition, storage and removal must be considered, rather than, as up to now, the latrine technology alone.

The current state-of-the-art presents planners with a choice between vault latrines which can be emptied by a (reliable) vacuum truck service, but cause a greater amount of sullage to be discharged to the environment, or, alternatively, pit latrines which can accept considerable quantities of sullage and are less liable to overflow in the absence of reliable pit emptying services, but accumulate compacted sludge which is very difficult to remove. The value of soakage in reducing pit emptying requirements is illustrated by the case of Dar es Salaam, where only 17% of a random sample of pit latrines had called on the vacuum truck service for liquids removal, the remainder requiring only sludge removal.

Twin-pit latrine systems retain all the advantages of pit latrines, whilst allowing for the cheap and simple manual removal of pit contents. These systems take maximum advantage of locally available resources: subsoil for liquids removal by soakage and manpower for solids removal. Thus, in addition to providing a high level of service, another equally important objective, non-reliance on imported technology, is achieved. Where ground conditions and span permit, this is definitely the technology of choice. Even in areas of high water table, twin pits can be used, if the ground is permeable, by building them up above ground level.

Impermeable substrata such as clay or rock, however, preclude the use of pit latrines. In these cases, any latrine built will essentially be a vault, in the sense which has been used throughout this analysis. The studies on compaction indicate that these should be sized for a maximum of one years' storage. Assuming a minimum household size of two and a mean of 5–10, this would necessitate collections every 2–5 months for the average household. The installation of small-bore sewer systems for sullage disposal would be a logical second step in upgrading these systems.

Where ground conditions dictate the use of vaults, some kind of pumping system will be required to empty them. The operation and maintenance of this service will almost certainly be the single most difficult task in the provision of hygienic excreta disposal for the population. The allocation of foreign exchange for the purchase of fuel and spares, the stocking of these (and prevention of their theft), manpower training and the development of an effective revenue collection and subsidy system are thus central to the planning of the whole sanitation project if vaults are to be used.

The widespread adoption of single pit systems is to be avoided except in cases where sufficient land is available on house plots to accommodate several relocations of the pit. Single or double pits can be used in areas of intermediate soil permeability, in conjunction with a liquids removal service for those pits where liquid accumulation exceeds seepage rate, but the same remarks apply to the central importance of this removal service.

Conclusions

Pit contents

The major technological problem in pit emptying services is the non-fluid behaviour of sludge. Sludge begins to be deposited after about 6 months' storage (if the pit or vault contains free liquid) and after about one year or less becomes compacted and difficult to pump. This compacted sludge may be quite dense (up to 1.75 kg/dm^3)

and its flow behaviour is characterised by a yield stress, and a drop in apparent viscosity with increasing shear rate. It is also thixotropic, reducing its viscosity subsequent to the application of shear. The combined effects of shear and dilution can cause dramatic decreases in resistance to flow when small (the order of a few percent) quantities of water are mixed with the sludge. This type of intractable sludge is found only in pit latrines whose large capacity allows sludge to build up over time.

Pit emptying devices

Vacuum trucks are the most commonly used pit emptying technology, and those from Japan appear to be more robust and cheaper than those from the industrialised West. Unfortunately, responses to enquiries in the industrialised countries of the Eastern bloc and Australasia were poor and it was not possible to evaluate the potential of equipment from these sources. Vacuum trucks suffer three major disadvantages:

- large size, limiting access to crowded settlements
- inability to handle compacted sludge
- technological complexity and high fuel consumption, causing operational and financial problems in poor countries.

Hand-operated diaphragm pumps should be relatively easy to develop for pit emptying purposes and would avoid the first and last of the problems just mentioned. However, the work load might be excessive on large pits.

Other fluid handling technologies have no particular advantage over the two just mentioned and have the added disadvantage of necessitating contact between the sludge and the pump.

To adapt fluid handling technologies for pit emptying, a mechanical device for shearing and adding water to the sludge would have to be developed.

