Wastewater treatment options

This Technical Brief reviews some of the options for wastewater treatment in low- and middle-income communities. It should be used as a guide to the main options available.

Wastewater management is a costly business. Once wastewaters (taken here to mean any combination of domestic sewage and industrial effluents) are produced and collected in sewerage systems, then treatment becomes a necessity. It is important to note that reducing the volume of wastewater produced and/or avoiding the need for sewerage and treatment in the first instance has many advantages; the decision to move away from properly implemented on-site sanitation should not be taken lightly.

On-site versus off-site sanitation?

On-site sanitation is often (and should be) the first option when considering a sanitation intervention. Such systems have very distinct advantages, not least because they are individual systems, so the disposal of faecal material is dispersed over a wide area, and not centralized as with a conventional sewage treatment works. One of the main disadvantages with centralized facilities is that when they go wrong, the resulting problems can be very acute.

From a *health* point of view, there is not much difference between any of the different options for sanitation (either on- or off-site) — so long as they are all functioning properly. It is largely a question of *convenience*; an off-site system where wastes are flushed off the owner's property is more convenient as it gets rid of the problem from the owner's property. Off-site sanitation is usually much more expensive than on-site.

There are instances, however, where off-site sanitation is deemed necessary — because of unsuitable ground or housing conditions for on-site systems, or because of a community's commitment to an off-site system. There is a certain amount of prestige in having an off-site connection; peer pressure is often a significant motivating force. Once the decision has been made to implement an off-site system, sewers become a necessity. Water has a large dispersion, dilution and carriage capacity, and is, therefore, used as the carriage medium in most sewer systems. Usually, potable water is supplied to the house and is used for flushing toilets, and as much as 40 per cent of household water use may be used for this purpose. Some countries do use dual supply systems where non-potable water (often sea water) is used for toilet flushing, but such a system requires more infrastructure and has obvious capital cost implications. Therefore, most sewer systems are heavy users of precious potable water supplies, which should be a factor when considering their implementation, especially in water-poor areas.

Re-use, recovery

Traditionally, sewage has been seen as a *problem* requiring treatment and disposal. Most conventional sewage treatment options are based on approaches to Northern countries' problems, which has usually meant a reduction in biodegradable organic material and suspended solids, plus perhaps some nutrients (nitrogen and phosphorous). Treatment has involved the 'removal' of these pollutants, but removal is usually conversion to another product, usually sludge. The disposal of sewage sludge is a major consideration in many locations, and it is often seen as an offensive product which is either dumped or burned.

The priorities in developing countries are often different from those in developed countries. Often the main issue is how to control pathogenic material, and any form of sanitation (on or off-site) should have this as its main objective. There are treatment options which can remove pathogenic material, notably waste-stabilization ponds.

Increasingly, sewage is being seen as a *resource*. The water and nutrient content, in particular, can be very useful for agricultural purposes (for example, through irrigation) if the sewage is treated to a suitable standard. There are treatment options which seek to use this resource potential. Traditional sewage treatment practices in South-east Asia, for example, seek to use wastes generated through pond systems which are used to cultivate fish and generate feed for animals. Some community-based approaches (in Latin America in particular) seek to separate 'grey' wastewater (non-faecally contaminated wastewater) from 'black' (faecally contaminated) water so that they can both be recycled and re-used as appropriate. In principle, the grey water can be re-used as irrigation water, and the black water/waste treated and re-used as fertilizer.

NOTE

Not all bacteria are harmful!

Bacteria may be:
Harmful,
Harmless (benign)
Helpful or Useful

Wastewater treatment tries to reduce the numbers of harmful bacteria

Wastewater treatment encourages useful bacteria to treat wastewater

Sewage treatment options may be classified into groups of processes according to the function they perform and their complexity:

Preliminary:	this includes simple processes such as screening (usually by bar screens) and grit removal. (through constant velocity channels) to remove the gross solid pollution.
Primary:	usually plain sedimentation; simple settlement of the solid material in sewage can reduce the polluting load by significant amounts.
Secondary:	for further treatment and removal of common pollutants, usually by a biological process.
Tertiary:	usually for removal of specific pollutants e.g. nitrogen or phosphorous, or specific industrial pollutants.

Traditionally, sewage treatment has taken place through the implementation of large centralized schemes. Many of these do not work — and when they do not work, the resultant pollution and health problems are often severe. The reason for failure is frequently that the options chosen in the first place, are not sustainable. Often, sewage treatment is a low priority when compared to water supply, and municipal councils simply do not have the resources to keep the facilities operational. In such circumstances, there is a growing body of opinion that advocates moves towards *decentralized,* local systems, which, it is argued, could be supported by community-based organizations. Such approaches have been implemented in parts of South America.

