Pre-treatment of domestic wastewater with pre-composting tanks: evaluation of existing systems

D. R. Gajurel, O. Benn, Z. Li, J. Behrendt and R. Otterpohl

Technical University Hamburg-Harburg
Institute of Wastewater Management
Eissendorfer Strasse 42, D-21073 Hamburg, Germany
(E-mail: gajurel@tuhh.de)

Abstract

A relatively new technology called pre-composting tank or Rottebehaelter, retaining solid material and draining water to a certain extent, has been found to be an interesting component of decentralised systems to replace the usual septic tank. Results of the investigation revealed that solid material which has been retained in the pre-composting tanks still contained a high percentage of water. However, there was no odour problem at and near the tanks. The pre-composted materials have to be further composted together with household and garden wastes for a year prior to their use as soil conditioner. The filtrate is further treated in constructed wetland. One of the major advantages of this system compare to other systems, as septic tanks, is that it does not deprive agriculture of the valuable nutrients and soil conditioner from human excreta and does not require expensive tanker truck. It can be the most appropriate system for application in regions where there is a demand for local reuse of the end product. It has to be stated that maintenance is a crucial factor.

Keywords

Decentralised wastewater systems, domestic wastewater, pre-composting tank, Rottebehaelter

INTRODUCTION

In Germany centralised wastewater treatment systems have been built and operated for more than hundred years. A huge amount of money has been already spent to build up and maintain these conventional systems. In the coming years, still huge investment has been estimated for repairing, rebuilding and extending existing systems (Hiessl, 2000). Although construction, maintenance and operation of sewer are very costly parts of the centralised wastewater treatment systems, more than 90 % of the population in Germany are already connected to sewer systems (Maus et al., 2000, Wilderer et al., 2000). Experience shows that centralised sewerage systems can be extremely expensive for regions with low population density, since costs of construction, operation and maintenance of long sewers are to be covered by small number of inhabitants. These costs are obviously unaffordable for major part of the population mostly living in developing countries. Thus, it is irrational to plan central sewerage for all rural and peri-urban regions of developing countries. Even in the USA, the complete coverage with sewerage systems is not possible or desirable, for both geographical and economical reasons (Crites and Tchobanoglous, 1998).

In decentralised systems, wastewater from individual house is collected, treated and disposed/ reused at or near the point of its origin. The most important benefits of this system compared to the centralised system are: 1) there is no need of laying sewer for transportation of sewage as in the centralised treatment tank, which is normally located far from the point of origin. Construction, maintenance and operation of sewer are very costly parts of sanitation system; and 2) there is a very lesser dilution of sewage than in the centralised system, which creates possibilities to reuse treated wastewater and nutrients. Therefore, decentralised wastewater treatment technologies will play a significant role, if they are low-cost and perform efficient reuse and/or safe disposal.

A relatively new technology of pre-composting tank (called Rottebehaelter in Germany, Austria and Switzerland) consists of an underground concrete tank having two filter beds at its bottom or two filter bags that are hung side by side and used alternately in an interval of 6-12 months (Figure 1).

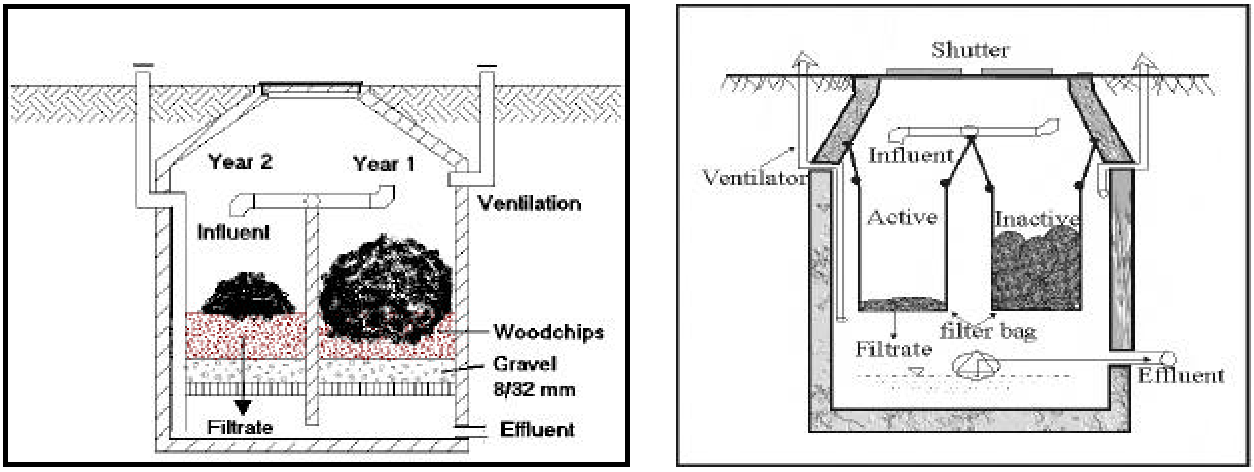

Figure 1:Pre-composting tank (Rottebehaelter) for decentral pre-treatment of domestic wastewater

