Decentralised wastewater treatment methods for developing countries

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March 2001

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1 Introduction

In many developing countries, public and private wastewater disposal systems are often very deficient or even entirely missing. In order to reduce or avoid further deterioration of the environmental conditions in these countries, the wastewater has to be treated. Speaking of organic wastewater from households, tourist facilities and small communities, the decentralised approach may be an appropriate solution for collection, treatment and disposal problems, implementing technologies with a rather low level of mechanisation near the place of generation. The choice of the appropriate technology will depend on several factors such as composition of the wastewater, availability of land, availability of funds and expertise. Different operation and maintenance options will have to be considered with respect to sustainable plant operation, the use of local resources, knowledge, and manpower.

Decentralised concepts provide treatment facilities on a comparably small scale, mostly for domestic wastewater from private households or communal institutions. As they are not restricted to merely managing individual user systems, they can close the gap between on-site systems and the conventional, centralised system.
Decentralised wastewater treatment can range in size from individual on-site systems serving one household to shared facilities serving up to about 5-10 households or public facilities for several households sharing one sanitary facility. For a population density between 200 and 600 capita/ha e.g., a larger communal facility may be applicable, treating the waste of 20-110 households in one reactor, while a toilet is provided in each dwelling.
The treatment steps may also be physically separated, combining on-site and co-operative treatment, mostly uniting wastewater streams after primary or secondary treatment from several decentralised facilities.
Due to the generally small distances between the place of origin of the wastewater and the treatment facility, there is no need for an elaborate collection system within a decentralised concept, thus reducing the demand for material, technical equipment, sewerage maintenance and capital investment.

2 Technical information

Speaking of decentralised treatment concepts for domestic wastewater, low maintenance processes will preferably be applied, especially as shortcomings are still the low level of scattered know-how and the lack of professional training. Treatment is mainly based on four systems including aerobic *(presence of oxygen)* and/or anaerobic *(absence of oxygen)* treatment steps:

- Sedimentation and primary treatment in sedimentation ponds, septic tanks,

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simple biogas digesters or Imhoff tanks, deep anaerobic ponds,

- Secondary anaerobic treatment in fixed bed filters or baffled septic tanks,
- Secondary and tertiary aerobic/ anaerobic treatment in constructed wetlands,
- Secondary and tertiary aerobic / anaerobic treatment in ponds, also shallow polishing ponds.

For a comprehensive treatment, different systems are usually combined according to the influent characteristics and the required effluent quality. Hybrid systems or a combination of secondary on-site treatment and tertiary co-operative treatment is also possible.

In general, it is advisable to use septic tanks (see chapter 2.1) to intercept the flow at each source of wastewater, the effluent from these tanks then possibly being routed to further treatment facilities that may be deployed at various levels of flow aggregation. The optimum distance of treatment and disposal facilities from the source of wastewater generation will be influenced by a great number of considerations for each specific case. One very important factor is if and how the wastewater can be re-used in a beneficial manner.

Most of the processes used in large-scale urban and industrial treatment plants cannot be taken into consideration as decentralised wastewater treatment methods – these are among others the activated sludge process, the fluidised bed reactor, aerated or chemical flocculation and all kinds of controlled re-circulation of wastewater.

Despite their reliability and impressive treatment performance, well-known and proven systems as UASB (upflow anaerobic sludge blanket reactor), trickling filter or rotating discs are not considered as being standard decentralised wastewater treatment methods for developing countries as these systems require careful and skilled attendance.

In the industrial wastewater context, special provisions may have to be made prior to the application of decentralised treatment designs. Pre-treatment steps that are necessary to make standard decentralised wastewater treatment methods applicable are e.g. an open settler for daily removal of fruit waste from a canning factory, buffer tanks to mix varying flows from a milk processing plant, grease traps or neutralisation pits to balance the pH of the influent.

2.1 Septic tank

2.1.1 Typical implementation area

Septic tanks are used for wastewater with a high percentage of settleable solids, typically for effluent from domestic sources (mostly black, i.e. toilet wastewater). Private households and enterprises in many communities, public buildings such as schools and hospitals currently use individual on-site and small-scale septic systems (up to about 50 households).

