A WELL FACTSHEET

Anaerobic treatment of municipal wastewater: How appropriate is it for low-income countries?

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This fact sheet is provided to help mid-level engineering managers make decisions on the use of anaerobic processes for the treatment of municipal wastewater. It gives a brief overview of aspects of anaerobic treatment processes, highlighting the advantages and disadvantages of a selection of treatment options. For more detailed information relating to anaerobic treatment in general and specific treatment process types, refer to the publications listed at the end of this fact sheet.

Introduction

Wastewater management can be a costly business. Reducing the volume of wastewater produced and/or avoiding the need for sewerage and treatment should be considered first, as it has many advantages. Deciding to move away from well planned, implemented and managed on-site sanitation should be given careful consideration.

Anaerobic processes in general

Anaerobic digestion is a well established treatment technology suited to treating high-strength wastes, or wastes containing high levels of solid matter. It is a low energy process that generates relatively low volumes of sludge, making it cheaper and simpler to operate than aerobic processes.

In addition, the temperature range in which the bacteria operate most efficiently is suited to application in tropical, or sub-tropical climates[1].

Advantages

The main advantages of anaerobic treatment are therefore that it:

- is a well-known and extensively applied process;
- is versatile for treating both ordinary and 'difficult' wastes;
- is a low-energy process, making it more environmentally friendly; and
- has lower running costs as a result of the low energy inputs.

Disadvantages

The main disadvantage of many anaerobic treatment processes is that they are not good at removing non-organic pollution within wastewater, such as nutrients or disease-causing micro-organisms (pathogens).

A typical Upflow Anaerobic Sludge Blanket (UASB) digester, with a retention time of 4 to 5 hours, can be expected to remove 75% of faecal bacteria and 90% of intestinal worms from a wastewater. Such removal rates may be impressive for limiting effects of chemical pollutants, but are negligible for pathogens which still present a health hazard after reduction by several factors of ten.

All anaerobic processes provide only partial treatment and therefore require the effluent to be treated further before it can be safely released into the environment.

Anaerobic treatment consists of a sequence of activities performed by different organisms. For digestion to be effective, it should operate as a finely balanced, living system – carefully controlled and closely monitored. Disruption to the balance of the organisms can hinder treatment. Anaerobic processes work best with 'steady' effluents – that is, they are not good at coping with variations in the flow or composition of the wastewater stream. So for example, anaerobic processes cannot cope with 'shock loads' of heavy metals that may come from industrial processes or from runoff water in storms.

Anaerobic ponds

The most commonly used form of anaerobic treatment for municipal wastewater in low-income countries is anaerobic ponds – typically in combination with facultative and maturation ponds to provide further treatment of the effluent.

Advantages

The main advantage of anaerobic ponds in a system is that they reduce by as much as 50% the land required for the facultative pond. For strong wastes (common in developing countries, as water consumption is low), the facultative pond is usually the biggest of all.

Another key advantage of ponds is their simplicity of construction and operation. No imported technology, spare parts or energy inputs are required, resulting in low capital and running costs.

Routine maintenance activities, essential for effective operation, are simple. Good operation and maintenance also limits the potential for nuisances from odours and insect breeding. A well supervised, unskilled workforce can effectively manage the system.

High-rate anaerobic ponds, developed in Colombia, combine the high performance features of an up-flow anaerobic sludge blanket (UASB) reactor with the simplicity of an anaerobic pond.

See Mara (2003, p.110) for more details.

Disadvantages

The key disadvantage of ponds is their high land requirement. Where land is scarce and/or very costly, ponds may not be a cost effective solution. Alternative treatment options requiring less space (such as package plants) can be considered, but full life time costs should be used in the decision-making.

Sludge only needs to be removed from an anaerobic pond every few years (2-5 years, typically). While this can be a manual operation, large volumes of sludge are removed that requires careful disposal in line with any local legislation. This may incur high costs.

