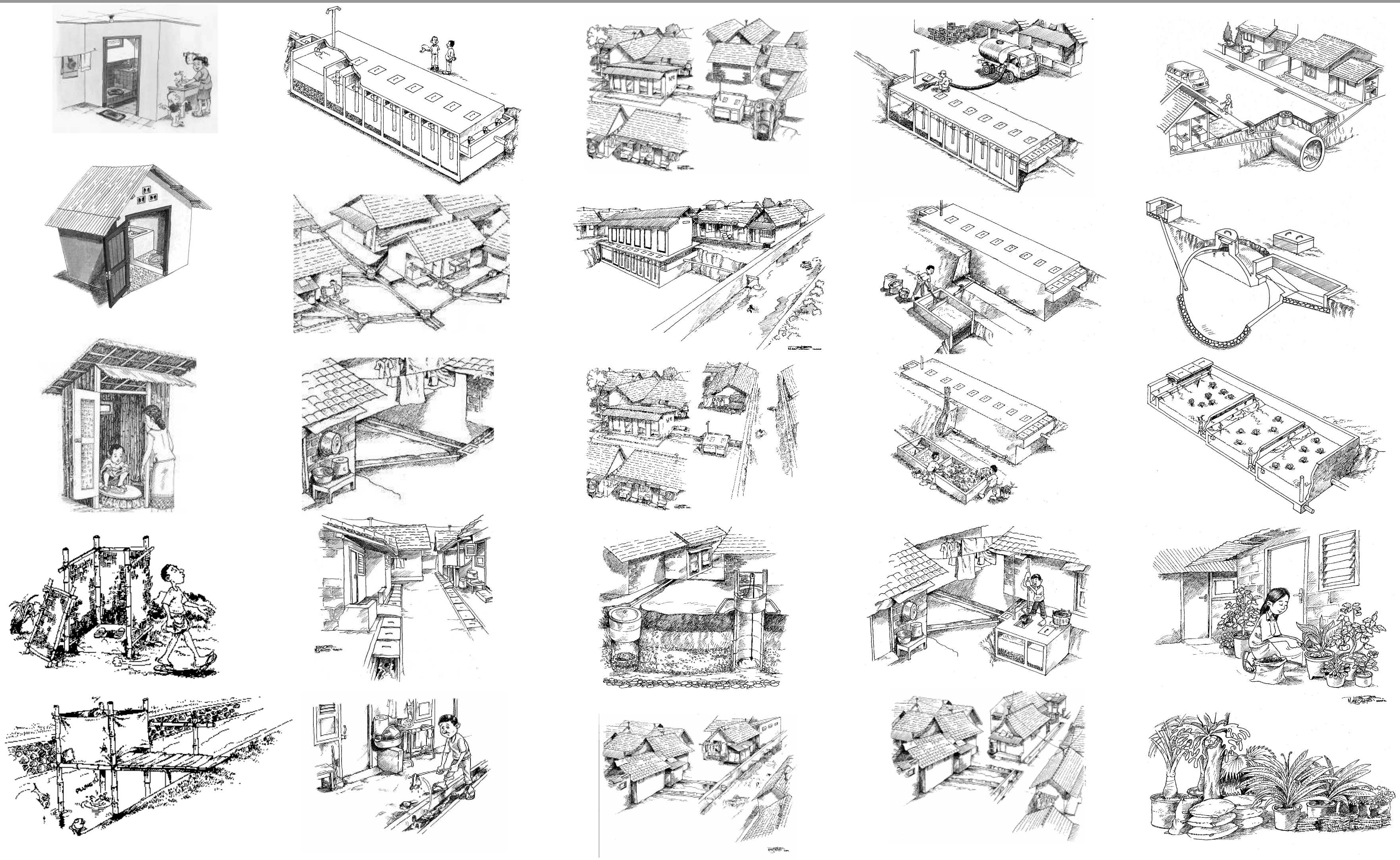
SANIMAS - Informed Choice Catalogue



BORDA

AusAID

Informed Choice for CBS – Why ?

It is proven that community-based sanitation systems are significantly more sustainable, e.g. have a longer lifetime, function more efficiently and are better maintained, if they fully reflect preferences of communities and local stakeholders

Informed Choice Catalogue - Benefits

- Helps to identify suitable sanitation options
- Facilitates the assessment of different sanitation system components with regard to stakeholder preferences
- Powerful tool for technical bottom-up planning
- Reference to get overall information about technical options at a “glance”

Informed Choice Catalogue – Information for Whom?

