13th WEDC Conference

Rural development in Africa
Malawi: 1987

Choices in pit latrine emptying

Chris Williams

ABSTRACT

This paper reviews the types of mechanical pit emptying equipment available, the effect of increasing travel distances on a pit emptying service and options for pit latrine sludge disposal.Data is presented for the Maseru urban area where the BREVAC LA equipment has been tested.

1. INTRODUCTION

Since 1980 the Urban Sanitation Improvement Team has been encouraging the building of VIP and VIDP toilets in urban and peri-urban areas of Lesotho. Due to a clay soil horizon we have found that the contents of the resting pit of a VIDP are often very wet and would not be easily emptied by hand - there is also the question of pathogenic contamination of wet pits - see also Makhetha (ref.1). Because of this we have moved towards recommending single-pit VIPs with mechanical emptying.

Over the past few years, a number of different technologies have been developed to empty pit latrines and to load the sludge into a tank unit (ref. 2). The problems of disposing of the sludge and the costs of the service are now the major issues. An analysis of haulage costs with distance and disposal alternatives will help us to make rational decisions on the level of service to be provided in to areas remote from the disposal point.

2. EMPTYING EQUIPMENT CHARACTERISTICS.

There are two basic categories of pit emptying equipment - those in which the pit latrine sludge (PLS) is loaded into a tank which is then driven to the disposal pond (non-transfering systems) and those in which either the sludge or tank from the emptying machine is reloaded onto alternative transport (transfering systems) e.g. ALH (ref.2). To date not much work has been done on transfering systems except a few experiments - there is room for more investigation.

Present non-transfering systems can be divided into those which use a combined pump and tank unit like the BREVAC machines used in Gaborone and Francistown in Botswana, and the BREVAC LA System as used in Maseru where the pump and tank units have independent motive power. These categorizations are shown in Fig. 1.

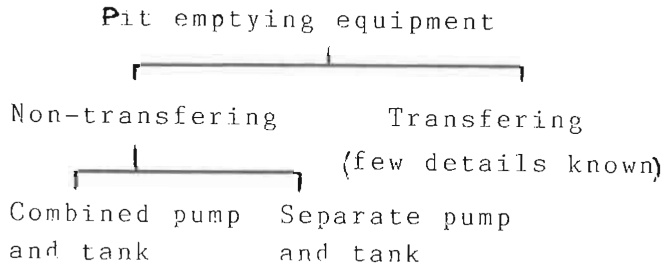

Fig.1 Classification of pit emptying equipment

The separate system is obviously more expensive to run if there are only a few tank units and hence the equipment will be operating basically as a tank and pump unit, but requiring 2 drivers and two fuel and maintenance bills. However, if the pump unit can be stationed in one area and a shuttle of tankers run to the disposal site costs should be reduced.

With both transfering and non-transfering systems, one key factor is the size of the payload. The larger the size the fewer trips will be needed to the disposal point. If the disposal point is quite distant this could provide savings on fuel and travel time. It also means that there is less likelihood that multiple trips will be needed to empty any oversized pits. The disadvantage of a larger tanker size is the difficulty of access - this can to some extent be overcome by the use of long hoses, although the setting up time and capital costs can be relatively high. In Botswana tests have shown that the BREVAC tanker could pull PLS 64m and the ROLBA tanker slightly less (ref.2).

In Maseru the access difficulties are indeed greater than in Botswana but it is likely that a full size BREVAC type machine with around 30m of hose will be able to empty the pit in over 95% of cases.

Systems based on septic tank emptiers have the disadvantage that they cannot empty all pits due to the relatively low air flow produced by the pump - hence they must work in a fleet with machines that are capable of pulling heavy sludges. In this case some apparent cost reduction will have to be balanced against a loss of flexibility.