2.1.2 Process description

The system consists of a closed, often prefabricated tank where sedimentation takes place and settleable solids are retained (see Fig. 1). Retention time of the liquid is in the order of one day. Sludge is digested anaerobically in the septic tank, resulting in a reduced volume of sludge.

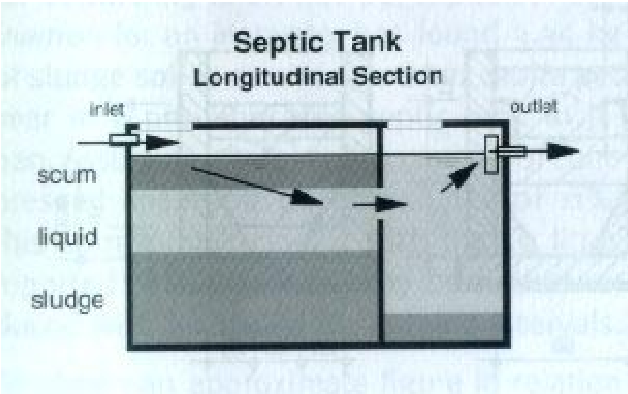

Fig. 1: Schematic diagram of septic tank (Source: [7])

The septic tank treatment process is totally passive. The only operation and maintenance activities required are

periodic inspection, cleaning of the effluent filter and pumping (sludge removal) of the tank. If the septic tank is sized properly, sludge removal only becomes necessary after several years. Its timing is not critical, but if no intermediate storage and handling facilities are available, it can only be executed if reutilisation possibilities are guaranteed, thus avoiding the need for additional facilities.
Often, villages are located in areas with soils that are generally unsuitable for on-site disposal of effluent from conventional septic systems, or they do not have the physical capacity on the small village lots. Leach fields for the disposal of septic tank effluent can either be located on-site or the effluent can be piped to a location with suitable soil (off-site), eventually with wastewater from other lots.

2.2 Biogas latrines, communal biogas plants

Biogas latrines and communal biogas plants are in principal a more advanced form of the septic tank system as described in chapter 2.1, communal plants usually being implemented in public institutions with a series of toilets. However, as biogas collection is part of the plant concept, as the retention time of the effluent is longer and the resulting water, nutrients and energy are utilised, biogas latrines are generally speaking more appropriate and future oriented because they can contribute considerably to resource protection. Household, garden and agricultural wastes are usually added to increase the gas yields, energy availability and the amount of fertiliser, if lifestock is available, pens can be connected directly to the plant.
(For further information on biogas latrines, see also **gate** Technical Information W9e „Basic sanitation and human excreta disposal in latrines“.)

2.3 Imhoff tank

2.3.1 Typical implementation area

Imhoff tanks are typically used for domestic or mixed wastewater flows above 3 m^3/d, the effluent usually receiving further treatment above ground. Therefore, odour emissions from the effluent should be low.

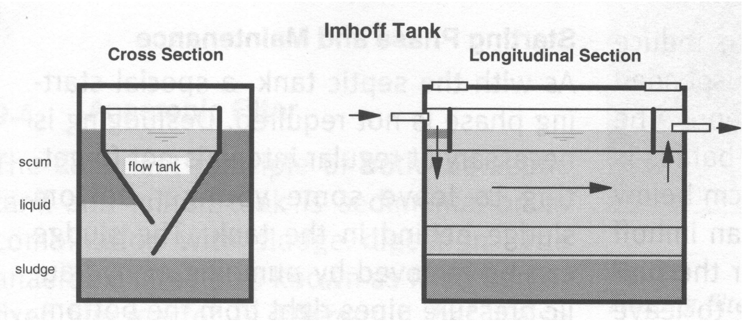

Fig. 2: Schematic diagram of Imhoff tank (Source: [7])

2.3.2 Process description

The tank consists of a settling compartment above the digestion chamber. The sedimented solids flow from the upper chamber through a slot in the bottom into the lower one, where they accumulate and are digested anaerobically. The fresh influent is separated firmly from the bottom sludge: funnel-like baffle walls prevent up-flowing foul sludge particles from being mixed with the effluent and from causing turbulence. The effluent remains fresh and odourless because the suspended and dissolved solids do not get into contact with the active sludge. Retention times of much longer than 2 h during peak hours in the flow portion of the tank would however jeopardise this effect.
Sludge removal should be done right from the reactor bottom to ensure that only fully digested substrate is discharged. Only a part of the sludge should be removed regularly (typically every 20-30 days) in order to keep some active sludge in the reactor. The removed sludge should immediately receive further treatment in drying beds or compost pits for pathogen control.

