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Mechanised emptying of pit latrines in Africa

1. INTRODUCTION

A major emphasis in sanitation during the 1981-90 International Drinking Water Supply and Sanitation Decade, has been the improvement of the basic pit latrine. These improved designs are mainly single and double ventilated improved pits (VIP and VIDP) (refs 1, 2). This need for simple forms of sanitation is because, even if adequate funds were available, there would be insufficient water to operate waterborne systems.

In the foreseeable future, sanitation for the mass of low-income families is likely to involve the storage of human excreta on the housing plot. The eventual handling of the material is now recognised as a major part of on-site sanitation technology. Indeed, it is seen as an important and problematical feature of pit type sanitation schemes, particularly in urban areas, where relocating a pit latrine on a housing plot may not be feasible when an original pit is full.

Considerable effort is being made to persuade householders to upgrade latrine design, by such methods as including a ventilation pipe to each sludge chamber. Apart from the obvious appeal of reducing odour nuisance, this investment of resources is encouraged if the latrine system is seen to be a permanent installation. Consequently, if a pit latrine is to be permanent, then it will need periodic desludging to allow continuing use.

2. WHY MECHANISED PIT EMPTYING

Much discussion has taken place on the desirability or otherwise of using mechanised methods to desludge pit latrines. There is the attractive idea that hardware for developing communities should always be hand operated and of basic technology. However, to lift compacted pit latrine sludge, commonly of a relative density of from 1.2 to 2.0, through even a short length of 100 mm diameter, flexible suction hose, the energy requirement could be as high as 30 kW (40 BHP). A single man, working continuously, can only produce about 75 watts (0.1 BHP) of useful energy. Even if his output is doubled (a strong man working in short bursts) he would only produce about 150 watts.

If it is required to remove compacted pit sludge by suction hose, then an appropriate and sufficiently powerful energy source must be utilised. The only manual alternative is sludge removal by bucket; for a typical pit latrine containing around 1,000 litres of sludge this would be a long, very unpleasant and hazardous operation. Skin contact could not be avoided with likely pathogen laden sludge. For a large proportion of African communities however, manual handling of sludges associated with human excreta is unacceptable.

Botswana is one African country that is urgently seeking solutions to the problems of pit desludging. The expressed need there is for effective mechanical equipment that can remove sludge of a wide range of consistency from chambers and transport it to disposal. This is required to be done in a manner that involves the minimum contact of personnel with the sludge and hence does not pose a health problem.

The UK Building Research Establishment (BRE) has had links with Botswana for many years, concerned with drafting Building Regulations and advising on building matters. In 1979, in collaboration with the Ministry of Local Government and Lands, BRE proposed the adoption of shallow, double chambered pit latrines, which were the forerunners of the many thousands of VIDP latrines now installed there. As an option for desludging these new latrines, as well as the many old single pits, BRE has developed a suction tanker called BREVAC to do this job. The development of BREVAC was necessary because ordinary vacuum tankers (cesspit emptiers) were not capable of handling pit latrine contents, which often consists of organic sludge, grit and general domestic rubbish.

3. IDENTIFYING THE PROBLEMS

The need for methods and equipment for pit desludging has been the subject of recent research by BRE, funded by UK's Overseas Development Administration, the World Bank/Technology Advisory Group (TAG) and the International Reference Centre for Wastes Disposal (IRCWD). IRCWD carried out a study to identify the range and nature of pit latrine sludges in Dar es Salaam, Tanzania and Gaborone, Botswana (ref 3). BRE used

this data to produce simulated sludges, so that currently available suction equipment could be evaluated.

The following constraints have to be considered in the evaluation of methods and equipment for chamber desludging:

- (i) Limited access to the house plot (perhaps no access road).
- (ii) Limited access to the sludge chamber (inaccessible siting of chamber on plot, sometimes access only through house).
- (iii) Limited access to the chamber contents (sometimes access only through the latrine inlet hole, limited hole size and headroom).
- (iv) Nature of the chamber contents (sludge and other debris):
 - (a) high resistance to flow (viscous composition)
 - (b) highly abrasive nature of the sludge (high grit content in unlined pit latrine sludge)
 - (c) presence of sticks and stones (sometimes used for anal cleansing).
- (v) Flow problems of getting sludge from a pit or tank into a pump system (eg reciprocating pumps need to be self-priming).
- (vi) Shortage of skills to operate and maintain equipment (planned maintenance is essential for efficient utilisation of mechanical equipment).
- (vii) Social implications (reactions of householders to odour and general disturbance).

The main constraints on system selection are those of access and the abrasive nature of the sludge. The only system likely to be feasible is a suction system, employing a flexible hose of between 75 mm and 100 mm diameter. Specifically for emptying pit latrines, a 100 mm diameter hose is most appropriate, to minimise blockages by large items (rags, beer cans, etc) and still be manoeuvrable by the operating crew when full. The facility to draw sludge through a long horizontal hose is desirable, where access to a chamber is restricted.

