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Anaerobic filters for on-site sewage treatment

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SEPTIC TANK - SOAKAGE pit systems have been the commonest form of sewage disposal in urban and suburban Sri Lanka, where only parts of the Capital, Colombo, is served by a central sewer network. Virtually none of the other major cities and towns have any form of central sewer network. Even in Colombo, the coverage remains poor, with an estimated 1.7 million people (approximately 80 per cent of the metropolitan population of Greater Colombo) being dependent on on-site systems for sewage disposal (Fernando, 1994).

Increasing urbanization (with some urban areas growing at a rate of up to 40 per cent per annum), together with high water tables and unsuitable soil conditions in many areas has led to a serious problem of ground water pollution as well as failure of these on-site systems. In many instances, partially treated effluent from septic tanks are diverted into nearby open storm drains, ditches and canals. A practical evaluation of many of these problem sites revealed that, in a majority of cases, the septic tank units were functioning properly, and the failures were due to problems associated with the soakage of effluent. With a view to addressing the problems of individual home-owners and small to medium scale commercial establishments, the viability of simple anaerobic filters to treat septic tank effluent up to a standard suitable for surface discharge was investigated. Initial laboratory scale tests gave promising results for septic tank effluents (Corea and Parameshwaran, 1994). Consequently, several field scale units were designed and constructed at several problem sites. These sites included individual homes, student dormitories and hostels, tourist hotels and commercial establishments. The common problems associated with these sites were:

- lack of physical space
- lack of facilities for off-site treatment
- high water table
- poor soil absorption capability.
- practical solution urgently required by users.

Several of the field units were designed and installed to rectify existing septic tank-soakage pit systems, while others were designed for new developments. A monitoring program was setup to monitor and evaluate the performance of these units in the long term, and to improve and to improve and economize on future designs.

Methodology

Due to practical difficulties in sampling all the field units continuously, it was decided to sample influent and effluent quality of one unit on a weekly basis. Other systems were to be visited and sampled if necessary on a reactive basis, whenever problems are reported by users, neighbours or regulatory authorities.

The unit selected for continuous regular monitoring was one installed at a staff hostel of the University of Peradeniya. The unit was designed to rectify an existing septic tank and soakage pit which was failing due to lack of soil absorption capacity, and resulting in malodorous effluent flowing into open storm drains. this was giving rise to strong complaints from neighbours and municipal authorities.

The rectification work involved the rehabilitation of the existing septic tank to seal leaks and repair structural damage, together with the construction of an anaerobic filter unit in place of the old soakage pit. The filter was designed to receive blackwater from a population equivalent of 50. The effluent from the filter was to be discharged to an open roadside storm drain flowing through a crowded residential neighbourhood. A schematic diagram of the anaerobic filter is shown in Fig. 1. The filter material comprised three layers of crushed rock, graded and washed. The filter material was supported by a perforated concrete slab, and the whole unit, together with an inlet and outlet chamber was cast in waterproofed reinforced concrete. The average porosity of the filter was approximately 50 per cent, and the hydraulic retention time was 18 hrs. at a design flow of 1.8 m^3/d.

After commissioning, the unit was inspected at least once a week and filter influent and effluent was sampled and tested for BOD_5, suspended solids and turbidity. A record of occupancy of the building was maintained, and the residents interviewed regularly for their response. All analyses were carried out in accordance to APHA Standard Methods for the Examination of Water and Wastewater, 1987.

Results and discussion

The influent BOD to the filter (i.e. the effluent from the septic tank) was found to be highly variable, while the effluent was usually of a consistently good quality for surface discharge. Table 1. gives a summary of the test results for the first 500 days of operation, while Fig. 2 shows the variation of influent and effluent quality for the same period. The suspended solids of the influent as well as the effluent was always below 30 mg/l, and effluent turbidity was consistent below 15 NTU.

