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Emptying On-Site Excreta Disposal Systems: Field Tests with Mechanized Equipment in Gaborone (Botswana)

In issue No. 17 (August 1982) of IRCWD News we published an article discussing the problems related to emptying on-site excreta disposal systems in developing countries. In this article it was suggested that further investigations and tests should be undertaken in the laboratory and in the field to develop new or adapt existing equipment, taking into account the difficult conditions encountered in many developing countries. In the meantime, such development work was carried out in England and Sweden. In autumn of 1983, three prototypes of new or adapted desludging equipment were ready for field trials. Tests were then conducted in Gaborone, Botswana from October 1983 to February 1984 to determine the technical limits of these prototypes in handling the material encountered in pit latrines.

The following article by **Andrew Bösch** *and* **Roland Schertenleib** *represents an extensive summary of the final report on the field tests conducted by the Gaborone Town Council's crews under the technical supervision of IRCWD and the Government of Botswana. Financial support and technical assistance were provided by the British Overseas Development Administration (ODA), the Swedish International Development Authority (SIDA) and the World Bank's Technical Advisory Group (TAG). 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, substantial progress will have to be made in the provision of sanitation for at least 1500 million people who at present dipose of totally inadequate facilities. Most of these people are not only unable to afford piped sewers, but these may also be technically inappropriate for them. Therefore, there is a need for alternative, well-proven technologies which, if properly designed, will safely dispose of excreta on site, and will also be socially accepted by the communities and affordable to the householder. The most important technologies benefiting millions of people are the Ventilated Improved Pit (VIP) latrine and the Pour-Flush (PF) toilet. These latrines may be relocated onto a new site when their pits are full, 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, pathogen-laden excreta. The magnitude of the pit emptying problem is therefore considerable and rapidly increasing as many cities and towns in developing countries are embarking on major latrine-building programmes.

In 1981, the International Reference Centre for Wastes Disposal (IRCWD) initiated a project to investigate the pit emptying problem. Field studies on existing emptying services and on pit latrine contents were conducted in Tanzania, Botswana, Japan, China, Thailand and the Republic of Korea. These studies revealed that in many Third World countries pit emptying services using vacuum tankers developed in industrialized countries have been in operation for many years. However, most of these services have proved inefficient and unsatisfactory except in some Far East countries, where predominantly vaults containing very thin sludges are emptied successfully. The main shortcomings identified during the study are reported in an article published in IRCWD News No. 17 [1]. They can be summarized as follows:

- *The physical size of the machinery can prevent adequate access to latrines. Currently used vacuum trucks are of sizes from two tonnes upwards and are too big to be able to drive into the hearts of many ancient cities or urban squatter settlements with their narrow, winding streets designed for pedestrian traffic.*
- *Conventional vacuum systems cannot handle some of the thicker, compacted sludges in old pit latrines.*

- *Maintenance of vacuum tankers is often poor. 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 particularly susceptible to breakdowns if preventive maintenance is neglected.*

- *Management and supervision of the emptying services are often ineffective.*

Based on these studies, IRCWD suggested that further investigations and tests should be undertaken in the laboratory and in the field to develop new or adapt existing equipment, while taking into account the difficult conditions encountered in many developing countries. This incited different countries to carry out further development work. For instance, the British Overseas Development Administration (ODA) contracted the Building Research Establishment (BRE) to develop appropriate methods for desludging on-site sanitation systems. Following suction trials with various pumping systems, BRE produced a specification for a suction tanker, which resulted in the design and construction of the BREVAC prototype. A similar project was initiated in Sweden. The Swedish International Development Authority (SIDA) appointed the National Institute for Building Research (SIBR) to conduct a project for bringing together Swedish expertise in the manufacture of pumping equipment and motor vehicle manufacture. The ROLBA prototype, based on a conventional Swedish vacuum tanker, was built for this project. A third prototype of emptying equipment was developed by ALH in the U.K., which is based on the principle of a vacuum excavator used to remove small quantities of earth in gas mains.

In 1983, all these prototypes were ready for field trials. For logistic and practical reasons it was agreed among the parties involved to conduct the trials in Gaborone, Botswana. The tests were conducted from October 1983 to February 1984 by the Gaborone Town Council's (GTC) crews under the technical supervision of IRCWD and the Government of Botswana, and with the financial and technical support of ODA, SIDA and the World Bank's Technology Advisory Group (TAG).

The objective of these field tests was to determine the technical limits of the prototypes in handling the material encountered in pit latrines, even though it was recognized that a testing period of only a few months would be too short to assess the suitability of the different equipment with regard to long-term operation and maintenance.

Alternative Techniques in Mechanized Sludge Removal

Mechanical emptying methods revolve at present almost entirely around the use of vacuum trucks, where atmospheric pressure and/or high airflow rates force the pit or vault contents along a hose into a tank under partial vacuum. This method of shifting the material 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. The literature refers to *vacuum* and *pneumatic conveying systems,* i.e. air drag, plug drag and 'suck and gulp' techniques. To distinguish between these systems, it is necessary to consider not only the performance of the vacuum pump, but also the design of the hose inlet and the manner in which it is used.

Vacuum System

This system operates with a high vacuum but low airflow rates. The transport of the sludge is effected through the hose inlet permanently submerged in the material to be shifted, whereby the atmospheric pressure acts on the surface of the sludge forcing it along the hose into the holding tank. Because the hose inlet is permanently dipped into the sludge, the material to be transported along the hose has to be liquid enough to flow. Therefore, the main problem with such systems is their ability to remove liquid and thin sludges only.

Pneumatic Conveying

This system works on the principle of entraining the material to be transported in a high velocity air stream. The optimum velocity, however, depends very much upon the type of product and the pipeline in which the material is being conveyed. To introduce air into the pipe, three techniques can be used:

a) constant air drag system:
This method requires the hose inlet to be held a few centimeters above the surface of the material to be shifted. Due to the very high velocity of air, particles of sludge are suspended in the air stream and drawn along the hose into the holding tank. This system, however, does require some operating skill and, as the hose inlet must be held a few centimeters above the surface of the sludge, it is very tiresome. In addition, it calls for large centrifugal fans to supply the necessary airflow (up to 55 m^3/min.).

b) air bleed nozzle:
An air bleed nozzle is composed of a rigid pipe connected to the inlet end of the sludge hose with a small air bleed pipe attached to its side. This pipe allows air to enter the end of the hose system, and thus maintains the airflow necessary for the transport of the sludge particles. When the nozzle inlet is immersed in the sludge, air is drawn down the air bleed pipe which is open to the atmosphere at its top end. Compared to a constant air drag method, this system has the advantage of not requiring such a high air blower.

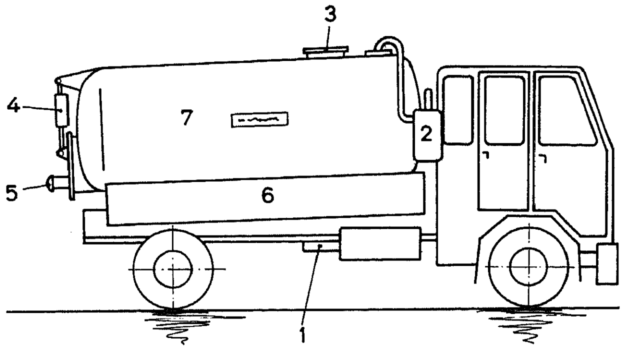
c) plug drag ('suck and gulp') system:
If the airflow rate is too low to allow work with a constant open hose end on the surface of the sludge or if no air bleed nozzle is available, pneumatic conveying can nevertheless be achieved by the so-called 'suck and gulp' or 'plug drag' technique. This method relies on raising and lowering the hose inlet in and out of the sludge, which gives the vacuum pump time to create a new vacuum inside the slurry tank between each up and down movement. By pulling the hose periodically out of the sludge, the vacuum inside the tank is released, and a high velocity air stream passes through the hose for a short moment, thereby carrying along the heavy particles.

This system, however, only works well if the pump capacity is adequate to create quickly a new vacuum inside the slurry tank between each up and down movement of the hose. This mode of transporting the sludge along the hose is therefore a combination of air drag and vacuum system and referred to in this report as the plug drag system.