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2.4 Anaerobic Filter

2.4.1 Typical implementation area

Anaerobic filters are implemented for wastewater with a low content of suspended solids, e.g. after primary treatment in septic tanks and narrow COD/BOD ratio. Biogas utilisation may be considered in case of BOD concentration > 1.000 mg/l. (BOD = biological oxygen demand, COD = chemical oxygen demand; both are the most common parameters for pollution).

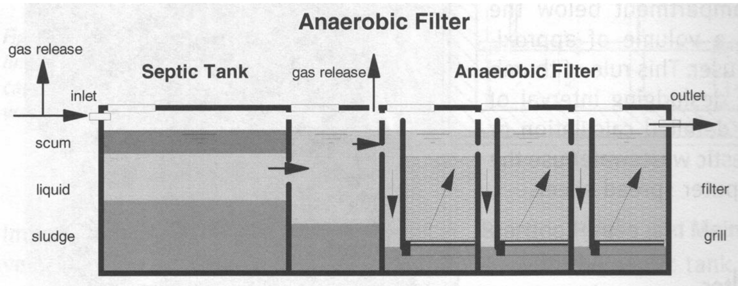

Fig. 3: Schematic diagram of anaerobic filter (Source: [7])

2.4.2 Process description

The anaerobic filter, also known as fixed bed or fixed film reactor, includes the treatment of non-settleable and dissolved solids by bringing them in close contact with a surplus of active bacterial mass. This surplus together with "hungry" bacteria digests the dispersed or dissolve organic matter within short retention times. Most of the bacteria are immobile. They tend to fix themselves to solid particles or to the reactor walls. Filter material, such as gravel, rocks, cinder or specially formed plastic pieces provide additional surface area for bacteria to settle. Thus, the fresh wastewater is forced to come into contact with active bacteria. The larger the surface for bacterial growth, the quicker the digestion. A good filter material provides a surface area of 90 to 300 m^2 per m^3 reactor volume. A rough surface is a "target area" for bacterial growth, at least in the starting phase. Later the bacterial "lawn" or "film" growing on the filter mass quickly closes the gaps in between the filter material. The total surface area of the filter seems to be less important for treatment than its physical ability to hold back solid parts.

2.5 Baffled Septic Tank

2.5.1 Typical implementation area

The baffled septic tanks, also known as "baffled reactor", is suitable for all kinds of wastewater, preferably for those with a high percentage of non-settleable suspended solids and low COD/BOD ratio.

2.5.2 Process description

The baffled reactor is a combination of several anaerobic process principles – the septic tank, the fluidised bed reactor and the UASB. Its upflow velocity which should not exceed 2 m/h, limits its design. Based on a given hydraulic retention time, the upflow velocity increases in direct relation with the reactor height. Reactor height cannot serve as a variable parameter to design the reactor for the required hydraulic retention time (HRT) so that the limited upflow velocity results in large but shallow tanks.

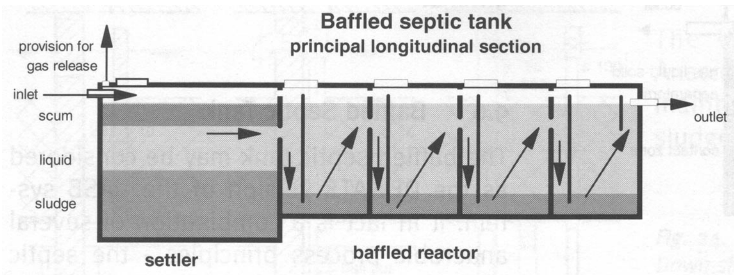

Fig. 4: Schematic diagram of baffled septic tank (Source: [7])

The baffled septic tank is ideal for decentralised wastewater treatment because it is simple to build and simple to operate. Hydraulic and organic shock loads have little effect on treatment efficiency. The baffled septic tank consists of at least four chambers in series. The last chamber can have a filter in its upper part in order to retain eventual solid particles. The first compartment is always a settling chamber for larger solids and impurities, followed by a series of upflow chambers. The water stream between chambers is directed by baffle walls that

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form a down-shaft or by down-pipes that are placed on partition walls. A settler can also follow the baffled septic tank as post-treatment.