Solids handling technologies which might be applied to pit emptying are air drag systems and screw or bucket conveyors. Air drag machinery tends to be large, heavy and expensive both in capital and operating cost and, in these respects, is generally worse than vacuum trucks. Further development would be required to adapt them for sludge removal, centering around the relatively minor problem of sludge build-up in the suction hose. Screw or bucket conveyor systems might also be suitable but would require extensive development to bring them into a form suitable for pit emptying.

Service management

Key decisions in pit emptying service management include the adoption of a transfer system, and scheduling and zoning of collections. The economics of transfer vary for each individual urban area, but in general the reduction of truck mileage by using large tankers specifically for haulage to final disposal is more attractive in larger urban areas, typically over a million inhabitants. Direct truck-to-truck transfer may be the most attractive method when combined with a radio call system. Fixed scheduling of collections reduces administration costs and allows accurate planning. In general, it is suitable for vault systems with intervals between emptying of up to a few months. For pit latrines, requirements are so variable (but less frequent) that emptying on demand is more advantageous. Subdivision of the collection area into zones simplifies administration and increases the familiarity of workers with their own area. For fixed schedule systems, one unit per zone is appropriate, whilst for variable frequency emptying, about 7 units per zone seems to work in practice.

Vacuum truck performance

Typical vacuum trucks can carry around 1500 loads per year on a typical working and maintenance schedule. The annual cost in maintenance and amortization is usually 20% – 25% of the capital cost of the vehicle. Total cost including infrastructure, staff and running expenses are of the order of US $ 10 per m^3 of liquids removed. The efficiency of vehicle utilisation shows a direct relation to the staffing of the emptying service, so in poor countries the use of a 4–6 man crew, effectively administered, is to be recommended.

Suggestions for further work

After having identified the main problem areas in connection with the operation of pit emptying systems and technologies in developing countries, and considering the fact that many cities and towns in developing countries are embarking on major latrine-building programmes which require the existence of such emptying systems, we suggest that further field tests and investigations should be undertaken urgently. Thereby, emphasis should be put on the difficult conditions encountered in many African cities.

a) There is still very little information on the suitability of pit emptying devices, other than European-type vacuum trucks, to handle relatively thick sludges found normally in African pits. Future field tests should be undertaken with further desludging devices available on the market, but which have not yet been used or tested in Africa:

   - Japanese type vacuum trucks which appear to be more robust and cheapter than those used in African countries up to now.
   - Vacuum tanks mounted on a trailer and pulled by a farm tractor. This is a relatively simple device used by European farmers to spread the liquid manure on the fields.

   At present, IRCWD is trying to identify manufacturers in Europe and Japan who are willing to cooperate in these field tests.

b) Investigations and tests should be undertaken in the laboratory and in the field in order to develop new or adapt existing equipment.
   Currently available fluid handling technology could be combined with some device for fluidising the sludge. Alternatively, "solid" sludge could be removed by an air drag or conveyor system, though these, too, would require development to a form specifically designed for pit emptying. It is probable that vacuum or diaphragm pump systems in conjunction with a

sludge fluidisation device will turn out to be more cost-effective than other options.

The British Building Research Establishment (BRE) and the Swedish Building Research Institute (SBRI) have shown great interest in carrying out investigations and field tests. In both organisations, projects could be started thanks to the support of the British Overseas Development Administration (ODA) and the Swedish International Development Authority (SIDA).

Authorities in developing countries, development agencies, research institutes and manufacturers interested in helping to find solutions to the pit emptying problem are kindly invited to write to the Manager of IRCWD.

References

Camp, Dresser and McKee, 1970: "Sewerage Planning in the Greater Taipei Area", **Appendix X "Supporting Material Concerning Nightsoil".**

Department of Preventive Health, S. Korea, 1978: "The Analytical Characteristics of Raw Sludge" (Appendix to a larger report).

Magara, Y., Sugito, D., Yagoma, K., 1980: "Design and Performance of Nightsoil Treatment Plants" **Journal of the Water Pollution Control Federation, 52,** (5), 914-922.

Carroll, R.F., 1981: "Emptying of Pit Latrines — Report of Site Trials of Four Suction Appliances", **Building Research Establishment Note**, No. 64/81.