Wastewater treatment options

Very few sewage-treatment facilities in most developing countries work. This is often because most technologies for sewage treatment are big, centralized schemes which have been developed in the North where adequate financial, material and human resources are available. Transferring these technologies to tropical low- and middle-income communities has many potential difficulties. However, there are some sewage-treatment options which are more appropriate to developing country scenarios. Such systems should generally be low-cost, have low operation and maintenance requirements, and, should maximize the utilization of the potential resources (principally, irrigation water and nutrients).

Preliminary and primary treatment are common to most sewage-treatment works, and are effective in removing much of the pollution. There are many different types of secondary process. The most common are described in the table opposite, with brief comments on their suitability for low- and middle-income countries.Tertiary treatment processes are generally specialized processes which are beyond the need of most communities.

Options for low- and middle-income communities

Most wastewater treatment processes have been developed in temperate, Northern climates. Applying them in most developing countries will have three main disadvantages:

- high energy requirements;
- high operation and maintenance requirements, including production of large volumes of sludge (solid waste material);
- they are geared towards environmental protection rather than human health protection — for example, most conventional wastewater treatment works do not significantly reduce the content of pathogenic material in the wastewater.

Aerobic versus anaerobic treatment

Most conventional wastewater treatment processes are 'aerobic' — the bacteria used to break down the waste products take in oxygen to perform their function. This results in the high energy requirement (oxygen has to be supplied) and a large volume of waste bacteria ('sludge') is produced. This makes the processes complicated to control, and costly.

The bacteria in 'anaerobic' processes do not use oxygen. Excluding oxygen is easy, and the energy requirements and sludge production is much less than for aerobic processes — making the processes cheaper and simpler. Also, the temperature in which the bacteria like to work is easy to maintain in hot climates.

However, the main disadvantages of anaerobic processes are that they are much slower than aerobic processes and are only good at removing the organic waste (the 'simple' waste, the sugary material) and not any other sort of pollution — such as nutrients, or pathogens. Anaerobic processes generally like 'steady' effluents — they are not good with coping with variations in flow or composition. For example, anaerobic processes cannot cope with shock loads of heavy metals (from industrial processes, for example).

The requirement in most low-income countries is for a low-cost, low-maintenance sewage treatment system. *Waste stabilization ponds* (WSPs) provide the best option in most cases — good levels of treatment at low capital and particularly low O&M cost. In addition, it is one of the few processes which provides good treatment of pathogenic material. This has significant application potential for re-use of the treated effluent in irrigation. The major disadvantage is that significant areas of land are needed for treatment. WSPs are used in many locations worldwide, including Africa and Asia.

Conclusion

Any wastewater treatment plant needs significant investment and O&M and control, and therefore *any* decision to implement such a facility should be carefully considered. WSPs provide the best option for a low-cost, low-maintenance system which is most effective in removing the pollutants of major concern.

Common options for secondary sewage treatment

(* indicates processes more suitable for developing countries)

Treatment process	Description	Key features
Activated sludge process (ASP)	Oxygen is mechanically supplied to bacteria which feed on organic material and provide treatment.	Sophisticated process with many mechanical and electrical parts, which also needs careful operator control. Produces large quantities of sludge for disposal, but provides high degree of treatment (when working well).
Aerated lagoons	Like WSPs but with mechanical aeration	Not very common; oxygen requirement mostly from aeration and hence more complicated and higher O&M costs.
*Land treatment (soil aquifer treatment – SAT)	Sewage is supplied in controlled conditions to the soil	Soil matrix has quite a high capacity for treatment of normal domestic sewage, as long as capacity is not exceeded. Some pollutants, such as phosphorus, are not easily removed.
Oxidation ditch	Oval-shaped channel with aeration provided	Requires more power than WSP but less land, and is easier to control than processes such as ASP (see below).
*Reed (or constructed wet lands) beds	Sewage flows through an area of reeds	Treatment is by action of soil matrix and, particularly, the soil/root interface of the plants. Requires significant land area, but no oxygenation requirement.
Rotating biological contractor (or biodisk)	Series of thin vertical plates which provide surface area for bacteria to grow	Plates are exposed to air and then the sewage by rotating with about 30 per cent immersion in sewage. Treatment is by conventional aerobic process. Used in small-scale applications in Europe.
Trickling (or 'percolating') filters	Sewage passes down through a loose bed of stones, and the bacteria on the surface of the stones treats the sewage	An aerobic process in which bacteria take oxygen from the atmosphere (no external mechanical aeration). Has moving parts, which often break down in developing country locations.
*Upflow anaerobic sludge blanket (UASB)	Anaerobic process using blanket of bacteria to absorb polluting load	Suited to hot climates. Produces little sludge, no oxygen requirement or power requirement, but produces a poorer quality effluent than processes such as ASP. (NOTE: other anaerobic processes exist, but UASB is the most common at present).
Waste-stabilization ponds (WSP) ('lagoons' or 'oxidation ponds')	Large surface - area ponds	Treatment is essentially by action of sunlight, encouraging algal growth which provides the oxygen requirement for bacteria to oxidize the organic waste. Requires significant land area, but one of the few processes which is effective at treating pathogenic material. Natural process with no power/oxygen requirement. Often used to provide water of sufficient quality for irrigation, and very suited to hot, sunny climates.