Package treatment plants: reactors

There are several commercially available anaerobic reactors, each type designed to provide a suitable biological environment in which anaerobic decomposition takes place in a much smaller space than required by anaerobic ponds.

As anaerobic bacteria multiply slowly, they are retained in package processes either by attachment, or through recycling.

Up-flow Anaerobic Sludge Blanket (UASB) digester

The most common form of anaerobic reactor used for sewage treatment in low and middle-income countries.

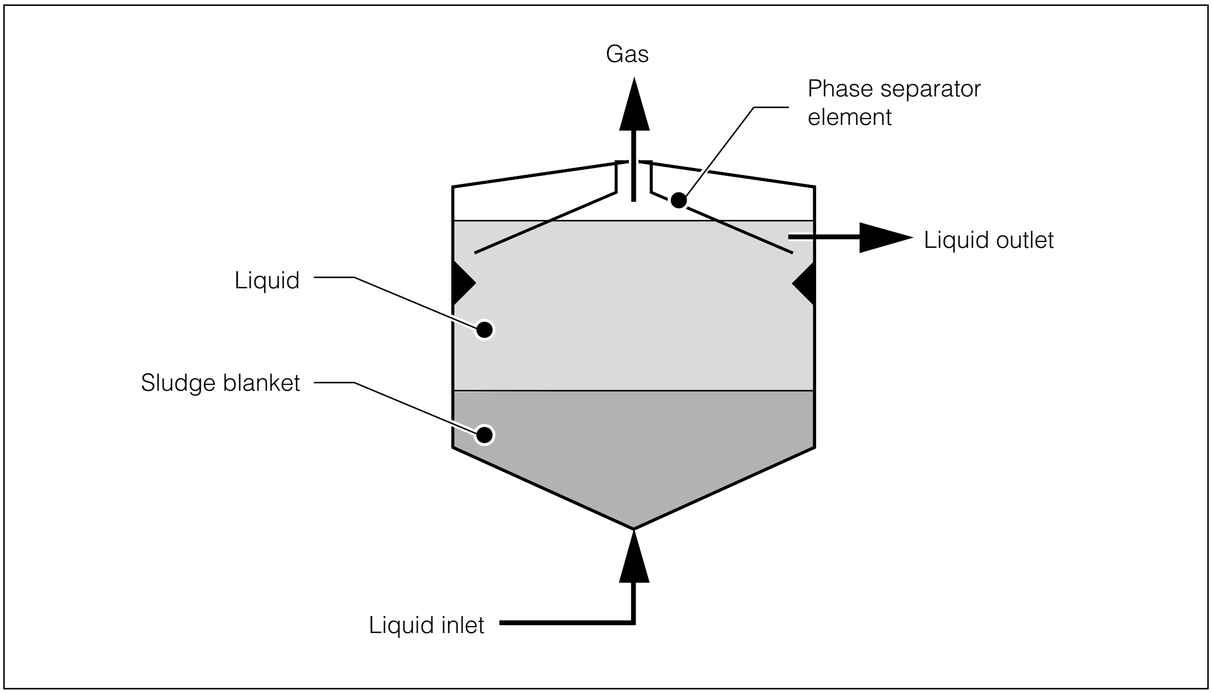

Figure 1. UASB digester

Up-flow or down-flow anaerobic filters

Suited to treating wastes containing organic matter in soluble form, which excludes many forms of municipal waste. It is more widely applied to treating industrial wastes.