Review on the Integrated Use of Anaerobic Digestion in Developing Countries – Some Preliminary Findings

For the last eight months IRCWD has been preparing a state-of-the-art review which is partly funded by UNDP. The review is considered to be part of UNDP's global project on Integrated Resource Recovery of which the World Bank is acting as the executing agency.

The literature has been extensively searched by computer, and six short-term consultants have been appointed in various regions of the world to collect information. Recently (March 19 – May 16, 1982) an extensive trip was made by the project leader (Dr D. Stuckey) *to visit these consultants, carry out field visits, and search for literature in various key libraries throughout the world. The following discussion is taken from his back to the office report. The review is scheduled to be completed by the end of the year.*

Overall perspective

The governments of most countries visited seemed to be extremely interested in the potential of biogas, and were keen to see it disseminated. However, depending on the region, the primary benefits emphasised varied. In Central and Latin America the interest was more in waste disposal and nutrient recycle rather than in energy generation. This is due to relatively low population densities and fairly high primary productivity. In Central America cuttings from coffee plants are relatively abundant, and are used primarily in stoves. Some of these countries have oil, and their hydro potential is still relatively untapped.

In S.E. Asia the case is quite similar, and Thailand and the Philippines primarily started using biogas for sanitation and waste treatment, although these countries are not unaware of the depleting fossil fuel supply. China was also concerned more with sanitation and nutrient recycle than with energy per se.

On the Indian sub-continent the situation is reversed. Due to high population densities and lower primary productivities, energy is seen as the prime focus of biogas, together with a concern about soil productivity. In addition, there are more religious taboos in this region about handling nightsoil, and using the gas which it produces. However, because of public health concerns the rural people are starting to accept the connection of latrines to digesters.

In Africa again the primary focus is more on energy due to the acute shortage of firewood, although there do not seem to be strictures on the handling and use of nightsoil.

Finally, in Egypt, the concern seems to be on all three facets, i.e. energy, sanitation and nutrients. This is due to their high population density, and limited water supply. Also since the Aswan high dam has reduced the silt load in the Nile the question of soil productivity is becoming more acute.

Diffusion and implementation

Throughout this trip the question of diffusion and implementation was raised many times. Despite the many obvious benefits of biogas, very few countries had succeeded in implementing large numbers. In many ways this is a unique problem since a large scale programme would involve the installation of the order of hundreds of thousands of digesters, and at the moment most countries, beside China, have very centralised systems of diffusion, primarily run by government agencies who are not geared to a massive diffusion programme. The problem is unique in the sense that it involves a large scale diffusion of a relatively complex technology (in a rural LDC context) into simple agrarian societies, and this has never been attempted before.

The problems are further exacerbated by three main factors:

(i) lack of perceived benefits.
In typical agrarian societies decisions rest mainly with the head of the household (invariably a man). His primary concerns are agriculture, and not household chores which are carried out mainly by the women and children. Hence any campaign to implement digesters based solely on their ability to provide gas for cooking and lighting, despite their obvious public health benefits, is likely to have problems. Also, in many regions of the world cooking fuel is primarily non commercial, and hence free besides the labour to collect it, which is considered a zero cost activity. Even in regions of the world where commercial fuel sources are used (usually kerosene or bottled butane), their prices are so heavily subsidised that the economics of installing a digester are so poor as to discourage all but the innovative. Also in most countries financing of the initial capital investment is often quite difficult.

(ii) initial capital investment.
Even in relatively affluent developing countries the investment involved in a family-size unit (3–6 m^3) is large ($ 250 – $ 500) compared with a family's annual income.

(iii) lack of an infrastructure for technical back-up and problem solving.
From the discussions held, and from the literature it appears that there are a number of courses available to circumvent these problems:

(i) lack of perceived benefits.
The basic problem here seems to be that the benefits occurring from biogas units are primarily **outside** the market economy, eg gas for cooking where firewood can be obtained free, or at least without a cash outlay; dung for fertilizer which can also be obtained without cost (usually); increased public health, which is a more long-term benefit and difficult to demonstrate conclusively. However, the expenditure for building the digester, eg steel, concrete, lies **within** the market, and hence requires a cash outflow which is not balanced by a corresponding cash flow of benefits.