Information about:

- Opportunities
- Merits
- Risks

of
Technical Options

Community Stakeholders

✓ Informed demand
✓ Education

Municipality Stakeholders

✓ Identify opportunities
✓ Anticipate consultation concerns
✓ Education

Informed Choice Catalogue - Structure

- ✓ The SANIMAS-ICC informs about major component options of sanitation systems – Toilets, Collection System, Treatment System and Disposal/Re-use -
- ✓ Within the “Technology Sheet”, design and function of presented technical options are described briefly
- ✓ Within the “Evaluation Sheet” technical options are assessed with the help of various criteria such as – Capacity, Costs, Self-Help Compatibility, Operation & Maintenance, Replication Potential, Reliability, Convenience and Efficiency
- ✓ Assessments made for specific options are summed up as statements which are classified as “Pro” and “Contra”
- ✓ The highly visualized lay-out encourages readers to browse through the contents

!!! The SANIMAS-ICC is no substitute for Technical Reference Publications

!!! The ICC presents a selection of sanitation system components only

Evaluation Sheet – Assessment Criteria

Within the evaluation sheet, CBS components are assessed on the basis of criteria relevant for stakeholders who want to select suitable options for Community-based sanitation system which represents their preferences. Comments made focus on the suitability of sanitation appliances and components for poor and densely populated urban areas in the Indonesian provinces of East Java and Bali and do reflect the TOR of the SANIMAS project.

Capacity

Comments on suitability of components for individual households and/or neighborhoods with up to 1000 inhabitants

Costs

Informs about investment, operation and maintenance costs

Self-help compatibility

Assessments made whether communities can effectively assist during construction and implementation and during which phases of implementation expert staff is required

Operation & Maintenance

Highlights personnel and technical requirements for successful operation and maintenance of technical options

Replication potential

Assesses relevant factors related to chances for independent replications of technical options at municipality/regency level