Description of the Equipment Tested in the Field

During a 4-month period, two vacuum tankers in regular service in Africa and three prototype pit latrine emptying systems were tested systematically. In addition, some tests were conducted with a hand-operated diaphragm pump.

Fig. 1:
CALABRESE Tanker

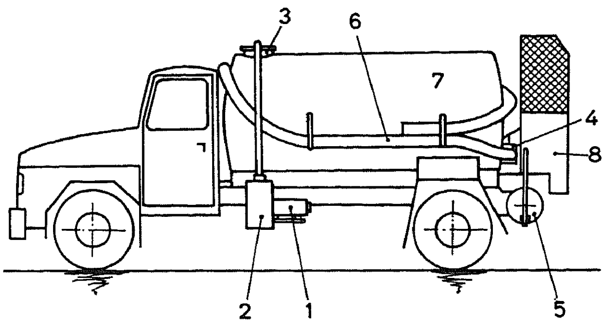


1. sliding vane vacuum pump
2. separator
3. hatch
4. hydraulic door opener
5. suction and discharge valves
6. hose container
7. slurry tank

CALABRESE Tanker (see Fig. 1)

The CALABRESE is a conventional medium-sized vacuum tanker currently in use in Dar es Salaam (Tanzania). It is equipped with a ***low-volume sliding vane vacuum pump*** and a tank of a 4.5 m^3 capacity. At the rear, the tank is equipped with a hydraulically-operated door unto which both the 100 mm suction and discharge valves are mounted. The suction supply line leaves the tank alongside the hatch and passes a small slurry separator before reaching the vacuum pump. ***The pump creates a vacuum head of 0.5 bar and a maximum airflow rate of 5.2 m^3/min.*** It is powered by the V-belt drive connected to the truck's gearbox. Emptying work is carried out with a maximum of 12 segments of 100 mm heavy duty PVC hoses, each 3 m long with quick couplings. The full tank is discharged under pressure by reversing the pump rotor speed. The whole unit is mounted on a Fiat 110 chassis powered by a 90 kW diesel engine. ***The performance of the pump enables the tanker to be used as a vacuum system.***

Fig. 2:
POOLE Tanker



1. sliding vane vacuum pump
2. sludge separator
3. hatch
4. suction valve
5. outlet valve
6. 100 mm hose wrapped around tank
7. slurry tank
8. platform with seats

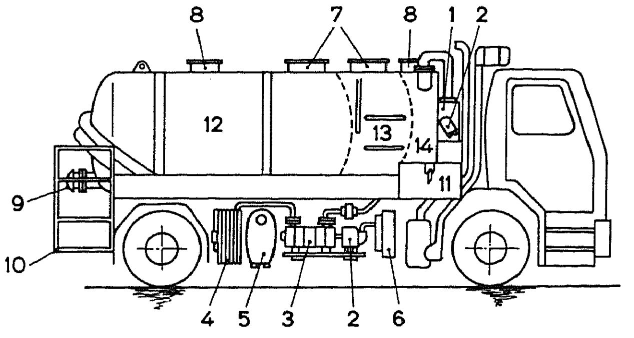
POOLE Tanker (see Fig. 2)

The POOLE is a conventional large-sized vacuum tanker currently in use in Gaborone (Botswana). It is equipped with a ***low-volume sliding vane vacuum pump.*** The 3.4 m long oval tank has a capacity of 7 m^3 and is permanently fixed on the chassis. Fitted to its rear end is a 100 mm suction flange with a lever-operated slide valve. The suction supply line leaves the tank through the hatch cover to a small water separator and through a paper filter unit to the vacuum pump. ***The pump*** is an air convection cooled sliding vane type which ***produces a vacuum head of maximum 0.67 bar at a maximum airflow rate of 2.3 m^3/min.*** It is mounted on a back stage and driven by an auxiliary one-cylinder Lister diesel engine. Discharging the full tank is carried out under static head through a 250 mm gravity outlet flap valve. The whole unit is mounted on a Toyota DA 116 chassis powered by a Toyota 105 kW diesel engine. Since 1982, however, all the chassis have been equipped with ADE engines (Atlantis Diesel Engines). ***The performance of the vacuum pump enables the tanker to be used as a vacuum system.***

ROLBA Tanker (see Fig. 3)

This prototype system was designed and manufactured by ROLBA to specifications by Ragn Sells and SBRI (Sweden) and with SIDA backing. It is a large-sized suction tanker ***equipped with a heavy duty sliding vane vacuum pump*** powered by a hydraulic PTO system. The tank is subdivided into three chambers: a 6 m^3 slurry tank fitted with a small rear door (0.4 by 0.45 m) onto which a 75 mm suction valve and a 100 mm suction and discharge valve (lever-operated globe valve) are mounted; a 1000 l clean water tank for cleaning and diluting purposes and a large slurry separator. The MORO M9 sliding vane ***vacuum pump performs a vacuum head of 0.8 bar and a maximum airflow of 17 m^3/min.*** It is driven by a hydraulic PTO system which consists of a central oil pump powered by a drive shaft from the truck's gearbox.

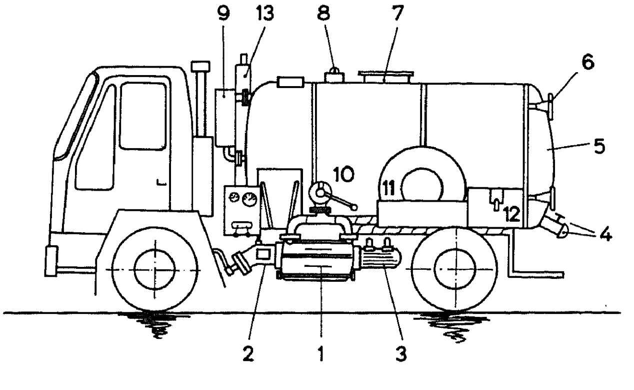
Fig. 3:
ROLBA Tanker



1. sliding vane vacuum pump
2. hydraulic motor
3. washwater pump
4. washwater hose
5. hydraulic oil tank
6. cooling radiator for hydr. oil
7. hatch
8. pressure safety valve
9. suction/discharge valve
10. platform
11. tool locker
12. slurry tank
13. clean water tank
14. slurry separator

This oil pump creates the oil pressure in the closed hydraulic system onto which the hydraulic motor for the vacuum pump and the hydraulic motor for the clean water pump are connected. A 130 l hydraulic oil tank supplies the necessary oil to the system. To carry the whole unit, Ragn Sells and SBRI have chosen a Scania P82H chassis powered by a 155 kW diesel engine. ***The performance of the vacuum pump enables the tanker to be used both as a vacuum and a plug drag system.***

Fig. 4:
BREVAC Tanker



1. liquid ring vacuum pump
2. hydraulic motor
3. service liquid pump
4. load and discharge valves
5. swing-out rear door
6. handwheel
7. hatch
8. pressure safety valve
9. water separator for discharge air
10. load discharge control valve
11. spare wheel
12. tool locker
13. tank hydraulic tipping cylinder

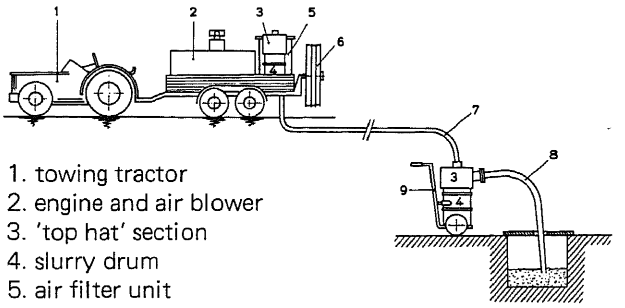
BREVAC Tanker (see Fig. 4)