There appears to be two strategies to cope with this problem. In areas where fuel is non commercial, i.e. free for the collecting, it is advisable to attach an income generating activity to the biogas plant, eg generation of electricity for pumping or village industries. This may be difficult to do with a family-size plant due to the limited gas production, although if a duel fuel engine was used, the hot water could be used to heat the digester and hence increase the gas production. The other "feedback" loop would be increased agricultural productivity which in turn could be used in the digester to increase the gas output. This alternative would obviously increase the capital investment of the plant, but could make it more viable due to a tangible cash flow. This philosophy, however, would make community-scale plants more attractive since the volume of gas produced would be that much larger, and could be allocated to both income-generating activities, and cooking.

In areas where kerosene and butane gas are used (and inevitably heavily subsidised) the strategy would be to convince the government to gradually shift the subsidy from the fossil fuels to biogas plants. This would make biogas units competitive even if there was no subsidy on them.

(ii) initial capital investment.
Some of the problems surrounding this issue could be dealt with by the strategies mentioned above. However, there is still considerable room for R and D to reduce the capital cost of the units, and make them more efficient in terms of gas yield per unit of capital invested. There are a great deal of empirical design criteria for digesters which often do not hold up under rigorous analysis and experimentation. It is only recently, due to the increased interest in biogas, that attempts are being made to rationalize the design of biogas units, and work by Prof. A.K.N. Reddy of Bangalore on KVIC plants has shown that the costs can be reduced by as much as 40%, with increases in gas production per kg of dung of up to 14%.

Promising topics in this area include the use of different materials and methods of construction to reduce the cost of gas storage; the use of solar heat to reduce heat losses from the digester and heat the influent; and studies of mixing and flow patterns which show that actual detention times in digesters are often only 50% of design, and hence lead to inefficient substrate utilization. In this regard, it is interesting to note that the Chinese are experimenting with floating cover designs, while the Indians are investigating the fixed cover Chinese design. This demonstrates that both of the leading biogas countries are learning from another and exploring new design avenues to reduce capital costs.

(iii) lack of an infrastructure for technical back-up and problem solving.
While this problem could be solved by an extensive government infrastructure like agricultural extension workers, some people have argued that this function should be put into the hands of private entrepreneurs so that the infrastructure would be profit and service oriented, and hence (hopefully) more efficient.

Obviously this course of action should only be undertaken under some sort of government control, but could arguably result in a more efficient diffusion and back-up. Some people would take this argument further and say that the infrastructure would be profit and service oriented, and hence (hopefully) more efficient.

If some, or all, of these strategies were implemented, it would appear that biogas diffusion and implementation could be speeded up, and hence alleviate some of the problems in rural areas.

Community biogas plants

The question of the role of community biogas plants was also raised many times during discussions. The benefits are fairly obvious and include economies of scale (and hence cost); surplus gas production for income generating activities; more efficient operation due to increased ability to have a full time operator and to use other materials besides cow dung; and finally, considerations of equity where the landless and cattless poor can be provided gas in return for their labour. The technical problems are not insurmountable and revolve around gas distribution, and operation of a more sophisticated technology compared with a family-size unit. However, the main problem seems to be the socio-cultural one. Community participation and cooperation are essential, and in many cases factions based on race, religion or village feuds disrupt this cooperation severely. The problem of involvement is also important since the unit belongs to the village and no-one feels particularly responsible.

Obviously there are problems still to be solved, and careful socio-cultural fieldwork and preparation are necessary if a large project is to be successful. The question then becomes a normative one to some extent, that is if the village is not ready for a community project should you force it upon them? This question raises the whole issue of development, and the diffusion of new technologies to enhance development. Obviously development means change, and without change development cannot occur. It is a circle that needs to be broken, and transformed into a self-reinforcing upward spiral. Hence, considerable thought should be given to strategies to convince village people that a community project of this sort will benefit them greatly.

Other considerations

1) The use of thermophilic processes was also mentioned a number of times, but the general conclusion was that the benefit it brought in shorter retention times (lower capital cost) and increased pathogens kills, did not balance the problems of operating and maintaining these more unstable units except in specialised industrial applications.