The filter was operating very close to design capacity with occupancies in the range of 47 - 50 people, with occasional drops below 30. In one instance the system was subject to

Table 1. Summary of monitoring results for the first 500 days

almost three times its design p.e. for a 24 hr. period with little significant effect on effluent quality. This resistance to hydraulic shock loads and variation in influent quality is in keeping with recent reports in literature (Panswad and Komolmothee, 1997, Kobayashi et al, 1983, Watanabe et al, 1993, Young 1991)

In a separate instance, the filter was accidentally dosed with insecticide, following which, some problems of odour were reported for several days until the filter recovered. However, in the main, the effluent has been clear and odour free, with no reported complaints from residents, despite the discharge point being within three metres of the nearest residential quarters. User satisfaction has been high, and no maintenance work has been required in over 18 months of operation. An initial problem of mosquito-breeding in the filter unit was over come quite simply by covering the vent pipe opening with plastic mosquito mesh.

The other anaerobic filter systems installed to date have varied from individual houses, to star-class tourist hotels with p.e.s ranging from 5 - 150. While some of these systems have been septic tanks followed by anaerobic filters to surface discharge, others had gravel percolation beds for treatment upto tertiary level with effluent re-used on-site for gardening, vehicle-washing and other outdoor uses. These systems were designed to handle blackwater only or combined black and gray water depending on the client requirements and site constraints. None of the installed systems have reported any major problems to date and have been performing to a high level of user satisfaction.

Conclusions

Based on the experience so far, the potential for anaerobic filters for secondary treatment of septic tank effluent upto a standard for surface discharge appears to be promising. The systems are low-cost with the cost of a unit being roughly in the same order as that of a septic tank with a five-year sludge storage capacity. They also have minimal running cost with the systems being entirely gravity flow and essentially self-operating. They also are particularly suited to urban and sub-urban unsewered areas, where land is precious. The entire system can be located conveniently underground, with the space above available for limited use. Maintenance, which is often the bug-bear of on-site systems, is simple and infrequent. An annual inspection should suffice for a properly designed and constructed system. Construction is relatively simple and can be done with locally available skills and material.

Construction costs could probably be reduced further in the future by using light-weight plastic off-cuts as filter material in place of crushed rock. This would also reduce the required strength of the perforated floor slab of the filter unit, which is currently a significant component of the total cost of the unit.. It has been reported that hydraulic retention time is the main criteria governing filter performance and that media specific surface has little effect if any (Young, 1991). This is probably due to the fact that the biomass is mainly present loosely trapped in the interstices of the media rather than attached to the media surface itself (Dahab and Young, 1982, Wilkie, 1984). This implies that filter media could be chosen according to local availability, cost, and ease of construction without significant changes in performance.

Acknowledgements

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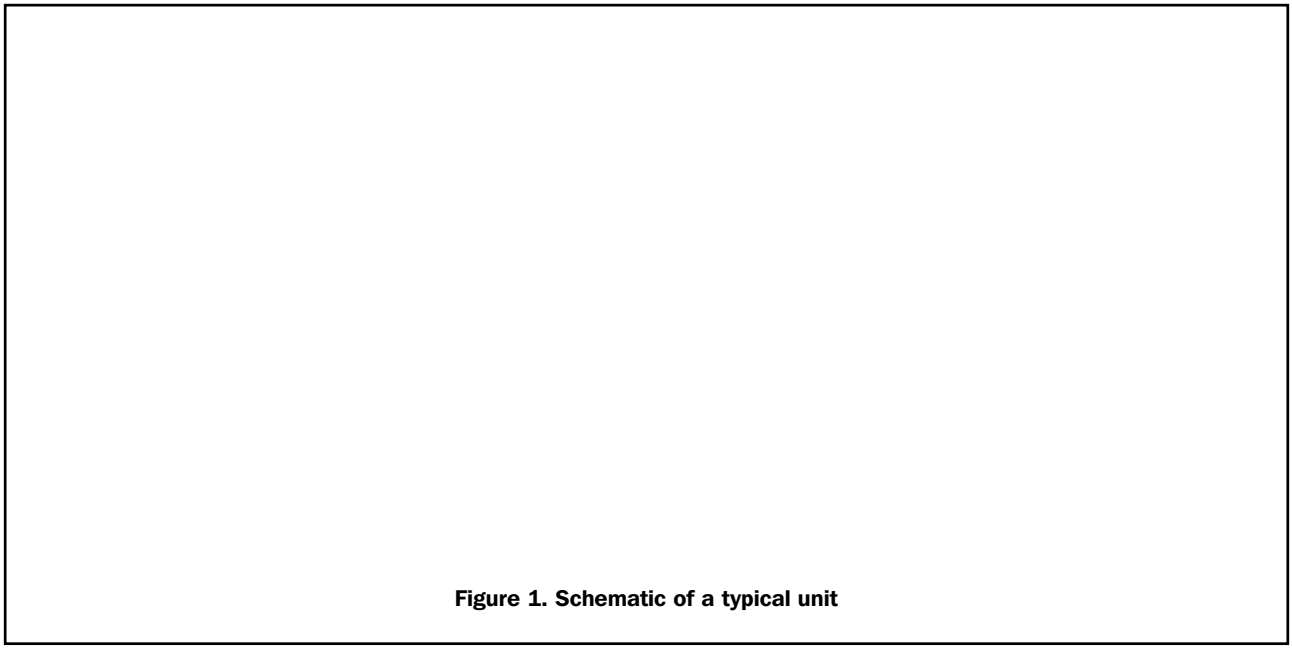