2.6 Constructed Wetlands

2.6.1 Typical implementation area

In general, constructed wetlands are used for wastewater with a low suspended solids content and COD concentrations below 500 mg/l. It is an excellent technology for upgrading septic tank effluent to a very high quality. Many trophic levels of organisms live in and on the filter bed, and the very large surface area of the media results in the process being relatively "low-rate". Due to these characteristics, failure will be slow and gradual, the mode of failure usually being clogging of the filter bed. Therefore, in case of failure, water will no longer flow through the bed at the charging rate, rather than poorly treated effluent will be leaving the plant.

2.6.2 Process description

There are three basic treatment systems, which may be numbered among constructed wetlands. These are:

- the overland treatment system,
- the vertical flow filter,
- the horizontal flow filter.

For **overland treatment,** the water is distributed on carefully contoured land by sprinklers or channels. The system requires permanent attendance and maintenance.

For **vertical filter treatment,** the wastewater is distributed by help of a distribution device to two or three filter beds, which are charged alternately. Charging intervals must be strictly followed which makes the vertical filter comparably difficult to operate.

The **horizontal filter** (see Fig. 5) is simple by principle and has a very low maintenance demand, given that it has been well designed and constructed. Design and construction require a solid understanding of the treatment process in general and a good knowledge of the respective filter medium used.

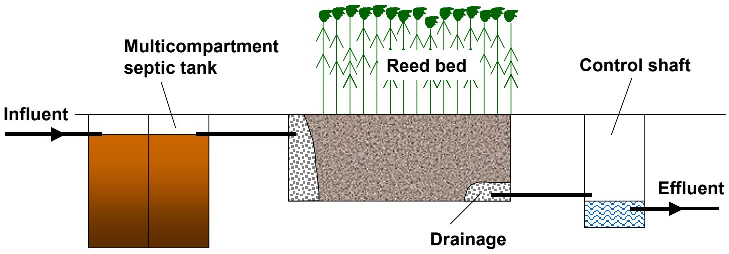

Fig. 5: Schematic diagram of horizontal filter (Source: TBW GmbH)

2.7 Anaerobic Pond

2.7.1 Typical implementation area

Usually, anaerobic ponds are integrated in a serial system of anaerobic, aerobic and possibly maturation ponds. It is possible to provide separate sludge settling tanks preceding the main pond, in order to reduce its organic sludge load.

2.7.2 Process description

Anaerobic ponds are deep (2 to 6 m) and highly loaded (0,1 to 1 kg BOD/m^3*d). Anaerobic conditions are maintained only through the depth of the pond; therefore a minimum depth of 2 m is necessary. Ponds with organic loading rates below 300 g/m^3*d BOD are likely to stay at an almost neutral pH. Consequently they release little H_2S (hydrogen sulphate) and are therefore almost free of unpleasant smell. Highly loaded anaerobic ponds have particularly high odour emissions in the beginning until a heavy layer of scum has developed. Prior to the formation of scum, a small upper layer of the pond will remain aerobic; these ponds may then be called facultative-anaerobic ponds.