3. TRAVEL DISTANCE AND COSTS

Costs for pit emptying services have been calculated in the past, notably by Carroll (ref.3) who obtained £4.73 per cum. of PLS after considering fuel, labour, maintenance, general overheads and vehicle replacement costs. Schulz (ref.4) obtained US $ 6.66 (= £4.62) per cum. PLS exclusive of vehicle replacement. Both these figures exclude disposal costs.

A large BREVAC type machine should be able to leave the yard (or disposal point) and pick up sludge at a number of pits before going to the disposal point. Hence we can obtain an average distance travelled per pit. In the study by Carroll (ref.3) in Gaborone this is somewhere around 4km.

Clearly costs go up with travel distances. This is basically due to the fact that spending longer travelling between pits or the disposal point means fewer pits can be emptied per day and hence the fixed costs can be divided between fewer customers. An analysis of travel time data shows that we could expect 2220 cum. of PLS to be emptied per year if the travel distance is 4km., 1805 for 8km. and 1311 for 16 km., assuming 185 working days (75% vehicle utilisation) and that 1 cum. PLS is removed from each pit. Ron Carroll and Geoff Ashall of the Building Research Establishment (UK) (private communication, 1987) have estimated that the total annual cost of the service is £16,247, so this would imply costs of £7.31, £9.00 and £12.39 for 4, 8 and 16 km. travel distances respectively - see fig.2. These calculations should be regarded as order of magnitude rather than highly accurate. In Maseru we have an average pit to pit distance of about 13km - this is partly because there is a steady but not high demand for services, so grouping by area is difficult. Interpolating from fig.2 we would expect the cost in Maseru to be £11.00 per cum. of PLS.

Carroll and Ashall further estimate that the total annual cost for a large BREVAC is divided up as follows - capital 54%, fuel 11%, labour 12%, maintenance 15% and general overheads 8%, assuming an interest rate of 14% p.a. Since the major element is capital cost, it could be useful to obtain a low interest loan or use aid funds for the first vehicle and then finance its replacement from revenue.

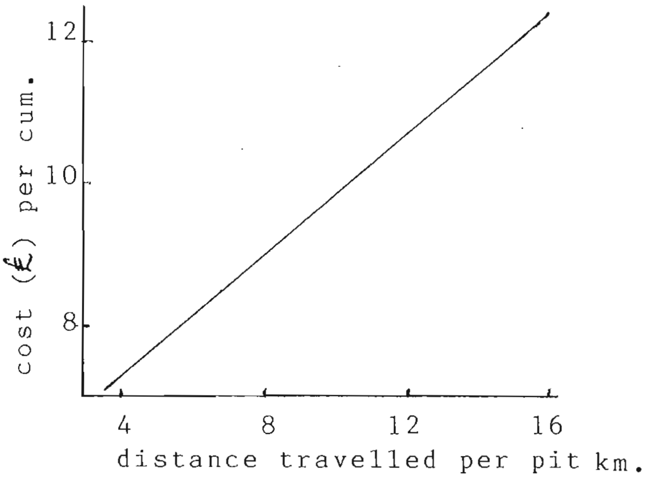

Fig.2

The kind of amount demanded is large in terms of clients' ability to pay a lump-sum in Lesotho - it could be paid in "rates" or some installment system payable <u>before</u> emptying. One cum. of PLS represents around 4 years accumulation for a household of 5, so the cost is effectively spread over 4 years.

It should be noted that in the early years of establishing a service it may be underutilised, as the number of pit latrines is building up. This will make the service more expensive during this period.

4. DISPOSAL OPTIONS

We are discussing the disposal of sludge from single pit VIPs so pathogenic waste will be present. The options for PLS disposal include dumping in sewage treatment ponds, trenching, sludge digestion, composting and discharge to sewers.

4.1 Ponds

Ponds could either be specially constructed for PLS (similar to nightsoil ponds), or have mixed use with a sewerage system. A simple apron with screened outlet leading to the first pond and washing-down facilities are the only special structures needed.