This prototype suction system was designed and manufactured by Airload Engineering, U.K., to specifications by BRE and with ODA backing. It is a medium-sized suction tanker with a ***high performance liquid ring vacuum pump.*** The whole tank has an overall length of 4.2 m and includes a 4.5 m^3 slurry and a 1 m^3 service liquid (water) compartment. To facilitate tank emptying and cleaning, a hydraulic tipping cylinder inclines the tank to a steep angle (approx. 60^o) and its rear door can be fully opened via four handwheels. Attached to the rear door are a 100 mm suction valve (lever-operated slide valve), a 100 mm discharge valve (handwheel-operated slide valve) and a 75 mm water drain valve. An additional 200 l container for washwater is fitted onto the side of the chassis. The heart of the suction system is the high performance liquid ring ***vacuum pump with a suction capacity of 0.8 bar and a maximum airflow rate of 26 m^3/min.*** To discharge the tank under pressure, the pump can also create a pressure head of approx. 1 bar by means of a load-discharge control valve which reverses the airflow to the slurry tank. A liquid ring pump is capable of handling entrained material and therefore does not need to be protected by a slurry separator. Its function principle, however, includes the use of a service liquid (water in this case), which is supplied through a closed circuit by a water pump coupled to the vacuum pump shaft. After passing the vacuum pump, the water is released through the discharge port along with the pumped air, and then separated from the air inside the water tank by the sudden decrease of the air velocity. The high pressure hydraulic oil necessary to run the hydraulic motor of the vacuum pump, the hydraulic motor of the clean water pump and the tank tipping cylinder is supplied from the central oil pump powered by a drive shaft from the truck's gearbox. The oil for this closed hydraulic system is stored in a 55 l oil tank. The vacuum pump, clean water pump and tank lift are engaged through PTO controls inside the cab. The service liquid (water) and the hydraulic oil are cooled by two separator cooling radiators powered by the truck motor's van. In response to the request by the Gaborone Town Council, BRE specified a Ford Cargo 1211 chassis with an 85kW diesel engine for BREVAC. ***The high performance liquid ring vacuum pump enables the tanker to be used both as a vacuum and a plug drag system. BREVAC also incorporates the air bleed device by the use of air bleed nozzles*** as a compromise to reduce the need for plug drag operation which can be very tiresome.

ALH Emptying System (see Fig. 5)

The prototype ALH remote system was designed and manufactured by ALH systems, U.K., particularly for use in areas such as squatter settlements where access with conventional pit emptying machines is not possible. ***The principle of this system is to move air rather than sludge over long distances, thereby increasing the operating range possibly up to 150 m.*** The equipment is trailer-mounted in order to reduce costs and utilize existing vehicles to tow the unit. It consists of a Lister diesel engine, powering a positive displacement air blower and a hose reel capable of carrying a 60 m by 75 mm air hose. Also transported on the trailer are one slurry drum, 'top hat' section, a 5 m by 100 mm sludge hose and the hand

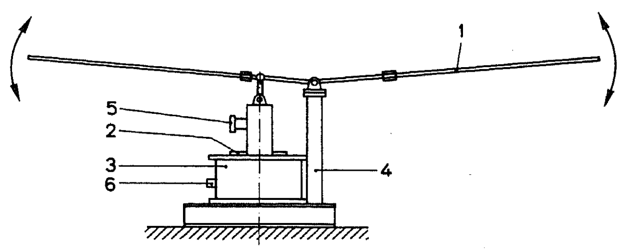
Fig. 5:
ALH Emptying System



1. towing tractor
2. engine and air blower
3. 'top hat' section
4. slurry drum
5. air filter unit
6. winding reel drum
7. 75 mm air hose
8. 100 mm suction hose
9. hand trolley

trolley. When work is carried out, one end of the 75 mm air hose is fitted to the pump unit on the trailer, while the other end is coupled to the 'top hat' section which fits over a standard oil drum (approx. 0.2 m^3) placed next to the pit. The vacuum is created in the slurry drum and the pit's content removed into it by using a short 100 mm plastic hose. The drums are transported to and from the pits by a small hand trolley. ***The positive displacement air blower performs a vacuum head of max. 0.5 bar at an airflow rate of 20 m^3/min.*** Its intake is protected by an air filter which consists of several fabric bags and equipped with a vacuum relief valve essential to prevent the pump from creating more than 0.5 bar vacuum in the event of a blockage. ***The feature of the pump enables the equipment to be used as a plug drag system.***

Fig. 6:
BUMI Hand Pump



1. extension bars (2 m each)
2. diaphragm
3. pump body
4. frame
5. outlet
6. inlet

BUMI Hand Pump (see Fig. 6)

This robust, hand-operated diaphragm pump with only three wearing parts has been designed and manufactured by Dunlop, Zimbabwe, to meet the irrigation needs of Zimbabwe's subsistence cultivators and the varied requirements of the commercial farmer.
Although developed for irrigation, the pump has a variety of uses and has been utilized experimentally for desludging latrines in Zimbabwe. This pump is operated by means of two 2 m-long extension bars (handles) allowing for two-man operation. The pump was bolted onto the back of a van to be driven to the latrines.

Test Procedures and Characterisation of the Material to be Shifted

To achieve comparable results, the same test procedure was used for the testing of each system:

Pits were emptied at a normal working pace until further removal became impossible. (For the CALABRESE, POOLE and ROLBA tanker this limit point was easy to establish since the sludge started to flow back from the suction hose into the pit. This flowback behaviour did not occur with BREVAC and the ALH equipment, but work was stopped as soon as the sludge removal rate fell to a low level). After finishing with the suction work, a 1 l sample was taken from the sludge remaining in the pit for analysis of moisture and volatile solids content and for a viscometer test. This represented the composition and flow behaviour of the heaviest sludge removable by a machine for a defined pit depth and hose length.

Fig. 7:
Flow Curve of a Sludge Sample

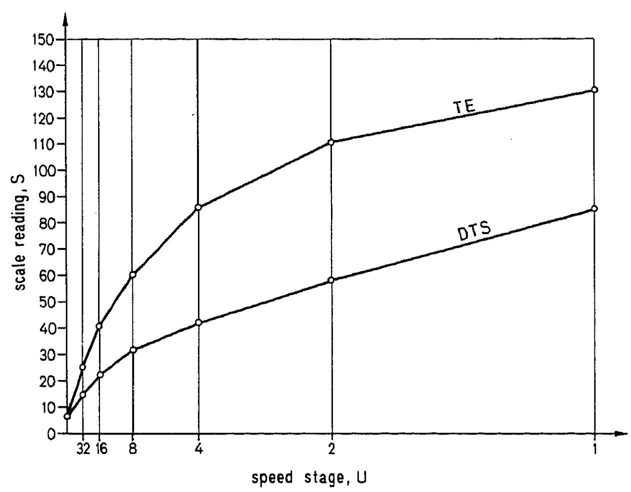
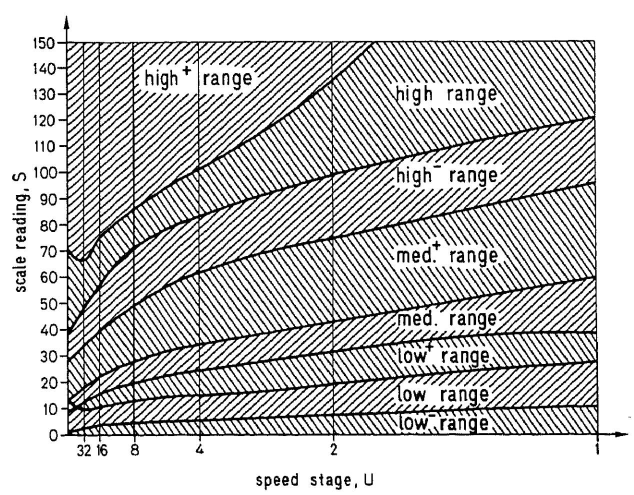


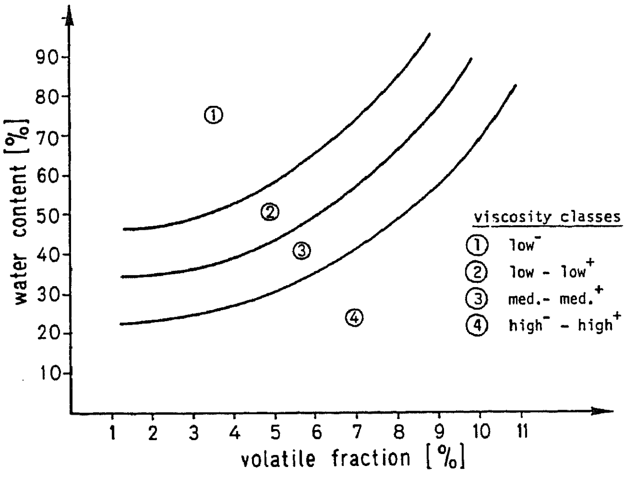
Fig. 8:
Viscosity Ranges of Sludge



To determine and compare the flow behaviour of the different sludge samples, flow curves were plotted based on viscometer measurements. As excreta-derived sludges exhibit thixotropic flow behaviour, two different flow curves were plotted (s. Fig. 7: TE = Thixotropic Equilibrium; DTS = Destroyed Thixotropic Structure). Each sample was classified by comparing its DTS curve with the viscosity ranges shown in Fig. 8. These ranges are based on those established by the British Hydromechanics Research Association [2].