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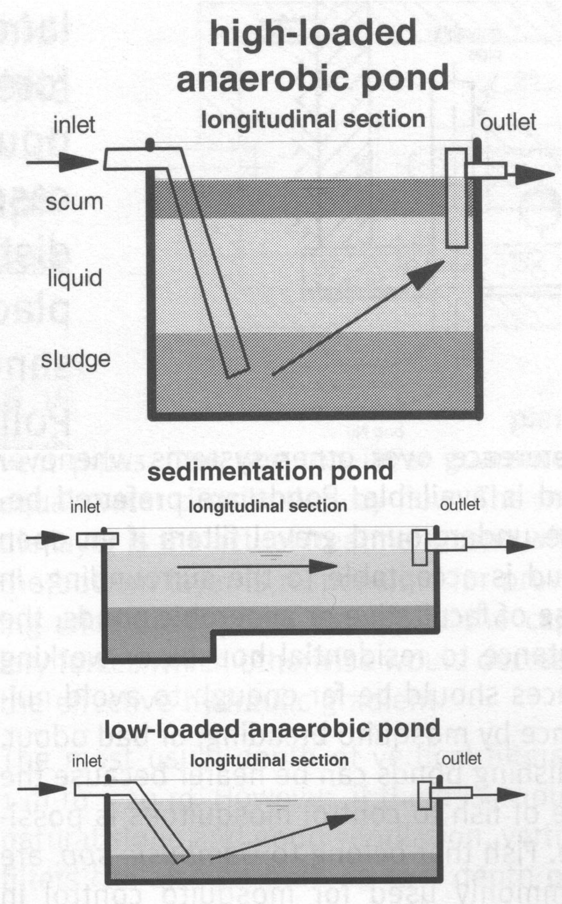

Fig. 6: **Anaerobic ponds** (Source: [7])

Depending on the strength and type of wastewater and the desired treatment efficiency, anaerobic ponds are designed for hydraulic retention times between 1 and 30 days. The settling tanks should have a HRT (hydraulic retention time) of less than one day, depending on the kind of wastewater. For domestic wastewater, the anaerobic pond may function as an open septic tank. It should then be small in order to develop a sealing scum layer. In that case, treatment efficiency is in the range of 50% to 70% BOD (biological oxygen demand) removal.

2.8 Aerobic Pond

2.8.1 Typical implementation area

Wastewater for treatment in aerobic ponds should have a BOD_5 content below 300 mg/l.

2.8.2 Process description

Aerobic ponds receive most of their oxygen via the water surface. For loading rates below 400 mg BOD/m^2*d, surface oxygen can meet the entire oxygen demand. Oxygen intake increases at lower temperatures and with surface turbulence caused by wind and rain.

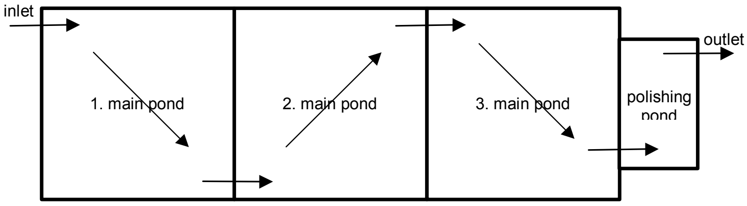

Fig. 7: **Flow pattern of aerobic-facultative ponds in series** (Source: [7])

Oxygen intake further depends on the actual oxygen deficit up to saturation point and thus may vary between 40 g 0_2/m^2*d at 20°C for fully anaerobic conditions and 10 g 0_2/m^2*d in case of 75% oxygen saturation. The secondary source is photosynthesic activity of algae. Too intensive growth of algae and highly turbid water prevent sunlight from reaching the lower strata of the pond. Oxygen “production" is then reduced because photosynthesis cannot take place. The result is a foul smell because anaerobic facultative conditions prevail. Algae growth is desired in the beginning of treatment, but not at the point of discharge as algae increase the BOD of the effluent. A small last pond with a maximum 1-day retention time can reduce algae in the effluent. A larger pond area and low loading rates with reduced nutrient supply for algae are the most secure, but also the most expensive measure. Baffles or rock bedding prior to the outlet of each pond have a remarkable effect on the retaining of algae. Treatment efficiency increases with longer retention times. The number of ponds is of only relative influence. Given the same total surface, efficiency increases by approximately 10% by splitting one into two ponds, three instead of two ponds add about 4% and from three to four ponds, efficiency may increase by

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another 2%. Aerobic stabilisation ponds should be shallow but deep enough to prevent weed growth at the bottom of the pond.

2.9 Performance and requirements

The performance of the different treatment systems depends on the influent characteristics and temperature, but can be defined by the following approximate BOD removal rates:

- 25 to 50% for septic and Imhoff tanks
- 70 to 90% for anaerobic filters and baffled septic tanks
- 70 to 95% for constructed wetland and pond systems.