4. THE BREVAC SUCTION TANKER (ref 4)

Resulting from experimental work at BRE, using simulated sludges and various suction systems, a specification was prepared for a suction tanker that could satisfy all of the constraints. The BREVAC suction system combines a partial vacuum effect with pneumatic conveying, in order to draw a range of sludges, from water to heavy viscous sludge.

To achieve effective sludge conveying, a liquid ring vacuum pump was selected, to extract air from a 4500 litre 'vacuum' tank. A maximum vacuum is achievable of up to 0.9 bar, together with high air flow. A major advantage over other types of vacuum pump, was the minimal risk of damage to the pump, by accidental carry-over of sludge particles with the air, and very little maintenance requirement. Getting sludge out of a pit and into a tanker was one problem, but due to the likely flow characteristics of the sludge, possible difficulties were predicted in getting the sludge out of the tanker for disposal. The BREVAC specification therefore, included a full sized opening rear door, with the facility to tip the tank.

5. BREVAC IN BOTSWANA

A BREVAC tanker was shipped to Gaborone, Botswana, in November 1983, to commence two years' of field trials, in service with the Gaborone Town Council. This was part of a collaborative project between BRE and the Botswana Ministry of Local Government and Lands.

Comparative testing of five suction systems, including BREVAC, has taken place in Gaborone, from November 1983 to February 1984. The tests were organised by IRCWD and the World Bank/TAG; a report of these tests is being produced by IRCWD (ref 5). In the report BREVAC was described as easily manoeuvred, having a very powerful suction, with easy access for tank cleaning.

The objectives of the long term trials of BREVAC are not only to assess its performance and durability, but to determine the likely costs of running a BREVAC tanker emptying service for pit latrines and small sludge tanks.

The data obtained so far indicates that BREVAC is performing very well, with little maintenance requirement. The vehicle chassis however, has presented some minor 'wear and tear' problems, common in running vehicle fleets in developing countries. Because of delays sometimes in obtaining basic spare parts, the utilisation of BREVAC in Gaborone is estimated provisionally to be about 75%.

BREVAC is in regular service, emptying a range of sludge chambers:

- (i) Single chamber pit latrines (basic design) 0.5 m³ approx capacity.
- (ii) Single chamber pit latrines (ROEC offset pit) 4 m³ approx capacity.
- (iii) Double chamber pit latrines (RECII) each chamber 2 m³ approx capacity.



BREVAC in Botswana

- (iv) Aqua privies (Botswana type B) 1 m³ tank capacity.
- (v) Septic tanks (commercial premises) various capacities.

Trials have been carried out using long horizontal hose runs; BREVAC has pulled the heaviest sludge, with over 80% solids content, over 64 metres through a 100 mm diameter hose. However, the most convenient hose length is around 10 metres, requiring the tanker to be close to the sludge chamber. Short hoses mean minimal washing after use, as well as keeping the number of possible leakage points at joints to a minimum.

6. COST OF A BREVAC EMPTYING SERVICE

It is common commercial practice in UK to set aside a proportion of income from a vehicle fleet to cover the cost of vehicle replacement ie capital is not raised by borrowing (ref 6). This basis is used here for estimating the cost of a BREVAC chamber desludging service.

To obtain a realistic indication of cost for a pit and tank desludging service, some data from BREVAC's field trials have been used in the calculations. The data available so far indicate that a typical working day for a BREVAC tanker allows for three round trips, ie visiting housing plots, collecting sludge and delivery to a disposal point. The volume of sludge collected on each round trip is limited to 4500 litres (tank capacity). Typically four to five chambers can be emptied per trip, at an average volume of sludge moved per chamber of 1 m³.

Taking a working year as 185 days (at 75% vehicle utilisation) and at three trips per day, then 2,497 m³ of sludge can be handled per year. Also, 2,497 chambers can be serviced per year. For an emptying cycle for pit latrines of at least three years, a population of 7,490 pits can be serviced by one BREVAC.

To establish a cost per household per year as a service charge to be levied per plot, the following have been taken into account:

Note: The value of the Botswana Pula has been taken as P1.645 = £1 (exchange rate at mid 1984)

(i) FUEL

Diesel fuel consumption per year = 4,625 litres (based on an estimated consumption of 25 litres per day and a diesel fuel cost of P0.63 per litre). Fuel cost = £1770 per year.

(ii) LABOUR

Operating crew of three plus driver, at a total cost per day of P24.6 (£15). Labour = £2770 per year.