In addition to the viscometer test, each sludge sample was analysed for its water content and volatile and non-volatile fraction. The analyses have indicated the existence of a correlation between the sludge composition (water and volatile fraction) and flow behaviour. On account of this finding, an empirical relationship between these three parameters could be developed. Figure 9 shows a proposed classification of viscosity based on sludge composition. Based on experience gathered during field analyses, it can be concluded that this Figure 9 will be a useful aid in predicting flow properties on the basis of the sludge composition, thereby no longer requiring the use of an expensive and sophisticated viscometer.

Fig. 9:
Classification of Sludge Viscosity Based on its Composition



Observations and Results

Work On Site with CALABRESE and POOLE

During a short visit to Dar es Salaam and discussions with the City Council, it was observed that many pit latrines cannot be reached with the medium-sized CALABRESE tanker. The very dense physical structure often prevents access to the latrines, and distances separating truck and pit of 100 m and more were experienced. In addition to the distance problem, the latrines are often located in the backyards and the only way to reach the pits is by setting up the sludge pipes through the house. While dismantling the pipes after pit emptying, the houses are unavoidably contaminated with sludge.

In contrast to Dar es Salaam, access conditions in Gaborone are very good. As a result, the large-sized POOLE tanker can be driven very close to the pits. Since POOLE is equipped with a 15-m long suction hose wrapped around the tank, no hoses have to be coupled together. Thus, the setting up time is short and the working conditions comparatively easy. The disadvantage of this "one-hose system", however, is shown in the friction loss remaining constant along the 15 m hose, although the actual distance separating truck and pit may be less than the whole hose length.

With both tankers, emptying work on pits containing heavy sludges was usually very tiring and difficult. Both units work on the principle of a vacuum system and are therefore limited to the raising of low-viscosity sludge and liquid only. Thicker sludge is to be removed by the application of the plug drag method, but as the airflow rates of the vacuum pumps used are too low to haul the free flowing air as well as the volume of the removed sludge, this method is not feasible for either tanker. In addition to the low airflow rates, reduced vacuum heads caused by clogged air filters were observed, thereby limiting the max. depth from which water can be raised to less than 1.5 m. This often leads the crew to wrong conclusions, i.e. wrongly blaming a blocked suction hose for failing to pump sludge from a 1.5-m deep pit. This causes further embarrassment as the mechanics then check the suction hose for a blockage which does not exist. The performance limits of the equipment is shown in Table 1.

Work On Site with ROLBA and BREVAC

While some difficulties in getting access to the latrines were experienced with the large-sized ROLBA tanker, BREVAC could be manoeuvred next to the pits more easily as it appears to be smaller than ROLBA or POOLE. During the tests it was observed that the crew preferred to work with the 100 mm diameter sludge hoses mainly because the 75 mm hoses were more susceptible to blockages by bulky material (bottles, rags, stones etc.) often found in pit latrines.

To evaluate the performance limits of the tankers, many trials were conducted on old double pit latrines with very dense contents. The sludges to be removed were a mixture of excreta-derived material and sandy soil, with the latter predominating as the pits were on the verge of collapse. This clearly indicates the need for proper lining of the pits in blockwork or brickwork. The contents of properly lined pits are likely to be less dense and as a result less powerful, and would therefore require less expensive and more easily maintained tankers.

The driest sample handled by BREVAC was composed of 13% water, 84.7% sand and only 2.3% organic matter. The measured density was 2,200 kg/m^3 and the flow properties represented a viscosity in the high$^+$ range.

Both tankers were equipped with a high pressure washwater unit. This facility was very much appreciated by the crew as it discharged them from having to carry water in tubs to wash down the sludge hoses and latrines after pit emptying. ROLBA's design also includes the use of the high pressure washwater to liquify the sludge before emptying it with the suction hose. The suction pull of both tankers was very powerful and the limits were set for pumping high-viscosity sludge for ROLBA working on a plug drag system with the use of the high pressure washwater, and high$^+$ viscosity sludge for BREVAC working with the use of air bleed nozzles (see Table 1).

Table 1:
Performance Limits of the Equipment Tested

	Sludge limit for a 1.5 m deep pit	Sludge limit for a 3 m deep pit	Limit of suction distance	Pits served per day (average)
CALABRESE	low⁻	low⁻	(36 m)	10 - 15 liquid layer only
POOLE	low⁺	low	20 m	12 - 17 liquid layer only
ROLBA	high	med⁺	58 m	8 - 14
BREVAC	high⁺	high⁺	64 m	10 - 15
ALH	high⁺	?	ALH 60 m. For remote systems in general up to 150 m	?
BUMI PUMP	low⁻/water	low⁻/water	-	-

Work On Site with ALH Equipment

Before applying the ALH emptying device as shown in Fig. 5, the problems concerning the handling of the full drums and, more important, of emptying them at the sludge disposal site had to be dealt with first. The methods considered proposed to collect the full slurry drums with a large collection lorry equipped with a crane or suggested the pulling of the ALH trailer unit by a small lorry which also transports about 18 drums. As no such vehicle was available and no convenient method was found to empty full slurry drums, it finally became apparent that the only reasonable solution would be to accompany the ALH trailer unit with a suction tanker which could dispose of the drums' content into the tank on the spot. During operation, drum overfilling problems were experienced as the level indicator on the drums' "top hat" section did not perform well. As a result, insufficient tests were carried out to be able to draw conclusions in pumping limits. There are indications, however, that the limits of pump units similar to ALH are the pumping of high-viscosity sludge. In addition to the overfilling problems, difficulties in transporting the full drums with the hand trolley over sandy ground were experienced, and setting up times of up to 30 minutes and more were measured. Based on the field experience it was agreed among the parties involved that remote systems await further investigations. Guidelines for the remote unit are given in the full report [3].

Work On Site with BUMI Hand Pump

In comparison to suction tankers where the material to be removed is shifted directly into the tanks, here the sludge has to pass through the BUMI hand pump. As a result, small objects jammed in the pump's diaphragm and, as the sludge hose measured only 50 mm in diameter, the hose inlet was therefore frequently blocked by bulky material. In addition, hand pumping is quite hard work in temperatures exceeding 35 °C and therefore the crew tended to stop work before the pits were entirely emptied. Only water and very thin sludges could be removed. The time to fill a 200 l drum was 30 min. The field experience suggests that the BUMI hand pump is not very suitable for pumping sludge, especially when dealing with pit latrines that contain a lot of sand and rubbish.

Long Hose Tests

In addition to the usual pit desludging trials, long hose tests have been carried out in order to compare suction tankers with the ALH remote system which has been especially designed for use over long suction distances. Both tankers BREVAC and ROLBA were tested under the same conditions and suction distances of more than 70 m were simulated. The following main problems were encountered for both tankers:

- Significant mud layers settled in the pipes and hoses which had to be rinsed out by sucking water through the pipes every 5 to 10 minutes.
- Locating of hose blockages was a very difficult, unpleasant and time-consuming operation which involved a systematical uncoupling of the hoses until the obstruction was found. It is very important that blockages are found with a minimum of hose uncouplings, as sludge pours out from every opened joint and contaminates areas where children play. In Dar es Salaam, where access to many latrines is only possible through the house, the clearing of blockages in this way would create unacceptable health risks.
- The hose operator should be able to break the vacuum as soon as large items block the hose inlet. However, communication between the hose operator and the operator at the suction valve on the tanker is often difficult as they are separated by up to 70 m distance and therefore out of earshot and often also unable to see each other.
- As the long pipe consists of several 3 and 4 m hose segments, the setting up time took 15 minutes and the dismantling and washing down time was 20 minutes.