The question of BOD loading from PLS then arises. Schulz (ref.4) claims that on average 90% of excreted BOD has decayed in a normal pit latrine. The bottom layers are usually fully decayed and the BOD content is found in the upper 'fresh' material. Assuming an accumulation rate of 50 l/c/yr, 1 cum of pit latrine sludge represents 20 person years accumulation. At 30g excreted BOD per day, this would imply that 20 x 30 x 365/1000 = 219kg BOD have been excreted, and therefore 21.9kg BOD should be found in 1cum of PLS. More experimental determinations of the BOD of PLS should be made. The decay of organics in the pit means that there will be a higher non-biodegradable content in PLS than nightsoil, so the silting up of ponds will be more serious.

Disposal to ponds is used in Gaborone and Maseru.

4.2 Trenching

PLS could be disposed of in a similar way to nightsoil by trenching. In Maseru our experience has been that mechanically emptied PLS is rather liquid and this means that it is difficult to cover over the trenches with soil after dumping due to the splashing of PLS on the workers. Hence a public health nuisance is created through the uncovered sludge. However, in well drained soils or with less liquid sludges this may not be such a problem, and trenching has the advantage that it can be a local disposal solution in remote areas - this could be particularly helpful in rural institutions like schools.

4.3 Sludge Digestion

As pointed out by Droste (ref.5), anaerobic sludge digestion must be evaluated against three criteria namely hygienic excreta disposal, biogas production and fertilizer production.

The system envisaged would consist of one or more digesters with inlet works and sludge drying beds.If there are pre-existing sludge digesters, either at a sewage works or for domestic biogas production then this choice seems quite feasible. The installation will require pumps and hence a power supply, making it more complex than ponds or trenching.The management of a digester is also more difficult than the previous two options.

4.4 Composting

Composting is an attractive alternative because of the potential for reusing resources - Shuval et al.(ref.6) have recommended the Beltsville Aerated Rapid Compost (BARC) system for composting nightsoil in developing countries . However, one problem with PLS is its relatively low organic content - this would mean that mixing with other materials would be necessary to obtain a good compostable mixture. The moisture content of sludge for composting should be between 40 and 60% (ref.7). Although the moisture content of PLS given in Carroll (ref.8) of 55% falls within these bounds, in Maseru our sludges tend to be too wet and dewatering would be necessary - this could be done by mixing with 'dry' materials like sawdust if they are available.

It should be noted that in Africa people are often unwilling to handle what was once excreta, so the supposedly useful final product (compost) may not be utilized (ref.9). The compost may also be of limited use in urban areas, and transport to agricultural land difficult or expensive.

4.5 Discharge to sewers

The screened discharge of PLS into sewers seems quite feasible, particularly if it is done near pump stations where a macerating effect is achieved. Alternatively there may already be facilities for emptying septic tank emptiers to cut down on haulage distances. This reduction of haulage distances to a central treatment works could mean that greater penetration of areas remote from the disposal point is possible. It may be necessary to add water if there is not a sufficient flow in the sewerage reticulation system at the disposal point. The PLS will either be treated in ponds or generate primary sludge in a 'conventional' STW. If it is felt that a 'shock load' could result, for example on trickling filters, then holding tanks slowly pumping the PLS into the sewers could be used. This would not be a problem with ponds.

4.6 Disposal costs and choices

A PLS disposal facility will incur capital and recurrent expenditure in its operation. Obviously the treatment unit costs should affect the choice of the disposal option, although many other factors such as land, capital and labour availability, the nature of the terrain and foreign exchange controls can also affect the decision (ref.10). It is hard to find much information in the literature on unit costs for the different treatment alternatives given above, so some rough outlines are presented below - land costs have been excluded.

Ponds: In Lesotho the cost of building waste-stabilization ponds was around M70 per person equivalent in 1982 (ref.11), and must be around M100 (UK£31.25, December 1986) by now. In 1 cum of PLS we have 21.9kg BOD (see section 4.1). This is equivalent to 548 person equivalants at 40g BOD/c/d. Hence the capital investment to dispose of 1 cum PLS/day is around £17,125, spread over a 15 year period, or about £6.17 per day (at 10% discount rate). In low-technology options like ponds we expect investment costs to be around 50% of the total costs (ref.10). Therefore the cost of disposing of 1 cum PLS in ponds could be around £12.