2) The value of the digested slurry is also important, and while monetary values have been put on its nutrient value, another important property is its soil conditioning value which has not been properly investigated. Obviously in comparing the value of the dung and the digested slurry, this is not critical since they are approximately equal. However, with the economic analysis of digested slurry versus commercial fertilizer (eg urea, superphosphate), this is an important attribute of the slurry which may be more economically significant than its nutrient value. This question needs to be answered with long-term field studies, and to the author's knowledge this has not been done.

   Another point with the digested slurry is the relative importance of its free ammonia content. Since nitrogen is taken up as NH_3 by plants it is useful to have nitrogen in the slurry as NH_3 and not as organic nitrogen. However, if the slurry is dried for some months before use, which is common practise in many regions of the world, the NH_3 volatilizes and is lost. In this case it would be better to have the nitrogen in the organic form which is not lost during drying. In order to achieve this, the digester should be run at higher C:N ratios than normal practice ($\sim$25:1 $\rightarrow$ 30:1) in order to incorporate all the free NH_3 as organic nitrogen in cell material.

3) Little interest was shown in most of the countries visited in the use of anaerobic processes to treat industrial wastes. While this is understandable in the light of the aim of meeting the basic needs of the rural poor, it is regrettable since this is one area where anaerobic digestion technology could gain a significant foothold, and act as a bank of trained technicians. It could also help in reducing the energy demand in industry and alleviate some of the more pressing problems in water pollution. It is recommended that further interest be stimulated in this area.

4) While there was considerable interest shown in biogas, very few countries had extended the concept to include the idea of **integrated** resource recovery, i.e. utilizing the process in an integrated scheme for food production (eg fish ponds), or using the outputs to increase biomass production (eg water hyacinth or algae growth). These concepts should be disseminated more fully through technical advice and assistance.

New IRCWD Projects

Treatment of surface water by horizontal-flow roughing filters followed by slow sand filters

Operational difficulties with Slow Sand Filters used for the production of potable water are experienced in developing countries. These problems are caused mainly by the inadequate raw water quality. The use of Slow Sand Filters is limited to raw water with little turbidity, hence requiring in most cases pretreatment of the surface water. Usually this pretreatment consists in destabilisation of the suspended solids by addition of chemicals (e.g. aluminum sulfate) and in subsequent separation of the destabilised matter by sedimentation or filtration. Because of the difficulty in obtaining chemicals and assuring their proper dosage, this process is normally not reliable enough to be applied in rural water supplies of developing countries.

Horizontal-flow Roughing Filters (HRF) are in discussion as an alternative and appropriate pretreatment process. The turbid water flows in horizontal direction through a sequence of 3 to 4 different gravel packs each about 2 to 6 m long. Due to its large silt storage capacity, these gravel packs require infrequent clearing (a few months to a few years). Cleaning is done by excavating, flushing and refilling of the gravel in the filter compartment. HRF need local material and manpower only and are therefore completely self-reliant.

Laboratory and field tests were conducted during the past few years at the Asian Institute of Technology, Bangkok/Thailand, and at the University of Dar es Salaam/ Tanzania. The experiences gained so far with the HRF are promising. It seems that HRF can meet the raw water quality standards required by the Slow Sand Filter.

The present investigations are aiming at developing proper design guidelines for the HRF. Laboratory tests are mainly financed by the Swiss Development Cooperation and conducted at EAWAG/IRCWD in Switzerland to study the processes in the HRF. Additional field tests will be run in Tanzania to check the results found in the laboratory.

Two workshops on HRF held in Tanzania are included in the 2 1/2 year project. They will serve as an information panel, and will motivate regional water engineers to implement the proposed treatment process.

Comments, suggestions and information concerning this project should be sent to: M. Wegelin, IRCWD.