The practical limit in pumping high-viscosity sludge over long distances was found to be 60 m. The field experience gained from the long hose tests suggests that remote systems such as the ALH should be used when suction distances are in excess of 60 m. (Additional tests in Sheffield, England, suggested that shifting low-viscosity sludge over distances in excess of 100 m is perfectly feasible with the use of a pneumatic conveyor system and with the application of an air bleed nozzle).

Work at the Disposal Site

As both the BREVAC and the ROLBA tankers were capable of removing very viscous and sandy sludges, some problems were experienced when emptying the full tanks. Although the sludge is discharged under pressure, outlet blockages caused by rags and rubbish occurred frequently. This was mainly due to the discharge valves being only 100 mm in diameter. In addition, heavy material such as sand and stones did not flow out with the liquid but settled to the bottom of the tank. This called for regular tank cleaning and caused considerable health hazards, as workers equipped with gas masks and shovels had to enter the tank when cleaning ROLBA. In contrast to ROLBA, BREVAC's tank was much easier to clean as the work is carried out by fully opening the rear door and tipping the tank to a steep angle. Such tank cleaning work was not necessary for the POOLE tanker as its performance is restricted to handling liquid and thin sludges only. From the experience gained during discharge, direct recommendations for tanker designs could be made and are given in the full report [3].

Maintenance

Unfortunately, since none of the prototypes were tested for more than four months, it is difficult to discuss their long-term maintenance and reliability. However, one tanker (BREVAC) is still undergoing trials in Gaborone for a further one-year period. These trials are supervised by a member of the Ministry of Local Government and Lands. According to the latest information, BREVAC's suction unit is still working well (for a year now), but some problems in getting spare parts for the Ford Chassis were reported from Gaborone.

Conclusions

Sludge Behaviour

The flow behaviour and hence the 'pumpability' of sludge found in pit latrines can be determined by analysing its composition in terms of water and volatile content. The flow behaviour can be classified into four viscosity classes according to the composition of a sludge.

Another factor which has to be taken into consideration when pumping sludge is its density. There is no correlation between flow behaviour and density. A sludge of a medium viscosity for example can represent a density range of 1051 up to 1628 kg/m^3.

Technical Requirements for Sludge Removal

The characteristics of the sludge to be removed will influence the type of suction system chosen. Economic and maintenance considerations clearly dictate that the cheapest and simplest machine capable of doing the job should be used. Based on the performance of the different equipment tested in Botswana, technical requirements for removing different types of sludge could be determined (s. also Table 2):*

- Thin sludges with a viscosity up to the low$^+$ range can easily be pumped with a vacuum system. The required pump performance varies from 0.5 bar suction and 2–10 m^3/min. airflow for shifting the sludge along a 15 m by 100 mm hose and 0.8 bar, and 2–10 m^3/min. for shifting the sludge along a 60 m pipe.

- To transport medium and high-viscosity sludge along a pipe, the application of a pneumatic conveying system is required. There are, however, different methods of achieving pneumatic conveying, i.e. constant air drag system (open nozzle a few centimeters above the surface of the sludge), air bleed nozzle and the plug drag ('suck and gulp') method. For medium and high-viscosity sludge, the use of an air bleed nozzle or the plug drag system is appropriate and both have proved to be very efficient in removing these types of sludges. The appropriate pump would need a performance of around 0.5 bar suction and 15–25 m^3/min. airflow to shift the sludge along a 15 m by 100 mm hose and 0.8 bar, and 15–25 m^3/min. to shift the sludge along a 60 m pipe. For distances beyond 60 m, a remote system should be considered.

- To transport very compact sandy material, a higher airflow rate is essential to work with a combination of constant air drag system and plug drag method. The pump performance required is about:
  - 0.5 bar suction and 25–35 m^3/min. airflow for 15 m by 100 mm pipe and
  - 0.8 bar and 25–35 m^3/min. for a 60 m long pipe.

  Distances beyond the 60 m value should be covered with a remote system.

- If the material is too dry to allow immersing of the nozzle end into the material, the application of the constant air drag system will be necessary. This method, however, calls for large centrifugal fans which can displace a lot of air (100 m^3/min. and more). In general, such machines are expensive, usually very sophisticated and therefore not appropriate for use in developing countries. In addition to this, the friction loss in the pipe is high due to the high air velocity. The mode of handling the hose requires great operating skill to keep the hose inlet a few centimeters above the surface of the sludge. As far as single-pit latrines are concerned, access to the pit contents is mostly only through the small squat-hole, thereby making this emptying method impossible.

Although it proved possible to pump thin sludge through a 100 m by 100 mm pipe, distances beyond this 100 m value should not be considered mainly because of the following factors:

- very long times required for setting up, dismantling and washing down (the setting up time for a 70 m pipe was found to be 15 min., and 20 min. for dismantling and washing down);

- if a blockage occurs, it is very difficult and time-consuming to locate the position of the obstacle in such a long pipe with many joints;

Table 2:*
Technical Requirements for Sludge Removal Equipment

ACCESSIBILITY (Distance)	SLUDGE FLOW BEHAVIOUR (VISCOSITY): class ①,② (low$^-$ - low$^+$)	class ③ (med - med$^+$)	class ④ (high$^-$ - high$^+$)
100-150m	remote syst.	remote syst.	remote syst.
60-100m	p = 0.8 a = 15-25	remote syst.	remote syst.
15-60m	p = 0.8 a = 2-10	p = 0.8 a = 15-25	p = 0.8 a = 25-35
0-15m	p = 0.5 a = 2-10	p = 0.5 a = 15-25	p = 0.5 a = 25-35

p = rel. vacuum (bar); a = airflow (m^3/min.)

* Note that the given values are valid only for level sites, 75 mm and 100 mm diameter hoses and a max. pit depth of 3 m.

- communication between the hose operator and the worker operating the suction valve on the tank over a 100 m distance is very difficult as they may be out of earshot and unable to see each other.
- accumulation of mud layers in the pipes and hoses which had to be rinsed out periodically by sucking water through the pipe.

Access to the Latrines and their Contents

Another important factor governing the technical limits of mechanical systems for emptying pit latrines is the accessibility which is determined by two aspects:

a) ***the distance between the pit and the place where a suction tanker can get the closest.*** This distance depends on the environment and differs very much from place to place. In Gaborone, access to the latrines was very good, in most cases within 15 m, while conditions encountered in Dar es Salaam were a lot more difficult and distances of up to 100 m were measured.

   It can be concluded from the tests that when shifting heavy sludge, the pipe should not be longer than 60 m. Distances beyond 60 m should be served by a remote system where only air is moved through the long pipe;

b) ***the size of the widest available opening to reach the pit contents.*** This depends on the latrine type. For all unimproved and single-pit VIP latrines, emptying is carried out through the squat-hole. Handling of the hose in these circumstances is very tiresome, and work with a nozzle is limited to two meters since the joint on its upper end will not go through the hole. It is therefore of utmost importance that all new latrines are equipped with removable .slabs providing easy access to the pits.

It is most important that the overall size of the equipment is taken into consideration when selecting machinery to work in a particular environment. For instance, in areas with poor access such as Dar es Salaam, small tankers will probably be appropriate, but in Gaborone where access is good, larger machines may be used.

Tested Equipment and their Limits

The tests in Gaborone have shown that the ROLBA, BREVAC and ALH prototypes are capable of removing the high-viscosity sludges which are often found in pit latrines. The high airflow rate of BREVAC made it possible to shift even dry sandy soil along a pipe.

The practical and technical limit for the maximum distance between the tanker and the latrine when shifting high-viscosity sludge along a pipe was found to be approximately 60 m. The limiting factor is the reduction in suction power due to the high friction loss caused by a build-up of mud layers inside the pipes. In areas where tankers cannot get closer than 60 m to the latrines, and where medium or high-viscosity sludge has to be handled, an alternative system with a remote unit has to be used.