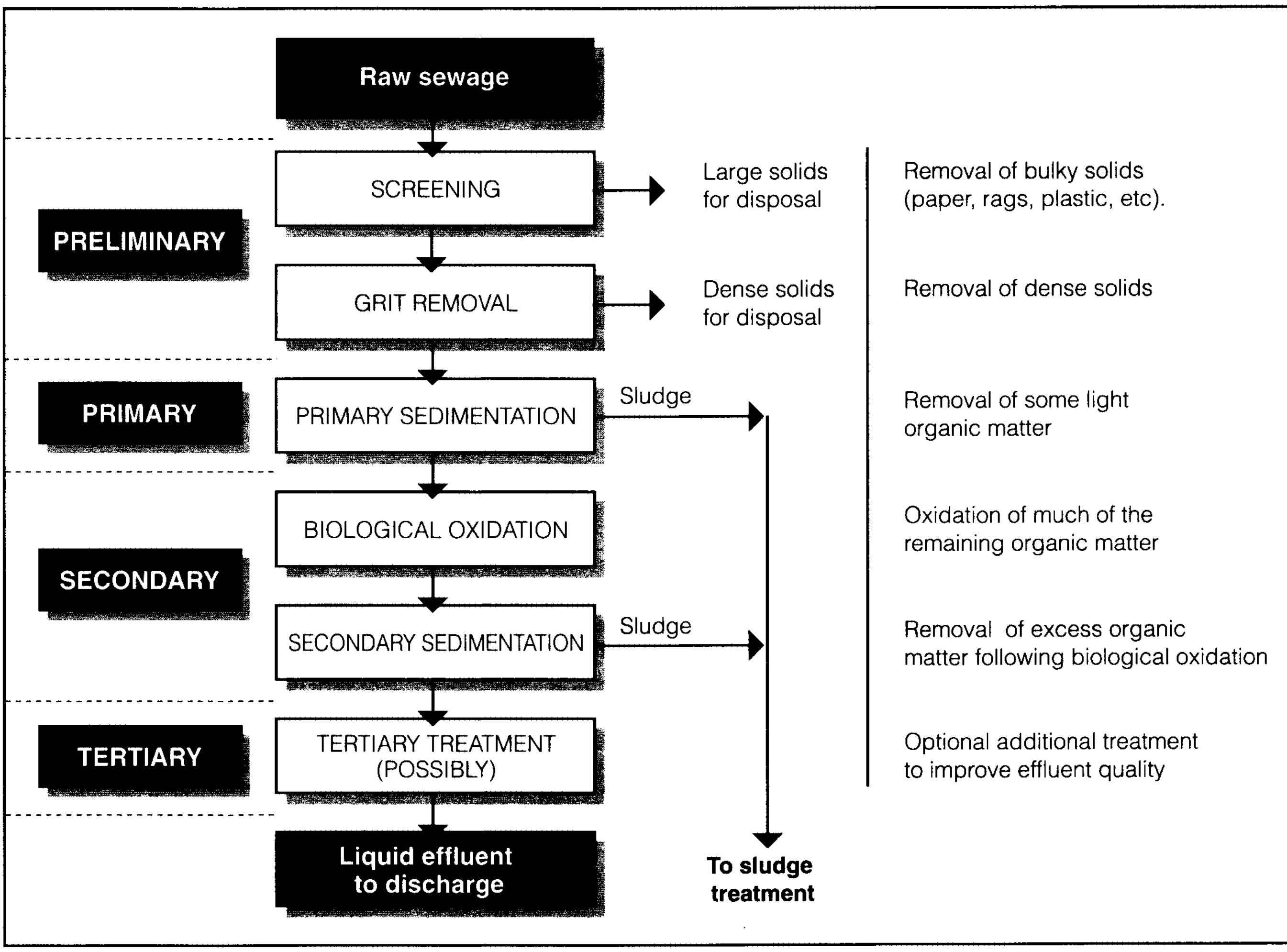

Figure 1. Typical stages in the conventional treatment of sewage

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Further reading

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