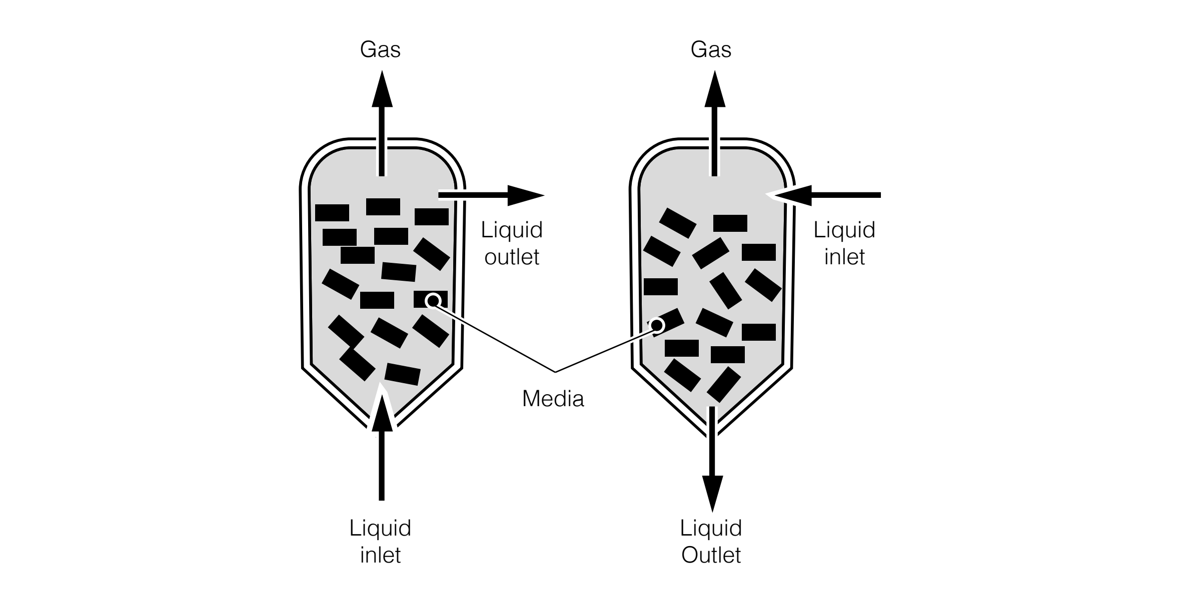

Figure 2. Up-flow and down-flow anaerobic filters

The main disadvantage of the anaerobic filter reactor is the high cost of the filter material. Early models made use of stones and rocks, but these were prone to blocking easily. Open plastic rings are more commonly used, which can cost the equivalent of the reactor vessel itself.

Without careful operation and maintenance procedures, blockages within the reactor cause operational inefficiency and/or failure.

Contact stirred tank reactor (CSTR)

The minimal internal fittings make it more suited to treating wastes with a higher solids content.