Suggestion for Further Work

With the field tests described in this report, the technical limits of the different equipment used in handling different types of sludges could be established. However, some questions in connection with the construction and operation of pit emptying systems and technologies suitable for developing countries still remain unanswered and require further investigations:

- The development of an alternative system is necessary for areas where tankers cannot get closer than 60 m to the pits, and where medium or high-viscosity sludge has to be handled. Under these circumstances, the development of a system with a remote unit is suggested. Based on our present knowledge about typical location of and accessibility to latrines in urban areas of developing countries, a draft specification for such a remote system can be given (see full report). However, it would be highly desirable to know more about the various conditions encountered in the developing world. This could be achieved by conducting a systematic survey of different towns in different continents.
- The tests in Gaborone which lasted 4–5 months could not answer the crucial question of how well does the equipment operate over a long-term period under difficult conditions. Therefore, the BREVAC tanker, the ROLBA tanker and the remote system to be developed, should be tested for at least one year under real-life conditions as encountered for instance in many African cities. Dar es Salaam (Tanzania) would be a good place to observe the long-term performance under such difficult conditions.
- In order to optimize the construction and operation of emptying equipment, it would be highly desirable to conduct further laboratory tests to establish the influence of air velocity on the flow rate for low, medium and high-viscosity sludge.

Consequences for Planning and Design of Sanitation Systems

The tests in Gabarone have shown that any equipment capable of handling heavy sludge are not simple, nor easy to operate and maintain. On the other hand, equipment which is considerably cheaper and relatively easy to operate and maintain can handle only water and thin sludges. This fact should influence the planning and design of future sanitation systems, especially in areas of developing countries where sophisticated machines cannot be maintained and operated properly over a long-term period.

Appropriate planning of latrine location as well as design of the single pits can facilitate considerably the emptying procedure and therefore lower the requirements of the emptying equipment. When planning a sanitation system, it should be taken into account that a medium-sized tanker is to get as close to the latrine as possible. Easy access to the pit itself in the form of a removable cover is also most important.

Under existing conditions, planners have a choice between two systems. The vault latrines, with a relatively small tank easily emptied by a simple vacuum truck, but requiring a reliable emptying service and producing a greater amount of sludge to be handled and discharged to the environment. Or the pit latrines, which can accept considerable quantities of water and are less liable to overflow in the absence of reliable pit emptying services, but accumulate compacted sludge which can only be removed manually or by sophisticated mechanized equipment.

Properly operated twin-pit latrine systems retain all the advantages of pit latrines, whilst allowing for simple manual removal of pit contents without health hazards. 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 physical and socio-cultural conditions permit, this is definitely the technology of choice.

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 where all the liquids and solids are retained for collection. Earlier studies by IRCWD [1] on compaction of sludge indicate that the content of the vault can be removed by regular vacuum tankers if the sludge is stored for not more than one year.

However, it has to be kept in mind that many urban areas have already established traditions of latrine construction and use, and that the sludge will have to be removed from thousands of latrines which have not been planned and designed in an optimal way to allow easy emptying. Any pit emptying service must clearly adapt itself to the requirements of the particular latrine technology already in use. Under such prevailing conditions, probably the most appropriate economic and operational solution would be to set up a tanker fleet with simple vacuum tankers which are relatively easy to operate and maintain, and some units of a more sophisticated type. The latter, which are far more expensive and more difficult to operate and maintain, will have to be used only for emptying pits of difficult access and containing heavy sludge.

References

[1] Schertenleib R. and Hawkins P.: Emptying On-Site Excreta Disposal Systems in Developing Countries: An Evaluation of the Problems; *IRCWD News No. 17, August 1982.*

[2] Chang E. and Taylor B.: Sludge Simulation for On-Site Sanitation Units in Developing Countries; *British Hydromechanics Research Association (BHRA), CR 1842, May 1982.*

[3] Bösch A. and Schertenleib R.: Emptying On-Site Excreta Disposal Systems: Field Tests with Mechanized Equipment in Gaborone (Botswana); *IRCWD Report No. 03/85.*

News from WHO

Water Authority Management Workshop Success

WHO Human Resource Management specialists, Mr Howard Gibson and Mr Neil Carefoot, successfully completed their first country level **Human Resource Management workshop** in **April 1985.** It was conducted **in Amman** for senior managers of the Water Authority of Jordan. The programme was **arranged by** the **Eastern Mediterranean Regional Office of WHO** and was **sponsored by USAID.** The 3-week workshop designed for senior managers of water supply and sanitation authorities, throughout the developing world, has four major aims, to:

- introduce managers to effective management approaches and techniques for strengthening human resource activities.
- help them to identify managerial and organizational constraints to performance and recommend strategies for improvement.
- train the managers to run similar workshops for their colleagues.
- help achieve "Decade" goals of safe water and sanitation for all by 1990.

Eleven senior managers of the Water Authority of Jordan very enthusiastically participated in the first two weeks and successfully ran an action planning workshop for eighteen of their management colleagues in the third week.

The President and Secretary General of the Water Authority were impressed by the recommendations for improving performance made by their managers on the final afternoon. Great interest was shown by the media in the workshop as it was featured three times on TV and four times in the press.

The workshop is based on the **"Human Resources Development Handbook"** by **Neil Carefoot** and **Howard Gibson,** which is endorsed and recommended by the International Water Supply Association Standing Committee on Waterworks Personnel.

Following this success, the Eastern Mediterranean Regional Office of WHO is promoting the 3-week Human Resources Management workshop in six priority countries.

«IRCWD NEWS»

We should like to welcome **Pierre-Christian Morand** who joined our group in February 1985. After graduating from the Swiss Federal Institute of Technology, Zurich, in geology, petrography and geophysics, he worked as hydrogeologist for several geological consulting offices in Switzerland. In 1984, after perfecting himself in mathematics/computer technology and hydrology, he spent, under assignment of a German geological firm, several months in Tunesia on a drinking water supply project. At IRCWD, he will act as our scientific advisor and coordinator of ongoing and planned field investigations related to the "Risk of Groundwater Pollution by On-Site Sanitation in Developing Countries". His activities will centre on improving the present guidelines for safe separation between water supply and sanitation installations.

New Publications

Human Resources Development HANDBOOK edited by **Neil Carefoot** and **Howard Gibson,** World Health Organization Document CWS/ETS/84.3, WHO, Geneva, September 1984, 228 pages.

The Human Resources Development (HRD) Handbook is a document intended for the use of HRD practitioners in developing countries, e.g., training officers and personnel officers as well as those top-level managers in water supply and sanitation programmes who are looking for ways and means to get a greater return on investments in HRD.

Divided into three major segments, the Handbook stresses the three components of the HRD process – PLANNING, TRAINING and MANAGEMENT. Each chapter provides both a rationale for the importance of the component and a guide to some of the elements which are considered essential for more effective development of human resources. In the Planning Chapter, for example, steps (and accompanying sample forms) are presented for the preparation of a Human Resources Development Plan. In the Training Chapter, guidelines are given for producing a Training Plan and also for developing an in-house training course. The Management Chapter discusses many of the elements inherent in manpower management; e.g. performance-based job descriptions, personnel policies and regulations, performance evaluation, training policies and budgets.

The theme of the Basic Strategy Document and the Handbook is that a much more integrated approach is needed in human resources development, linking training with organizational change, career development, planning and management systems and the other deficiencies that have been identified.

Readers will be interested to know that the English version of the HRD Handbook is available throughout WHO's network of offices. French, Spanish and Turkish translations will follow soon. Further information can be obtained by contacting one of WHO's regional offices.

Reprints of this HRD Handbook can be requested from Manager, Environmental Health Technology and Support, Division of Environmental Health, World Health Organization, 1211 Geneva 27, Switzerland.

Guidelines for planning COMMUNITY PARTICIPATION in water supply and sanitation projects by **Anne Whyte,** World Health Organization Document ETS/83.8, WHO, Geneva, 1983, 60 pages.