Composting: Shuval et al (ref.6) present calculations to show that the BARC system costs around US $50 (=£34.70) per dry ton. In 1 cum. of PLS we have an average 612kg of dry material (ref.8), so the cost of composting could be around£21/cum PLS.

Trenching: It is estimated that it would cost about M10 (=£3.13) to manually excavate a suitable trench for 1 cum PLS. If we double this figure to allow for fencing, tools, mixing materials and other overheads, we find that it should cost around£6/cum PLS to dispose of the sludge by trenching.

Sewer Extension: As a concrete example we consider the Khubetsoana housing estate on the outskirts of Maseru, built with World Bank assistance.There are approximately 1000 pit latrines on this site, so if we assume that 1 cum. PLS is taken from 4 latrines by a full-size BREVAC type machine, then the average travel distance per pit will be about 6 km., which corresponds to £8.15/cum. (fig.2). At present the nearest sewage pump station is 3.5 km. away, downhill.

If the sewer was extended to the housing site, then the distance/pit could be reduced to something like 2 km. - we have to allow for daily travel from the yard. Extrapolating fig.2 this implies £6.60/cum. Hence we would save£1.55 per pit, or £1550 over 4 years.This alone certainly cannot justify the extexsion of the sewer, as construction costs alone are around £20/m (ref.11).

5. CONCLUSIONS

Considering non-transfering systems, it seems clear that the rule is, the bigger the better, and that smaller sized (limited access) vehicles should only be considered when access problems are severe.In this case the transfering systems may be more appropriate, but so far there seems to be little practical experience with running these machines under non-experimental conditions.

It appears as if the cost of pit emptying increases quite sharply as distance travelled per pit increases, implying that careful routing and zoning and the provision of more than one disposal site for large urban areas will be important.

As regards disposal options, the cost comparisons are difficult to work out with much confidence, but disposal by trenching or into ponds where land is available are suggested to be the most economical solutions for the Lesotho data.

Fig.3 BREVAC LA equipment in action

REFERENCES

1. MAKHETHA S.N. Single pit versus double pit latrines - lessons and experiences from Lesotho. 13th WEDC Conference. Lilongwe, Malawi, 1987.

2. BOESCH A. and SCHERTENLIEB R. IRCWD News. No. 21/22. Duebendorf, Switzerland, May 1985.

3. CARROLL R.F. Mechanised emptying of pit latrines in Africa. 11th WEDC Conference papers, Dar es Salam, 1985.

4. SCHULZ C.R. An Economic Cost Comparison of waterborne sewerage and the Ventilated Improved Pit latrine in Garissa, Kenya, TAG, Washington, 1985.

5. DROSTE R.L. Excreta Reuse Options: Composting and Biogas, in Water Supply and Sanitation in Developing Countries. Eds. E.J. Schiller and R.L. Droste. Ann Arbor, Michigan, 1982.

6. SHUVAL H.I. et al. Night-soil Composting. World Bank, Washington, 1981.

7. KALBERMATTEN J.M. et al. Appropriate Sanitation Alternatives, A Planning and Design Manual. John Hopkins U.P. 1982.

8. CARROLL R.F. BREVAC - A mechanised method of emptying sanitation chambers. BRE, Watford, UK, 1984.

9. FEACHEM R.G. et al. Alternative Sanitation Technologies for Urban areas in Africa. P.U. report No. RES 22, World Bank, Washington D.C., 1979.

10. THE DANISH ACADEMY OF TECHNICAL SCIENCES. Industrial Wastewater Treatment in Developing Countries. Lyngby, Denmark, 1985.

11. GKW CONSULT. Thirteen Towns Sanitation Project Preinvestment Study - First Phase Plans. Maseru, Lesotho, 1984.