It has been found to be an interesting component of the decentralised systems to replace the usual septic tank, in which seeping nutrients and pathogens have caused the groundwater as well as nearby surface water contamination throughout the world (Esrey et al., 1998). In combination with constructed wetlands this system has been increasingly used in rural areas of Austria, Switzerland and Germany for domestic wastewater treatment. The solid materials that are retained, partly dewatered and pre-composted in the pre-composting tanks for a year can be further co-composted together with other biological waste and reused locally. The filtrate which is treated in constructed wetland can be discharged into nearby watercourses. Constructed wetlands are simple and cheap in construction and operation (Otterpohl, 2001). Therefore, it has been widely used in Europe and transferred successfully to some developing countries (Haberl, 1999, Shrestha et al., 2001).

In Germany some existing pre-composting tank systems were evaluated. In this paper, results of the evaluation of the systems and their potential and limitation for decentral application are presented.

INVESTIGATION OF THE EXISTING PRE-COMPOSTING TANKS FOR DECENTRAL PRE-TREATMENT OF DOMESTIC WASTEWATER

Description of the system

In Germany some existing pre-composting tanks for decentral pre-treatment of domestic wastewater were investigated. Inside the tanks two filter bags, one that is being used called active filter bag and another that has been already used called inactive filter bag, are hung side by side and used alternately in an interval of 6-12 months. The capacity of the systems varies from 4 to 40 inhabitants. Most of the systems have been in operation for 4-5 years. Pre-composting tank is made up of concrete monolithically and constructed underground outside the building (Figure 2). It is covered with a prefabricated concrete slab and provided with ventilation. A shutter for changing filter bag, adding straw into the pre-composting materials, inspection and cleaning has been provided on the covering of the tank. The filtrate is collected at the bottom of the tank which is (only bottom portion) divided by a partition wall with an overflow and a pumping sump. The filtrate is pumped with the help of a time and level controlled submersed pump in an interval of 2-5 times per day into the adjacent constructed wetlands, where it is treated and then discharged into the watercourses. Due to the appropriate sloping in some systems, an overflow pipe is provided, through which the filtrate flows into the constructed wetland.

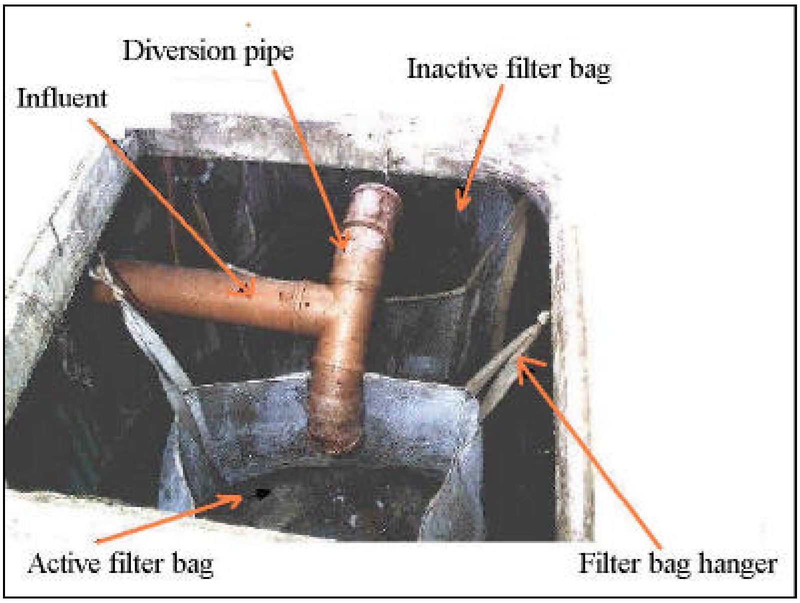

Figure 2. Existing pre-composting tank for decentral pre-treatment of domestic wastewater

Performance of the pre-composting tanks

Pre-compost material: In September 2000, samples from the pre-composting tanks were analysed. The results for inactive and active filter bags are shown in tables 1 and 2 respectively. In both filter bags, active and inactive, moisture content of pre-compost materials was higher than optimal range

Tab.1. Characteristics of pre-compost materials of the inactive filter bag

Tank	Moisture % Fresh matter	Loss in Ignition % Dry matter	Total P % Dry matter	Total K % Dry matter	Total S % Dry matter	Total C % Dry matter	Total N % Dry matter	C:N	pH
1	83.73	71.7	1.59	0.19	0.48	38.20	3.06	12.48	5.92
2	79.07	92.9	2.65	0.62	1.35	50.10	2.67	18.76	6.71
3	84.67	69.3	1.94	0.17	0.47	35.20	2.81	12.53	6.45
4	80.29	67.0	1.45	0.14	0.63	35.90	2.14	16.78	7.28
5	88.35	72.7	1.07	0.23	1.76	43.40	2.78	15.61	7.04

(40-60 % for composting). Moisture content above 70 % leads to anaerobic condition (Bidlingmaier, 1983). Thus, anaerobic condition must have taken place in both bags. However, no odour was noticed during the sampling. Also people living in the house have not complained about odour problem so far. Low temperature (Table 3) and low reduction of volatile solids suggest that slow decomposition process took place in both filter bags. It might have caused slow and low emissions of odour, which were not detected with human nose in the open air.