These values and the required effluent quality decide the choice of treatment systems. For example, septic tanks alone are not suitable for direct discharge into receiving waterbodies, but may be suitable for treatment in areas where the groundwater level is low. For a maximum BOD discharge of 50 mg/l, the anaerobic filter in combination with a septic tank can be sufficient for wastewater of 300 mg/l BOD without further post treatment. Stronger polluted wastewater would require a constructed wetland or pond system for final treatment. The following values indicate the approximate permanent land demand for setting up a treatment plant:

- Septic tank, Imhoff tank: 0,5 m^2/m^3 daily flow
- Anaerobic filter, baffled septic tank: 1 m^2/m^3 daily flow
- Constructed wetland: 30 m^2/m^3 daily flow
- Anaerobic ponds: 4 m^2/m^3 daily flow
- Facultative aerobic ponds: 25 m^2/m^3 daily flow.

These values are approximate figures for wastewater of typical strength. However, the required area increases with the degree of pollution. In case of closed anaerobic systems, there may be no land requirements as they are usually constructed underground. Area for sludge drying beds is not included; this will range between 0,1-10 m^2/m^3 daily flow, depending on degree of pollution and desludging intervals.

Table 1 gives an overview over process combinations for the decentralised treatment systems and post-treatment steps described in this information, Table 2 shows the main advantages and disadvantages of the treatment systems.

Table 1: Decentralised wastewater management options* (Source: modified after [6])

Source of wastewater	Wastewater treatment	Wastewater disposal
Individual residences	*Primary treatment*	Subsurface soil absorption system
Public facilities	Septic tank	Drip application
Commercial establishments	Imhoff tank and variations	Surface water discharge
	Biogas latrines	Constructed wetlands
	Communal biogas plants	Spray irrigation
	Secondary treatment	Recirculation (comm. establishments)
	Aerobic/anaerobic unit	
	Anaerobic filter	
	Baffled septic tank	
	Anaerobic pond	
	Aerobic (aerated) pond	
	Constructed wetlands	

* The given treatment options may require a collection system to convey the wastewater to the treatment facilities, depending on number and location of sources of wastewater.

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Table 2: **Advantages and disadvantages of decentralised wastewater treatment systems** (Source: [7])

Type	Kind of treatment	Kind of wastewater treated	Advantages	Disadvantages
Septic tank	sedimentation, sludge stabilisation	wastewater with main pollution by settleable solids, esp. domestic	simple, durable, little space because of underground construction	low treatment efficiency, effluent not odourless
Imhoff tank	sedimentation, sludge stabilisation	wastewater with main pollution by settleable solids, esp. domestic	durable, little space because of underground construction, odourless effluent	less simple than septic tank, needs very regular desludging
Anaerobic filter	anaerobic degradation of suspended and dissolved solids	pre-settled domestic and industrial wastewater of narrow COD/BOD ratio	simple and fairly durable if well constructed and wastewater has been properly pre-treated, high treatment efficiency, little permanent space required because of underground construction	costly in construction because of special filter material, blockage of filter possible, effluent smells slightly despite high treatment efficiency
Baffled septic tank	anaerobic degradation of suspended and dissolved solids	pre-settled domestic and industrial wastewater of narrow COD/BOD ratio, suitable for strong industrial wastewater	simple and durable, high treatment efficiency, little permanent space required because of underground construction, hardly any blockage, relatively cheap compared to anaerobic filter	requires larger space for construction, less efficient with weak wastewater, longer start-up phase than anaerobic filter
Constructed wetlands (Horizontal gravel filter)	aerobic-facultative-anaerobic degradation of dissolved and fines suspended solids, pathogen removal	domestic and weakly polluted industrial wastewater after removal of settleable and most suspended solids by pre-treatment	high treatment efficiency if properly constructed, pleasant landscaping possible, no wastewater above ground, cheap in construction if filter material is locally available, no odour nuisance	high permanent space requirement, costly if right quality of gravel is not available, great knowledge and care required during construction, intensive maintenance and supervision during first years
Anaerobic pond	sedimentation, anaerobic degradation and sludge stabilisation	heavily and medium polluted industrial wastewater	simple in construction, flexible with respect to degree of treatment, low maintenance requirements	wastewater pond occupies open land, there is always some odour, at times strong, mosquitoes are difficult to control
Aerobic pond	aerobic degradation, pathogen removal	weakly polluted, mostly pre-treated wastewater from domestic and industrial sources	simple in construction, reliable in performance if properly dimensioned, high pathogen removal rate, can be integrated well into natural environment, fish farming possible if large in size and loading is low	large permanent space requirement, mosquitoes and odour can become a nuisance if undersized; algae can raise effluent BOD