(iii) MAINTENANCE

Notional maintenance cost, taken as the recorded cost of spare parts and labour over the first year of operation x 2 (for typical year) = £2,520 per year.

(iv) GENERAL OVERHEADS

Overheads taken as 20% of other costs (i), (ii) and (iii) = £1,420 per year.

(v) VEHICLE REPLACEMENT

Vehicle life notionally ten years. Therefore replacement cost should be covered by income in ten years.

The vehicle life could be less than ten years, but also there will be a residual value of the vehicle. However the notional annual sum for vehicle replacement taken here is based on a vehicle cost of £42,000 every ten years, using interest earning income from plot levies = £3,340 per year.

Because a vacuum tanker service in Gaborone is a small part of the work carried out from the Town Council Depot, no allowance has been made for a share of the cost of facilities at the Depot (other than vehicle maintenance), buildings depreciation, etc, or organisational costs of Council staff (other than the operating and servicing personnel).

The total annual cost for a BREVAC desludging service is the sum of items (i), (ii), (iii), (iv) and (v) = £11,820.

If one BREVAC services a population of 7490 plots (pits) ie empties 2497 pits per year at an emptying cycle of three years, then the cost per pit emptied = £4.73 (P7.79). Therefore the annual emptying cost per pit = £1.58 (P2.60). This charge can be recovered as a monthly levy, such as the present practice in Gaborone. This levy would need to be £0.13 (P0.22) per plot per month. At

an average capacity of 1 m³ per pit, the cost for sludge handling = £4.75 (P7.79) per m³.

In the case of a Town Council desludging service in Gaborone, a notional service cost of P0.25 per month has been included in housing plot charges, this plot charge being considered as income for the emptying service. The annual income for a pit emptying service is therefore P3.00, equivalent to £1.82, per annum per plot. If accrued interest is taken into account, the annual income per plot could be of the order of £2.00.

In fact, in Gaborone, the emptying period for the new generation of double pits is likely to be around four years; this could reduce the necessary plot levy. Other factors that may effect the cost calculations are the write-off period and a residual value for the tankers, as well as the effect of inflation on interest that is earned on the accumulating plot levies.

Another saving might be made by careful planning of periodic chamber emptying. By arranging for sludge collection from adjacent plots, rather than widely scattered plots; it is likely that the number of round trips of BREVAC each day could be increased from three to four. This would proportionally increase the population of pits served per tanker, increasing the income to the emptying service, as well as reducing the cost per pit emptied.

7. SITE ACCESS

Even though BREVAC has the capability of drawing heavy sludge over long horizontal distances, it is laborious and time consuming to lay out long hose runs and clean the sections after use before stowing on the tanker.

The long hose facility, therefore, should be considered as only for occasional use, eg where a temporary obstruction prevents normal access to a sludge chamber.

An ideal solution would be to provide planned vehicle access to all housing plots that have, or are intended to have, on-site sanitation, such as a pit latrine.

In recent 'site and services' housing schemes around Gaborone vehicle access has generally been provided. In older low-income housing areas, where the original access was by footways only, considerable effort has been expended to provide vehicle access as part of an upgrading programme which includes mechanised pit emptying.

8. FURTHER DEVELOPMENTS OF BREVAC

As a result of experiences so far with running BREVAC, minor improvements can be made to its specification, not only to improve its function, but also to simplify servicing. Wider application of BREVAC is important, not only to bring added capability to Town Councils for desludging pits and tanks, but also to obtain feedback on site running at different locations to aid future development.

BRE has licensed Airload Engineering Ltd in UK to build BREVAC suction tankers, incorporating pump systems similar to the original BREVAC. Options are available on such features as tank capacity and therefore vehicle size. Details and prices for commercial BREVAC tankers can be obtained from:

Airload Engineering Ltd
Unit 8, Pembroke Dock Industrial Estate
London Road, Pembroke Dock, Dyfed SA72 4RS
UK

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REFERENCES

1. Carroll, R F. Sanitation for developing communities. BRE Overseas Building Note 189. UK Building Research Establishment, May 1982.
2. Mara, D D. Sanitation alternatives for low income communities - a brief introduction. The World Bank, Washington, February 1982.
3. Hawkins, P. An evaluation of technical problems in emptying on-site excreta disposal systems. WHO International Reference Centre for Wastes Disposal, Dubendorf. September 1981.
4. Carroll, R F. BREVAC: a mechanised method of emptying sanitation chambers. BRE Information Paper IP 1/84, UK Building Research Establishment.
5. Bosch, A. Pit latrine emptying devices. Preliminary report. WHO International Reference Centre for Wastes Disposal, Dubendorf, February 1984.
6. Lowe, D. The economics of commercial vehicle operation. Fleet Efficiency Guide No. 3. Ford Motor Company Ltd, Brentwood, August 1983.