In recent years community participation has assumed an increasingly important role in development philosophy. This has been especially so in the health sector where, within the framework of Primary Health Care, it has been stated that communities have both the right and the responsibility to be involved in the planning and implementation of their own health programmes. Similarly, in water supply and sanitation programmes, planners have come to realize that community participation is an essential ingredient for projects to be successful. This represents a vast change from former procedures where the community was seen as the passive recipient of facilities planned and supplied by central government.

It is against this background that "Guidelines for Planning Community Participation in Water Supply and Sanitation Projects" has been prepared. The guidelines are in a simple and readily understandable form that leads the planner through the "what, when, where, why, how and who" questions associated with the community participation process.

The guidelines are currently available in English and French in limited quantities. Copies may be requested from Manager, Environmental Health Technology and Support, Division of Environmental Health, World Health Organization, 1211 Geneva 27, Switzerland.

Rural Water Supply – Operation and Maintenance – Eight Questions to Ask, World Health Organization Document ETS/83.9, **WHO,** Geneva, 1983, 15 pages.

Unfortunately, poor operation and maintenance (O & M) practices have in many instances largely contributed to a decreased utility, or even to an early failure, of newly constructed water supply and sanitation facilities.

This paper has accordingly been prepared to draw attention to the variety of factors which can influence O & M. The subject is, however, extremely wide, and any attempt to cover in a single paper the whole range of variables which can affect the O & M of water supply and sanitation services in both the urban and the rural subsectors would be a complex task. Therefore, attention has been focused on the O & M of rural water supply facilities.

To bring further focus to the subject, those factors which are known to exert the greatest influence on rural water supply O & M practices have been identified and grouped under eight principal questions in the form of sub-questions. The questions can be utilized as a checklist to ensure that matters pertinent to the establishment of proper O & M practices receive full consideration during the identification, planning and construction phases of a project cycle. Alternatively, they can be applied to existing situations where evaluation has shown that O & M practices are adversely affecting the proper functioning of a supply.

Copies may be requested from Manager, Environmental Health Technology and Support, Division of Environmental Health, World Health Organization, 1211 Geneva 27, Switzerland.

Rural Water Supplies, EURO Reports and Studies 87, 1983, 66 pages. This is a report on a meeting convened by the **WHO Regional Office for Europe, Copenhagen** and held in Stevenage, England, from 1 to 5 November 1982.

The Working Group on Rural Water Supplies in the European Region discussed current technology applied to small water supply systems in Europe, particularly in isolated rural communities. It also dealt with present approaches and new technology, as well as other related

aspects such as surveillance, maintenance and the inclusion of chemicals.
The Working Group which was divided into three subgroups for part of the meeting discussed the following:
- the technology of water treatment and disinfection for all types of source and distribution system;
- the technology of water supplies, other than treatment and disinfection, particularly source selection and protection and distribution, for all degrees of treatment and forms of distribution;
- appropriate organization, administration, surveillance and personnel training.

Each subgroup was charged with making recommendations in its particular area of competence, both for the benefit of Member States and for further international action.

Special terms for developing countries are obtainable on application to the WHO Programme Coordinators or WHO Regional Offices or to the World Health Organization, Distribution and Sales Service, 1211 Geneva 27, Switzerland. Orders from countries where sales agents have not yet been appointed may also be sent to the Geneva address, but must be paid for in pounds sterling, US dollars, or Swiss francs.
Price per copy: Sfr. 7.—.

Manual on the Design, Construction and Maintenance of Low-Cost Pour-Flush Waterseal Latrines in India by **A.K. Roy et al.,** 1984, 110 pages, TAG Technical Note No. 10, UNDP Interregional Project INT/81/047, The World Bank.

This manual has been prepared for agencies, contractors and individuals involved in various aspects of the low-cost pour-flush waterseal latrine programme in India. The inherent principles are, however, of general application, and, with minor modifications, the technical details can be readily adapted to meet the needs of different areas, particularly where water is used for ablutions.
The manual provides the salient features of design, construction and maintenance as well as the administration of low-cost pour-flush waterseal latrines with off-set twin pits. It contains extensive drawings, tables of quantities of materials for different designs as well as standard forms for by-laws and for general project administration and supervision.

Copies of this manual are available from: International Bank for Reconstruction and Development, The World Bank, 1818 H Street, N.W., Washington, D.C. 20433, USA.

Monitoring and Evaluation of Communication Support Activities in Low-Cost Sanitation Projects by **Heli E. Perrett,** 1984, 26 pages, TAG Technical Note No. 11, UNDP Interregional Project INT/81/047, The World Bank.

This note deals with the subject of monitoring and evaluation of communication activities that support low-cost sanitation (LCS) programmes. It focuses more on the monitoring of such activities than on the impact the activities have, on the grounds that: (a) a well-designed Project Support Communications (PSC) programme, kept sensitive to community and individual needs through regular feedback will necessarily have an impact on overall programme success; (b) programme monitoring can become a useful and essential management tool, guiding managers in decision making by providing them with relevant current information. Impact evaluations are often static means of measuring results of project intervention too late for those results to be used profitably; c) impact evaluations, especially those which try to measure actual habit change, are frequently flawed due to the extreme difficulty of identifying and controlling compounding variables.

It uses sample questions, sample findings and possible solutions to illustrate procedures that are described for data collection, data handling and analysis. The timing, frequency and procedures for reporting findings are discussed; and it ends with hints for dealing with common mistakes and a discussion of responsibilities and resources for monitoring and evaluation.

While all illustrations are drawn from communication components of sanitation projects, much of the discussion has broader relevance.

Copies can be obtained from: International Bank for Reconstruction and Development, The World Bank, 1818 H Street, N.W., Washington, D.C. 20433, USA.

A Monitoring and Evaluation Manual for Low-Cost Sanitation Programs in India by **Ronald Parlato,** 1984, 80 pages, TAG Technical Note No. 12, UNDP Interregional Project INT/81/047, The World Bank.

This is a monitoring and evaluation manual based on field work done by the author in India in January-February 1983. It is meant to provide a methodological framework within which Indian institutions may develop more detailed evaluation designs; and within which implementing government agencies may establish monitoring systems. Furthermore, it is thought that this manual can have wide-spread application outside the region as well, for its analytical approach — looking at the financial, administrative, and management aspects of programme implementation; the socio-economic and cultural constraints of individuals within the target population; and the quality of design and construction of the latrine itself — should apply to all low-cost sanitation programmes regardless of technical option, region, or country.

Owing much to the basic design of the Minimum Evaluation Procedure (MEP) of the World Health Organization (WHO), the evaluation is an attempt to assess the determining factors related to problems as well as to the identification of those problems and their implications. As such it should provide a useful methodological complement to the MEP.

The Manual should also be read as a companion piece to the recently published TAG Technical Note No. 11 entitled "Monitoring and Evaluation of Communication Support Activities in Low-Cost Sanitation Projects". The two documents read together provide a comprehensive analytical approach to assessing the many elements of low-cost sanitation programmes.

Following a discussion of preliminary findings in the implementation of urban pour-flush latrine programmes in India, this manual presents in summary form, the conceptual framework for and basic components of the evaluation (Section II), and proposed monitoring system (Section III). A full description of all procedures suggested for implementation of both evaluation and monitoring, including questionnaires, procedural notes, design of analytical framework, etc., will be found in Annexes I–VI.

Requests for copies should be addressed to: International Bank for Reconstruction and Development, The World Bank, 1818 H Street, N.W., Washington, D.C. 20433, USA.

The Design of Ventilated Improved Pit Latrines by **D. Duncan Mara,** 1984, 73 pages, TAG Technical Note No. 13, UNDP Interregional Project INT/81/047, The World Bank.

Traditional (unventilated) pit latrines are a very common sanitation facility in many developing countries. They have, however, two serious disadvantages: Generally they have a bad smell, as well as substantial numbers of flies and other disease-carrying insects breeding in them. Additionally, they are all too often poorly constructed, with the result that pit collapses are common. These disadvantages are substantially reduced in VIP latrines, which have been found to be socially very well accepted in those countries where they have been installed.