Laboratory studies on anaerobic processes to treat sullage in developing countries

For millions of people in developing countries, the adoption of low-cost on-site excreta disposal technologies such as improved pit latrines, compost toilets and pour flush latrines with soakpits or vaults is the only affordable means of improving their desperate hygienic situation. However, it requires that separate facilities be provided for the disposal of sullage which is defined as all domestic wastewater other than toilet wastes. Sullage contains some excreted pathogens and a variety of organic compounds, most of which are readily biodegradable except some "hard" detergents present in locally available washing powders. Approximately 40 to 60 percent of the total household production of waste organics (excluding garbage) is associated with sullage: i.e. some 20 to 30 grams BOD per capita daily. Indeed, there are many canals and streams in urban areas of developing countries that are grossly polluted by sullage and garbage. To indiscriminate sullage disposal may not only damage the environment but may also have serious public health consequences.

Since January 1982, IRCWD has been carrying out laboratory studies on anaerobic processes in order to assess the feasibility to treat sullage before it is discharged into an open drain. Anaerobic processes have the advantage of generating little excess sludge, which facilitates the maintenance. In addition, with moderately concentrated wastes, they can yield energy in the form of methane.

The two reactor types tested in this project are the "Anaerobic Filter" and the "Anaerobic Baffled Reactor" (ABR), a reactor type developed by Bachmann and McCarty at Stanford University. Both systems are designed in such a way as to retain the active biomass in the reactor. This offsets the problem of slow growth in anaerobic systems, and hence the reactors can be operated at short hydraulic detention times (6–24 hrs).

Preliminary results show good COD removal in both systems, with a slightly higher elimination in the Anaerobic Filter. Since both systems are operating satisfactorily, their performance will be evaluated in the laboratory, especially with regard to COD removal at different temperatures and hydraulic loads. By end of the year, enough data should be available for designing pilot plants to conduct field experiments in a developing country.

Depending on the specific situation, it is envisaged to install reactor units for single houses and/or for group of houses.

New Publications

Participation and Education in Community Water Supply and Sanitation Programmes, A Literature Review, (revised edition) by **Christine van Wijk-Sijbesma** (IRC Consultant), International Reference Centre for Community Water Supply and Sanitation, The Hague, The Netherlands, December 1981, 222 pages.

This revised edition focusing on water and sanitation in developing countries, incorporates additional information obtained from the extensive documentation IRC has since received from many readers of the first edition published in 1979. The revisions mainly concern the chapters on planning and evaluation, as well as the sections on economic conditions, manpower, the mass media, user education, delegation of authority and water rates, and on training.
New annexes feature topics like educational inputs and manpower aspects of participatory water and sanitation projects.

Copies can be obtained from IRC, P.O. Box 5500, 2280 HM Rijswijk, The Netherlands. Price: US $ 15.–. Individuals and organisations based in and from developing countries may apply for a complementary copy.
Spanish and French versions of the revised edition are in preparation.

International Drinking Water Supply and Sanitation Decade: Project and Programme Information System, June 1981, 25 pages.
This booklet has been prepared by the unit for **Global Promotion and Cooperation for Water Supply and Sanitation (GWS)** of the World Health Organization, Geneva, Switzerland.

Main guidelines (a three-stage system) for a Project and Programme Information System have been devised by WHO to help government officials dealing with water supply and sanitation matters and international staff and others involved in different capacities in the external support of the International Drinking Water Supply and Sanitation Decade. It advises officials on how to prepare proposals for potential funding agencies.

This booklet may be obtained free of charge from the Unit Manager, GWS, World Health Organization, 1211 Geneva 27, Switzerland.

The **International Drinking Water Supply and Sanitation Decade Directory**, first edition, June 1981, 407 pages. The information in the Directory, which was collected by the World Bank, the World Health Organization and UNDP, was compiled by **WorldWater magazine**, in collaboration with WHO.

This is a nation-by-nation guide to water supply and sanitation policies and Decade targets in 116 developing countries. The Directory shows how many people are currently served with safe drinking water supplies and proper means of sanitation in each country. It gives the national plans to meet the UN's target of 100% coverage by 1990. The Directory analyses the current situation and gives a review of the importance attached to the separate sectors in the past.

There is also a section on the water and sanitation policies of some of the major development banks, UN agencies, bilateral aid organisations and voluntary organisations.

The first edition will be followed by a review of progress in 1983. This second edition will be based on the responses to a request to developing countries to report data on progress achieved during the first two years of the Decade, and their revised plans for the remainder of the Decade.