Figure 1. Schematic of a typical unit

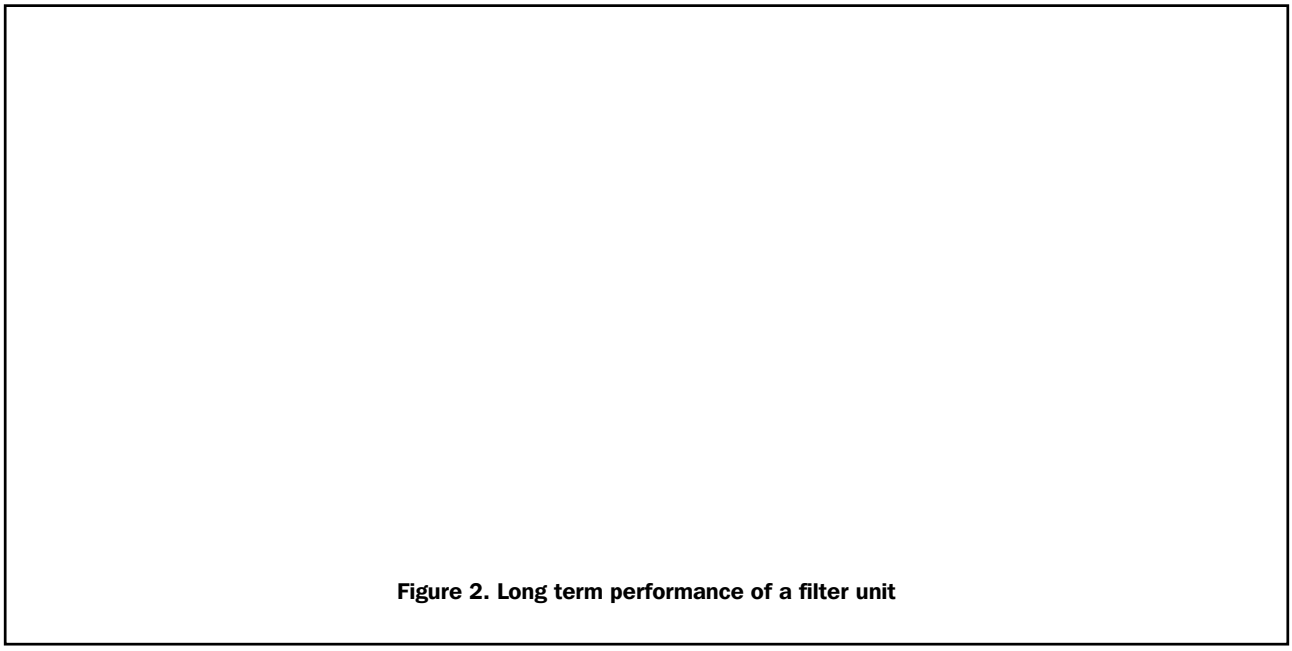

Figure 2. Long term performance of a filter unit

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