This Technical Note develops a general approach to the design of ventilated improved pit (VIP) latrines, based on TAG's recent experience in Botswana, Brazil, Ghana, Kenya, Lesotho, Tanzania and Zimbabwe. Further details of country-specific designs (currently for Botswana, Tanzania and Zimbabwe) are given in other Technical Notes in this series.

Requests for copies should be addressed to: International Bank for Reconstruction and Development, The World Bank, 1818 H Street, N.W., Washington, D.C. 20433, USA.

Urban Sanitation Planning Manual Based on the Jakarta Case Study by **Vincent Zajac et al.,** July 1984, 158 pages. This is a World Bank Technical Paper No. 18 of the "Appropriate Technology for Water Supply and Sanitation" series.

This report addresses one of the most vexing problems in planning sanitation improvements in urban slum (or "poor people") areas: How to quantify the situation in a given urban area so that planning can be focused on the most meaningful needs. What is the existing status of sanitation in the proposed project area, what facilities are already there, which are productive (or non-productive) and why, what are the gaps which must be filled in order to achieve a minimum desired level of community sanitation in the area, and how can the data be obtained so that the planner can proceed to identify and design the specific facilities needed to achieve the desired improvement? What are the users perceptions of their sanitation needs, how are they willing to participate in the improvement process?

The present report describes a special methodology which has been developed on how to plan and conduct such a survey, how to analyze the results, and how to utilize them for describing and specifying the needed new facilities. The methodology is based on its actual application and utilization for planning a major urban sanitation improvement project in Jakarta, Indonesia. It describes design of questionnaires, investigator training and computer analysis of data in a form that will permit other project planners to utilize the process. In addition, information is provided that will enable planners to estimate the time and cost of a sanitation survey.

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

Rural Water Supply Development – The Buba-Tombali Water Project – Guinea-Bissau 1978–1981. This publication was prepared by the International Reference Centre for Community Water Supply and Sanitation **(IRC)** under assignment of the Directorate General of Development Cooperation, Ministry of Foreign Affairs, Kingdom of the Netherlands, 1982, 118 pages.

The project's objective was to provide an adequate supply of safe water to the population in the two southern regions of Guinea-Bissau. Quantity as well as quality should be sufficient throughout the year, while walking distance should be limited.

To try to achieve this with fairly simple techniques and at moderate cost, the project was directed to the construction of shallow wells equipped with a pump or a bucket.

Experiences of similar projects in other developing countries have shown that constructing a well does not in itself guarantee that it will be actually used. For this reason, in the Buba-Tombali project a separate section was created with the special task of stimulating the proper use of the new wells. Co-operation between this "social activation" section and the project's technical sections was promoted vigorously, and proved to be one of the strong features of the project.

One result of the pilot project was that, contrary to what was expected, it would be necessary to construct dug wells as it proved impossible to provide exclusively hand-drilled tubewells.

This report describes the organization and results of the first phase of the well construction project for the period 1978–1981.

Not covered in this report are the construction of water distribution systems in three small villages for which preparations were made by the project team in Buba, and the support provided to the central services of the Ministry in Bissau.

Requests for information should be directed to: International Reference Centre for Community Water Supply and Sanitation (IRC), P.O. Box 5500, 2280 HM Rijswijk (The Hague), The Netherlands.

Hand Drilled Wells — A Manual on Siting, Design, Construction and Maintenance by **Bob Blankwaardt,** April 1984, 132 pages. This handbook was published by the Rwegarulila Water Resources Institute, Dar es Salaam, Tanzania.

This manual on Hand Drilled Wells is the product of 3 years field and classroom teaching experience, first at the Morogoro Wells Construction Project and later at the Rwegarulila Water Resources Institute.

It is built up in six parts. The first part — Chapter 1 — is an introduction to the subject. In the second part — Chapters 2 and 3 — the most necessary hydrogeological theory is given. Part three which includes Chapters 4 and 5, deals with site investigation and the criteria for approving a site for construction of a well. In part four — Chapter 6 — the design of the well is discussed, and in part five — Chapters 7 to 11 — the actual construction of the well including the installation of a hand pump. In the last part — Chapter 12 — a possible approach towards the maintenance of pumps and wells is indicated. In order to keep the size of the chapters on site investigation and well drilling operations limited, the survey and well drilling equipment have been described in separate appendices.

This book will be of use not only to pre-service students but also to craftsmen, technicians and practising engineers, as well as to project planners. It contains the most important operations described as step-by-step procedures and is illustrated with many drawings and photographs.

A translation of relevant parts of the book into Kiswahili is planned.

Copies of this manual can be obtained from TOOL Foundation, Entrepôtdok 68A/69A, 1018 AD Amsterdam, The Netherlands. ISBN 9976-936-01-X.

Fish Culture for Small-Scale Farmers by **Peter Edwards** and **Kamtorn Kaewpaitoon,** illustrated by **Apichart Ngarmniyom,** March 1984, 44 pages. This manual was published by the Environmental Sanitation Information Center (ENSIC), Asian Institute of Technology, Bangkok, Thailand.

The text of the manual presents the basics of aquaculture in simple language, is profusely illustrated with line drawings, and assumes no previous knowledge of fish farming. The manual has been kept as simple as possible to avoid the pitfall of ending up as a textbook.

The method of fish culture described is based on the Chinese practice of raising fish on livestock manure and agricultural wastes or residues. The most important aspect of pond management is the production of protein-rich, natural food, particularly plankton, by means of fertilization of the water with animal manure. Other pond inputs such as waste food, aquatic macrophytes, termites, and even rice bran and boiled broken rice should also be used where feasible, but the most cost-effective way to raise fish for small-scale farmers may be through the development of plankton-rich water.

The manual is based on practical experience of raising fish in fertilized ponds, both on the Asian Institute of Technology campus and at the village level in Thailand. Observations of integrated fish farming systems in China also provided considerable insight into the raising of fish in waste-fed ponds.

Copies of the manual are available either in English or Thai from Dr J. Valls (ENSIC), Library, AIT, P.O. Box 2754, Bangkok 10501, Thailand. ISBN 974-8200-09-4.

Updated Guidebook on Biogas Development, Energy Resources Development Series No. 27, July 1984, 178 pages. This book is a **United Nations Publication** ST/ESCAP/275.

The first edition of this publication was brought out in 1980 to serve as a guidebook on the practical aspects of small-scale biogas development suitable for use in rural areas in developing countries, especially those of the ESCAP region.

This present publication is the second revised and updated version of the original guidebook and contains additional chapters on prospects of meeting fuel energy needs through biogas, a review of biogas development, biogas fermetation process, and the microbiology of biogas fermentation. In the annex, additional information on common methods of analysis, the report of the Workshop on Uniformity of Information Reporting for Biomethanation Systems, case studies on cost benefit analysis of biogas technology, and a list of institutions engaged in biogas research and development, has been provided.

Specialists responsible for developing the use of biogas in rural areas and individuals who wish to build their own biogas plant will find the information in this book useful.

Order can be placed with: United Nations, Sales Section, New York, USA or Geneva, Switzerland, quoting the Sales No.: E.84.II.F.14. Price per copy: $ US 17.50.

Current Practices in Environmental Engineering, Vol. 1, 1984, 248 pages. The International Overviews is edited by **Alam Singh** and **U.S. Sharma** of the Geo-Environ Academia, Dept. of Civil Engineering, University of Jodhpur, Jodhpur 342 001, India.

This serial publication contains contributions from 21 specialists in the form of full articles and abstracts on the latest advancements in the practice of Environmental Engineering with emphasis on purification of water and reuse, disposal and reclamation of municipal and industrial wastes, pollution abatement, protection against radiation hazards, industrial hygiene, control of communicable diseases, appropriate technologies for rural communities and other topics of interest on environment and ecology.

This publication is available from: Editorial Office c/o Dept. of Civil Engineering, University of Jodhpur, Jodhpur-342 001, India. ISSN 0253-5114. Price per copy: Rs 250.— or US $ 50.— or UK £ 35.—.

S. Peter, Editor
"IRCWD News"
Swiss Federal Institute for Water Resources and Water
Pollution Control (EAWAG)
Ueberlandstrasse 133, CH-8600 Duebendorf, Switzerland