Journalists in developing countries, and non-commercial organisations, may request a free copy of the Directory from their local UNDP representative, or by writing to: Mr Ingvar Ahman, GWS Unit, World Health Organization, 1211 Geneva 27, Switzerland. Other individuals and organisations should contact the publisher, Thomas Telford Ltd, 1–7 Great George Street, London SW1P 3AA, UK. Price: £ 40.– post-free in the UK, or US $ 100.– by air overseas.

Rural Sanitation: Planning and Appraisal compiled by **Arnold Pacey** with research by **Catherine Goyder,** 1980, 68 pages. OXFAM Document, published by Intermediate Technology Publications Ltd., ISBN 0 903031 72 8.

This book has been written mainly for hospital staff and community development workers in Third World countries who may be planning programmes to improve sanitation or hygiene in rural areas.

Although the term "sanitation" can, strictly speaking, cover water supply as well as excreta disposal, it has been assumed here that sanitation is not concerned with major improvements to village water supplies. It might, however, deal with the smaller improvements that an individual householder may make. Therefore, this booklet does include brief notes on household water supplies, mentioning backyard wells, small water filters and, in particular, rainwater storage tanks. However, these subjects are considered from the standpoint of planning, not technology. As with the other booklets in this series of publications on "socially appropriate technologies", it is focused mainly on experience gained from practical projects.

Requests for copies should be addressed to: Intermediate Technology Publications Ltd., 9 King Street, London WC2E 8HN, UK.

How to Build and Use a Compost Latrine by **Uno Winblad** and **Wen Kilama,** 1981, 15 pages. This pamphlet was published by the Swedish International Development Authority (SIDA), ISBN 91 586 7009 2.

It provides some of the latest findings on the theme of composting latrines and gives practical guidance for the construction, management, maintenance and use of compost latrines and improved pit latrines. The emphasis is on measures that can be implemented with limited resources. It is illustrated with simple drawings that show each step of the building process.

It is in fact a simplified version of one chapter in "Sanitation without Water", a manual aimed at Africa but also useful to readers in other developing countries. With some adaptation to local conditions, the technical solutions put forward in these two books are applicable to other parts of the world.

An Arabic edition of "Sanitation without Water" by the same authors is to be published by the WHO Regional Office for Eastern Mediterranean, P.O. Box 1517, Alexandria, Egypt. "How to Build and Use a Compost Latrine" is to be published in Swahili and Amharic. Requests for copies should be addressed to the Health Division, SIDA, S-105 25, Stockholm, Sweden.

Appropriate Sanitation for Urban Areas by **John Hebo Nielsen** and **Jes Clauson-Kaas,** February 1980, 138 pages. This book was published by Cowiconsult, Consulting Engineers and Planners AS, Virum, Denmark.

Besides describing the background for selecting an appropriate sanitation technology, an attempt was made to give a method of relating investments directly to the household income. It is also suggested that everybody must financially contribute to the solution of the sanitary problems, the overall objective being the improvement of public health.

Project appraisal is described and an approach to appraise benefits accrued is included. This approach (AIC-method) also indicates how cost-effective investments are made.

To illustrate the suggested approach to investments in sanitation schemes and appraisal of alternative solutions, a case study was applied to the provincial capital of Morogoro in Tanzania.

Detailed background material made it possible to consider physical, socio-economic and socio-cultural conditions when selecting sanitation technologies to be applied in urban African areas.

This booklet may be obtained from: Cowiconsult, Consulting Engineers and Planners AS, 45 Teknikerbyen, DK-2830 Virum, Denmark.

Manual for Rural Water Supply (with many detailed constructional scale-drawings), Publication No. 8, 1980, 175 pages. This manual was published by **SKAT**, St. Gall, Switzerland, but compiled and edited by HELVETAS, Zurich, Switzerland and Yaoundé, Cameroon.

Intending to provide Community Development officials, engineers and field staff who are planning and implementing water schemes in rural areas with useful information, a Manual for Rural Water Supply was first issued in 1975 (SATA-Helvetas Buea, Cameroon). Since then, improved and more adapted techniques and material have been developed which lead to this revised second edition of the Manual for Rural Water Supply.