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3 Requirements for successful plant management

Despite their significantly reduced need for maintenance and control compared to conventional, centralised wastewater treatment facilities, the management of decentralised wastewater treatment and collection systems is no less important.
If a certain degree of community participation is possible, both the social acceptance and the financial performance of a treatment plant will in the majority of cases improve. Depending on the chosen treatment system, community participation may include

- the provision of some in-house structural elements and of unskilled labour for construction (where applicable);
- the maintenance of easy-to-operate plant compartments and drains/ sewers;
- regular desludging activities.

The necessary degree of formal organisation of simple maintenance activities will increase with a rising number of households connected to the respective plant. Drain and sewer maintenance should in any case be organised on the village or neighbourhood level to a certain extent.

If the given local conditions allow the construction and operation of a shared or communal reactor, this alternative offers the advantage that caretakers can be paid by the connected households. These can then be held accountable and are a smaller and more “professional” group to be approached by local government for e.g. training purposes than individual households. In addition, shared reactors can be located strategically in order to improve access for desludging carts.

4 Non-technical benefits of decentralised wastewater treatment

Given the use of appropriate technologies, the decentralised management concept offers several environmental, fiscal and societal benefits relative to conventional practice.

4.1 Environmental benefits

- Centralisation causes the concentration of large flows in one pipe, lifting station or treatment plant, so that any mishap would have far-reaching consequences. In a decentralised concept system, the flows remain comparably small at any point, therefore causing only comparatively small environmental damage in case of failure.
- In general, bypasses, leaks or overflows are far less likely in a decentralised concept system. The treatment technologies employed are usually less susceptible to failure, lifting stations will mostly be unnecessary or at least greatly reduced in number. Conveying only liquid effluent to multiple treatment centres, the collection system will consist of shorter runs of smaller pipes containing fewer openings, implying far less potential for infiltration to and losses from the piping system as well as overflows.
- Construction work for decentralised treatment systems will cause less environmental damage due to their reduced size.
- Likewise, smaller collection system pipes that can be routed more flexible will be installed at shallow depths, therefore avoiding the tearing up of the surface for the installation of large interceptor mains, which typically run in creek bottoms.
- Environmental disturbance will also be minimised in the long run because existing piping will usually not need to be torn up in order to increase the treatment capacity. The demand for

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system extension can be met by integrating new treatment centres rather than by routing a continually increasing flow to existing facilities.

- Treatment and reuse can be "tailored" to the waste stream. Industrial wastewater does not necessarily have to be mixed with domestic wastewater in order to achieve a certain flow rate, which might be necessary for centralised treatment. Instead, the industry can be asked to implement treatment methods specific to their wastewater characteristics and reuse opportunities.

4.2 Socio-Economic Benefits

- Reuse of effluent becomes more cost efficient: If non-potable water demands such as landscape irrigation, toilet flush supply and cooling tower makeup are required, the effluent can easily be made available throughout the service area, closer to points of potential reuse, thus decreasing the cost of the distribution system for reclaimed water.
- Flow management of a decentralised system is able to accommodate almost any level of water conservation considered economically attractive or ecologically necessary. Reduced wastewater flows will generally not cause clogging problems in the collection system, as normally only liquid effluent is transported, whereas in centralised systems, surface water or other influents may lead to undesired intake of solid material into the collection system, thus causing clogging problems.
- The decentralised concept is easier to plan and finance. Each project is small compared to the typical "regional" concept. The management needs of each area or new development are considered separately and can be implemented independently.
- Many of the costs can be privatised or assigned directly to the activity generating new financial demands on a much fairer basis.
- Capacity expansion and therefore capital requirements can track demand much more closely, thus minimising the amount of money spent to construct facilities which will not be used to capacity for years to come, as it frequently occurs in conventional, centralised systems.
- As implied previously, with the hardware systems decentralised, there would be no reason to impose a "one size fits all" management approach.
- Different strategies can be employed in various parts of the service area, responding in the most fiscally efficient and environmentally responsible manner to each set of circumstances.
- The system can be designed and installed without taking further extension into consideration, whereas centralised systems often spur growth, even requiring it to be fiscally viable in many cases.