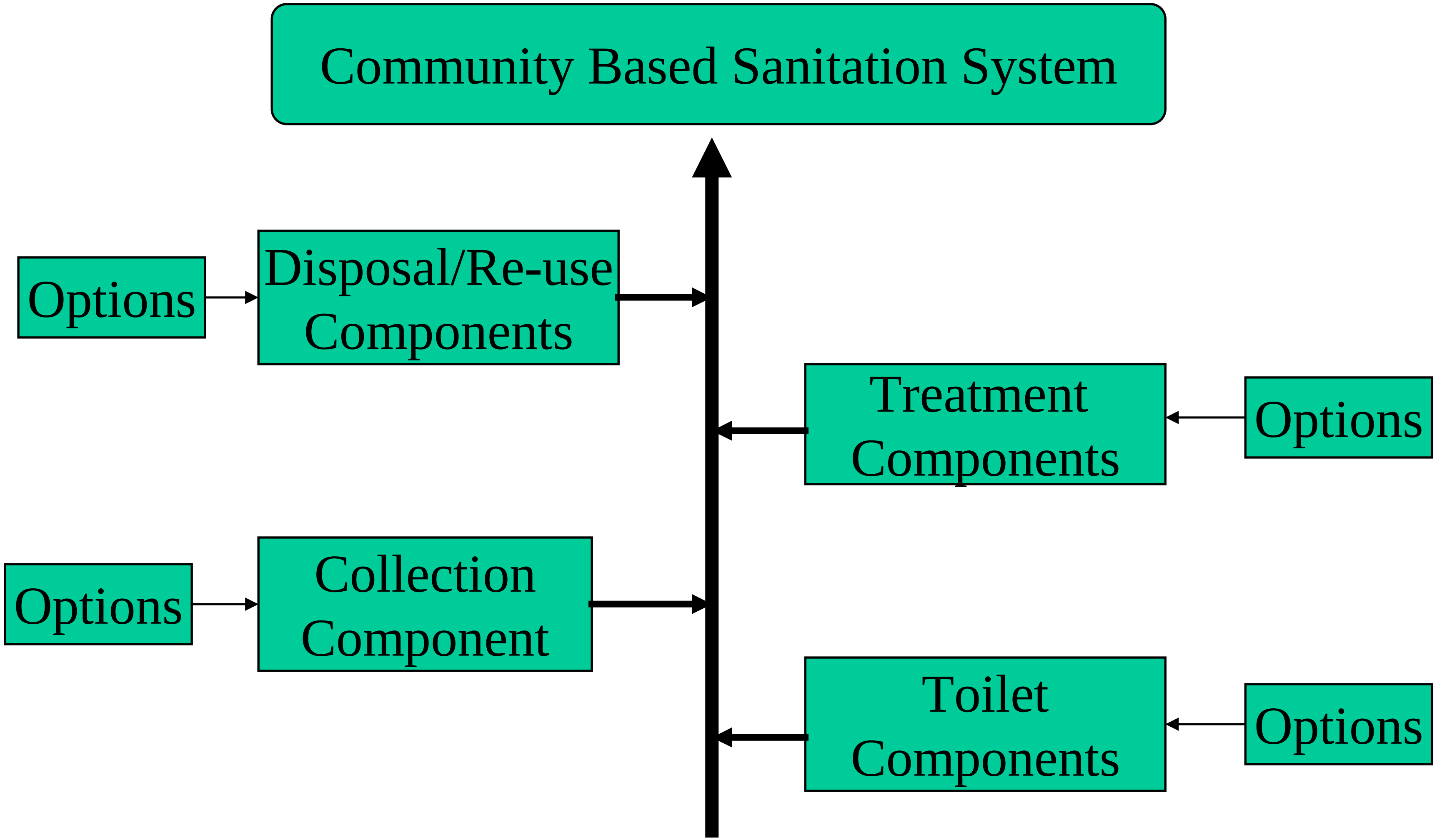
Reliability

Informs about merits and risks related to problem-free operation of technical options

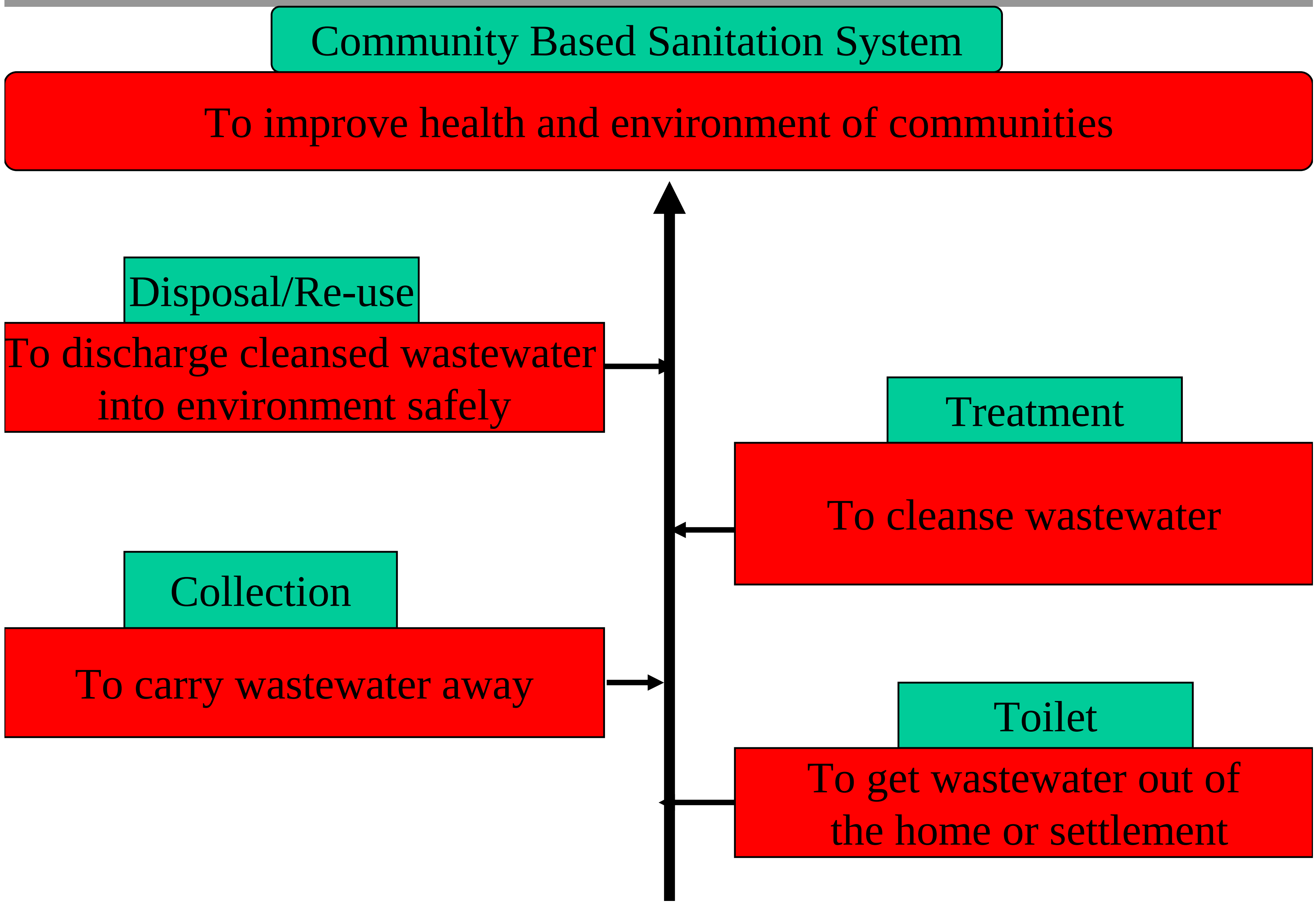
Convenience/Efficiency

Advantages and disadvantages related to user convenience and treatment efficiency are described