It is based on actual field activities during the last fifteen years in the United Republic of Cameroon (West Africa). It provides a guideline on how to identify, plan, organize and execute drinking water projects. Manyfold aspects such as hydrology, safety standards for drinking water, design of water schemes, construction and maintenance, spring catchments, barrage and river intake systems, distribution systems and water lifting are treated. The material is suitable specially for engineers and construction supervisors but serves also to give a comprehensive overview of all aspects of rural water supply to non-technical people.

Emphasis is on solid, long-lasting structures of simple design and on the use of labour-intensive methods and local materials wherever possible.

The field of well digging is covered very briefly only, and the exploitation of alternative energies for water lifting is referred to only in connection with the use of hydraulic rams. Specific alternative technologies such as alternative cements, the use of bamboo and other local material for reinforcement and traditional, local construction skills are not included since the manual is based on action oriented projects rather than research.
A French edition is also available.

Copies of this manual can be obtained from: SKAT, Swiss Center for Appropriate Technology, Varnbüelstrasse 14, CH-9000 St. Gall, Switzerland. Price: Sfr. 34.– per copy.

Health Aspects of Excreta and Sullage Management – A State-of-the-Art Review by **Richard G. Feachem, David J. Bradley, Hemda Garelick,** and **D. Duncan Mara,** December 1980, 318 pages. This report has been published by the World Bank's Transportation, Water, and Telecommunications Department under the heading "Appropriate Technology for Water Supply and Sanitation", Series volume No. 3.

This report sets out to provide information about the interaction between excreta and health so engineers and planners may make more informed and rational decisions regarding the effects on disease of improvements in excreta disposal and the ways in which particular excreta disposal and reuse technologies affect the survival and dissemination of particular pathogens. It has been written with an emphasis on presenting the complex, and sometimes contradictory, evidence as clearly and concisely as possible.

Volumes in the "Appropriate Technology for Water Supply and Sanitation" report series, are available free of charge from: The World Bank, Publications Unit, 1818 H Street N.W., Washington, D.C. 20433, USA.

UNDP Decade Bibliography, 28 pages.

The United Nations Development Programme is now distributing a Bibliography as a reference service, and it lists books, newsletters, reports, etc. on World Water and Sanitation Decade topics.

The Bibliography is divided into 17 subtopics such as general information about problems, issues, and approaches, as well as about health, water-related diseases, sanitation, and regional reports, to name a few.

Copies of the Bibliography are available from: UNDP, Division of Information, Room DC-1900 (Mr W. Hailemelekot), One UN Plaza, 1st Avenue, New York, N.Y. 10017, USA.

Answers to Pollution Puzzle

1 G	2 O	3 A		4 V	5 A	6 U	7 L	8 T		9 S	10 R	11 A
12 A	I	R		13 E	N	S	U	E		14 R	I	B
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22 T	23 R	24 U	E		25 S	O	26 S		27 A	28 R	25 T	30 S
31 A	E	R	A	32 T	E	D	L	33 A	G	O	O	N
34 B	S	B		35 T	R	E	A	T		36 M	O	I
37 L	E	A	38 C	H	I	N	G	F	39 I	E	L	D
40 E	T	N	A		41 N	T	S		42 D	O	S	E
			43 I	44 T		S		45 W	L			
46 M	47 I	48 N	N	O	49 W		50 F	A	E	51 C	52 A	53 L
54 P	R	O		55 S	E	56 W	E	R		57 O	D	E
58 N	E	W		59 S	T	E	E	P		60 W	O	E

CIRCULAR

IRCWD is evaluating the impact of the use of its Newsletter "IRCWD News" and identifying its users.

In the tear-off section on the back of this page, we are requesting information which will help us in our evaluation. In case you haven't already sent us this form, kindly fill in the requested information and return by 31 October 1982.

If no reply is received from you by that date, we will assume that you do not wish to continue receiving "IRCWD News".

Thank you in advance for your help.

S. Peter, Editor
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Do you wish to continue receiving "IRCWD News"? YES ☐ NO ☐

Comments or suggestions: ______________________________

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Name: ______________________________

Organisation: ______________________________

Full mailing address: ______________________________

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