4.3 Financial benefits

A decentralised concept system may be less costly than conventional practice for the following reasons:

- The collection system infrastructure can be sized comparably small:
  Typically, a large majority of the total costs of a conventional, centralised system is spent on transport of the substrate to the point of treatment. A decentralised concept system does not need large interceptor mains and few if any lifting stations. Instead, resources can be utilised for appropriate treatment and reuse opportunities. Reuse can deliver additional fiscal benefits by substituting potable water demands.
- The required collection system, employing small-diameter effluent sewer concepts, is less costly to install than conventional mains. The savings are usually even higher than the construction costs for e.g. septic tanks which enable the use of the small-diameter effluent sewers.

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- Little or no undesired infiltration/inflow is probable to enter this type of collection system, thus decreasing system maintenance costs and peak loads on plants, perhaps allowing some components to be downsized.
- The technologies favoured for implementation in decentralised concept systems generally incur minimal maintenance liabilities.

Decentralised concepts cannot be the solution to all wastewater management problems, there will always be specific cases where centralised treatment plants are more appropriate. Still, the many potential benefits of the decentralised strategy indicate that it is a method which deserves greater attention, especially in smaller communities and the developing urban fringe. Most of the barriers to broader implementation of the decentralised concept are clearly institutional rather than technical. These matters command the attention of policy-makers, regulators, operating authorities, engineers, developers and interested members of the public. Given the water resource challenges encountered in many parts of the world, it is time to engage in a rational analysis of all possible management strategies, not merely those accepted as "conventional wisdom".

5 References and further information

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5.1 Useful Links

http://www.idrc.ca/cfp/rep27_e.html
International Development Research Center (IDRC). Report about Community-based technologies for domestic wastewater treatment and reuse as an option for urban agriculture.

http://www.geocities.com/RainForest/Vines/5240/Septic_Tanks.html

gate Information Service / gtz, PO Box 5180, 65726 Eschborn, Germany
Phone: +49 (0)6196 / 79-3094, Fax: +49 (0)6196 / 79-7352, Email: gate-id@gtz.de, Internet: http://www.gtz.de/gate/gateid.afp

Platform by Yahoo (Yahoo! GeoCities); Septic Tank page. Articles, questions and other contributions about Septic Tanks.

http://www.estd.wvu.edu/nsfc/NSFC_SFarchives.html
Environmental Services and Training Division (ESTD), part of the National Research Center for Coal and Energy at the Universitiy of West Virginia. Overview of articles published in the "Small Flows Quarterly". Small community wastewater issues.

http://www.ecological-engineering.com/zeroD.html
Ecological Engineering Group. Paper presented at the International Ecological Engineering conference, June 6, 1999: "Zero effluent-discharge systems prevent pollution: conserving, separating and using up effluents on site". About Wastewater Gardens.

http://www.iwap.co.uk
International Water Association (IWA), IWA Publishing (IWAP): non-profit publisher providing information services on all aspects of water and related environmental fields.

http://www.oneworld.de/scripts/emedia.prg/archiv/1952
'One world'-platform. Paper about constructed wetlands, reuse of wastewater and solid waste.

http://wastewater.net
Wastewater Net Message Forum: Links to wastewater related issues.

5.2 Institutions and Organisations

Bremen Overseas Research and Development Association (BORDA),
Industriestrasse 20, 28199 Bremen, Germany
Phone: ++49 (0)421 / 13718
Fax: ++49 (0) 421 / 1655323
Email: borda.bre@t-online.de

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, German Appropriate Technology Exchange GATE Information Service
P.O. Box 5180, 65726 Eschborn, Germany
Phone: ++49 (0)6196 / 79-3093,
Fax: ++49 (0)6196 / 79-7352,
Email: gate-id@gtz.de,
Internet: http://www.gtz.de/gate/gateid.afp

Food and Agriculture Organisation of the United Nations (FAO)
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Internet: http://www.anaerob.com