Loss on ignition was more in inactive filter bags except in tank 2 where it was very high, that is decomposition process was slow and low in tank 2. In inactive bags of tanks 4 and 5, pH was in the optimal range, 7-8 for composting. In all other tanks both active as well as inactive filter bags pH was lower than optimal range. It was due to formation of volatile organic acid. In all tanks C:N ratio of pre-compost was in between 20:1 and 12:1. In compost C:N ratio should be 10-20:1 (Epstein 1997). So far influence of phosphor, potassium and sulphur in composting process has not been established. However, compost should be rich in these substances because they are very important nutrients to the plants. In all filter bags temperature was below 20 ^{o}C. This range of temperature is not sufficient to kill disease causing pathogens (Feachem et al. 1983). Therefore, the long time composting is necessary in order to obtain pathogens low compost.

Tab.2. Characteristics of pre-compost materials of the active filter bag

Tank	Moisture % Fresh matter	Loss in ignition % Dry matter	Total P % Dry matter	Total K % Dry matter	Total S % Dry matter	Total C % Dry matter	Total N % Dry matter	C:N	pH
4	84.38	74.42	1.24	0.14	0.56	45.10	2.65	17.02	6.56
5	86.39	85.6	0.85	0.22	1.39	49.10	3.77	13.02	6.30

Tab.3. Temperature inside the filter bag

Tank	Surrounding ºC	Active Filter Bag ºC	Inactive Filter Bag ºC
1	15	13	12
2	20	15	18
4	16	20	18
5	13	16	16

Filtrate: Filtrate was sampled randomly only once for each tank and analysed. The results are presented in table 4. In tanks 1, 2 and 3 organic substance and nutrients concentration were higher than in tanks 4 and 5. But, in tank 5, the organic substance and nutrients concentration were surprisingly low. It might be due to only bath water was being passed through filter bag at the time of sampling. And high concentration of nitrogen in tanks 1, 2, 3 might be due more urine was being passed through the filter bag at the time of sampling.

Tab.4. Characteristics of filtrate

Tank	COD mg/l	N-NO2 mg/l	N-NO3 mg/l	Kjeldahl N mg/l	Total N mg/l	Total P mg/l
1	398.0	n.d	n.d	113.0	113.0	18.5
2	758.0	n.d	n.d	114.0	114.0	17.7
3	458.0	n.d	n.d	152.0	152.0	12.1

4	416.0	n.d	n.d	50.6	50.6	6.4
5	47.8	0.6	13.2	3.78	17.6	1.05

Acceptance of the system

A survey was conducted to evaluate the acceptance of the system by sending questionnaire to the owners of the system as well as on site discussion with them. They have either agriculture land or garden. In five investigated Rottebehaelter systems, which were installed at owner's own will, the acceptance of the systems was satisfactory. From the ecological and economical point of view they have decided to implement such a system, where reuse of separated and composted matter in the garden/agriculture and avoiding high cost for construction of long sewer have been the deciding factors. The alternative could have been conventional septic tank or connection to the conventional centralised system.

The systems have been running for 4-5 years without any operational problem. The filter bags have been emptied in the interval of about 8-12 months. The helping means for the emptying of the bags, for the small tanks rope has been used, otherwise wheel loader. The owners do by themselves the filter bags emptying job and disposal of the pre-compost materials, although service for that has been offered. The pre-compost materials have been further composted with garden compost and brought to the field. Their readiness to manage their system by themselves clearly indicate that the system is acceptable to them.

CONCLUSIONS

For regions with low population density, Rottebehaelter or pre-composting tanks in combination with constructed wetlands can be an interesting component of the decentralised systems to replace the usual septic tank. One of the major advantages of this system over other systems as septic tanks is that it does not deprive agriculture of the valuable soil conditioner from human excreta and does not require expensive tanker truck. The system is low-cost and performs efficient reuse/safe disposal. The positive reactions of the owners of the tank are an important signal. They have been satisfied with the system and would decide again for such a system. The tanks run so far without any disturbance. As a whole it gives a positive experience. However, improvement is needed in order to be used widely; for example, water content of the pre-compost was very high, and must be lowered to optimal level required for the composting process.

Rottebehaelter has demonstrated to be beneficial and can be combined with concepts of source control sanitation where most of the nutrients can be recovered in high concentration. It can be the most appropriate system for application in the regions where there is a demand for local reuse of the end product. It has to be stated that maintenance is a crucial factor, removal and handling of the pre-composted material has to be improved. In addition, proper procedures of further composting and usage should be established. Compared to septic tanks, there are a couple of advantages that make further development worthwhile.

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