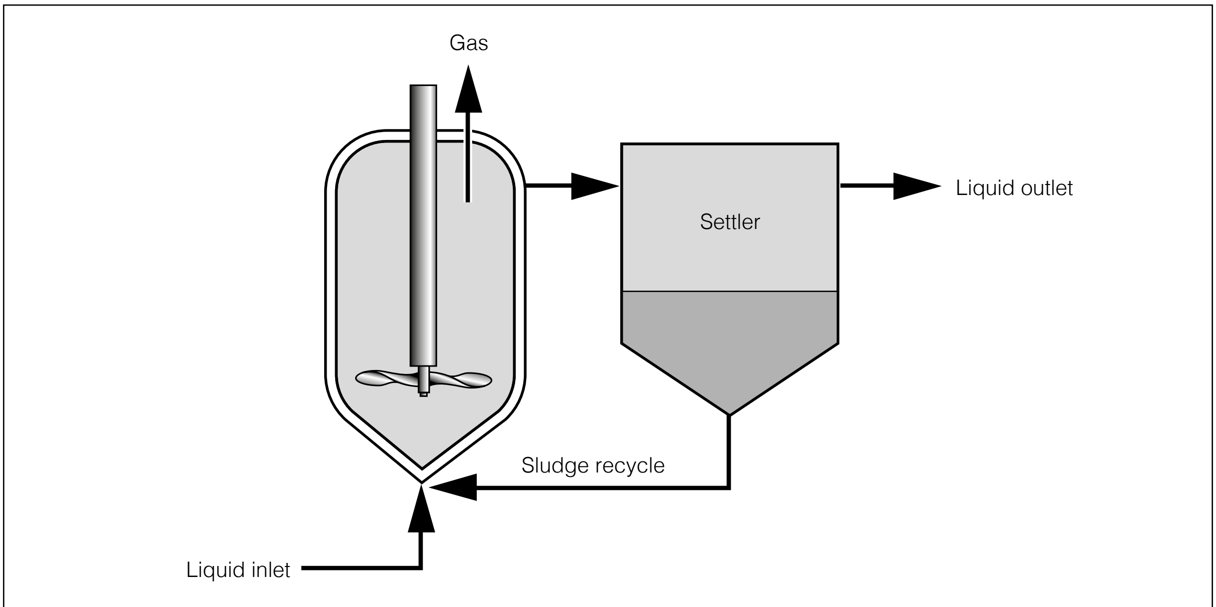

Figure 3. CSTR reactor

Problems encountered with reactors

While there are cases of successful application of anaerobic treatment reactors in low-income countries, problems have also been frequently encountered.

These typically include:

- poor design and construction quality;
- corrosion of equipment and construction materials; and
- insufficient knowledge of the process leading to poor operation and maintenance, with subsequent failure of plant.

Whilst anaerobic processes have several advantages, it is important to realise that they operate more slowly and therefore require a higher capacity (volume or land area) to achieve similar treatment results to aerobic processes.

Post-treatment requirements

Anaerobic processes provide reasonable treatment of simple organic material, but for the effective treatment of other, non-organic components, additional treatment is needed.

In low- and middle-income communities where pathogenic pollution should be of most concern, the use of anaerobic treatment in itself is not sufficient. A maturation pond (similar to the final pond in a waste stabilisation pond complex) is often specified as a post-treatment requirement for pathogen removal following anaerobic treatment.

Summary

Anaerobic digestion is a well-established technology for the treatment of wastewater in developed countries, requiring low energy inputs and yielding relatively small amounts of stabilized sludge.

Treatment systems such as anaerobic ponds, UASBs, anaerobic filters and CSTR provide a high removal of organic loads, but limited removal of pathogens and other pollutants.

Package plants are relatively expensive to construct and require skilled operators to maintain the conditions for achieving good results. Their role in wastewater treatment is typically limited to roughing treatment of the organic waste in effluent streams of high organic content (domestic sewage in municipalities, or industrial waste from processes such as sugar cane processing).

The use of anaerobic ponds, in combination with further treatment (typically facultative and maturation ponds), provides an appropriate low-cost solution to many applications of municipal wastewater treatment, provided sufficient land is available and affordable, on which to locate the ponds and safely dispose of the sludge generated.

Further reading

GTZ (2001a), *Anaerobic methods of municipal wastewater treatment*, Technical Information W3e, gate information service/gtz, Germany. http://www5.gtz.de/gate/techinfo/techbriefs/W3e_2001.pdf (Oct 05)

Mara, D., (2003), *Domestic wastewater treatment in developing countries*, Earthscan, London, UK and Sterling, VA, USA

Parkinson, J., and Tayler, K., (2003), *Decentralised wastewater management in peri-urban areas in low-income countires, in Environment and Urbanization*, Vol 15, No 1, April 2003 http://www.iied.org/HS/documents/EU15-1Parkinson_Tayler.pdf (Oct 05)

Parr, J., *Wastewater treatment options*. Technical Brief 64, in Shaw R., (ed), Running Water - More technical briefs on health, water and sanitation, ITDG Publications, Rugby, UK http://www.lboro.ac.uk/well/resources/technical-briefs/technical-briefs.htm (Oct 05)

[1] Mesophilic bacteria (the most common form of bacteria), are ideal for anaerobic digestion. They grow within the temperature range of 10-45°C, with optimum growth occurring between 30-40°C.

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