ICC: Component Selection Tree



Purpose of CBS-Components



Contents 1 – Toilet and Collection Options

Toilet Systems T

Dry Systems

Simple pit latrine TD1

Ventilated improved pit latrine (VIP) TD2

Composting latrine TD3

Traditional Eco-toilet TD4

Modern Eco-toilet TD5

Water reliant systems

Overhung latrine TW1

Pour-flush toilet, PFT TW2

PFT with leach pit TW3

PFT with individual septic tank TW4

Community PF-toilet block TW5

Collection Systems C

Drains

Open rainwater drains CD1

Covered rainwater drains CD2

Shallow Sewerage

Condominial sewerage CSS1

Simplified gravity sewerage CSS2

Settled sewerage CSS3

Settled pumped sewerage CSS4

Conventional Sewerage

Conventional gravity sewerage CCS1

Combined gravity sewerage CCS2

Vacuum sewerage CCS3

Contents 2 – Treatment & Discharge/Re-use Options

Treatment Systems

Main Treatment Systems MT

Septic tank	MTS 1
Imhoff tank	MTS 2
Anaerobic reactor, fully mixed	MTS 3
Anaerobic baffled reactor	MTS 4
Anaerobic filter reactor	MTS 5
Anaerobic lagoon	MTS 6
Facultative lagoon	MTS 7
Aerobic lagoon	MTS 8
Aerated lagoon	MTS 9
Trickling filter	MTS 10
UASB reactor	MTS11
Rotating biological contactor (RBC)	MTS12
Sequencing batch reactor (SBR)	MTS13
Oxidation ditch	MTS14
Activated sludge unit (ASU)	MTS15

Secondary Treatment Systems ST

Planted horizontal sand filter	STS1
Planted vertical sand filter	STS2

Disposal/Re-use of Effluent and Sludge

Discharge/re-use of effluents DRE

Discharge into river	DRE1
Soil infiltration	DRE2
Irrigation	DRE3
Aquaculture	DRE4

Disposal/re-use of Sludge

Sludge drying bed	DRS1
Reed bed	DRS2
Composting	DRS3
Mechanical dewatering	DRS4
Vacuum truck	DRS5
Agricultural re-use	DRS6

TOILET SYSTEMS

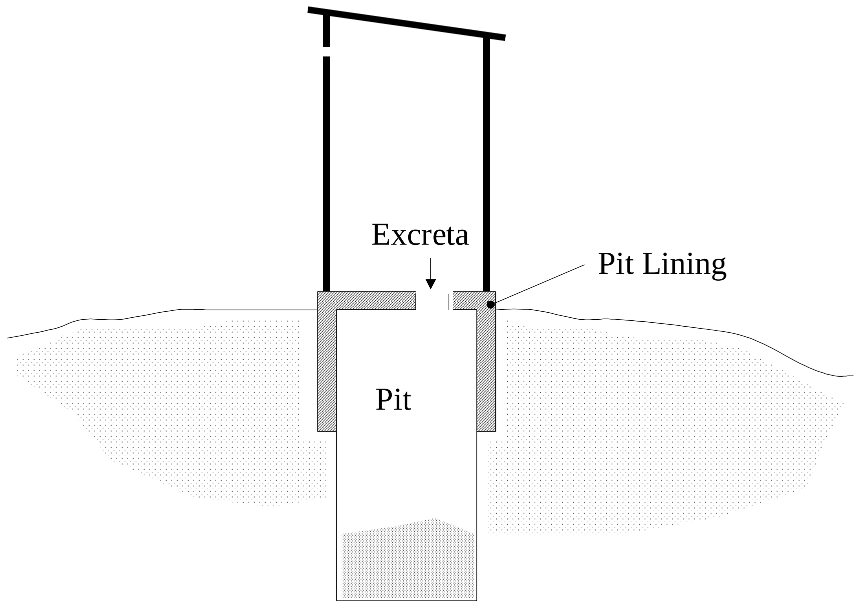
Dry-Toilets

Simple pit latrine

Description:

Pit latrines are made of a latrine superstructure and a hole for defecation. A pit cover slab can be used to reduce odour and hinder flies. Average depth is 3 m. The depth is usually limited by the groundwater table or rocky underground. The underground of the latrine should be water pervious. Dry anal cleansing is advantageous to minimise water content. No sullage treatment is included. The latrine can be used until it is filled up half a meter below the top. Relocation of latrine is usual after the pit is full. Life time depends on the number of users.

Pit latrines are always located outside the house.



Evaluation Sheet

Simple pit latrine

Capacity: One unit can serve one or several households. Space for relocation and/or desludging of pit required

Costs: Very low investment costs - among the cheapest systems; maintenance requires re-location or emptying of pits

Self-help compatibility: Toilet can be constructed without expert inputs;

Operation & Maintenance: Operation and maintenance is simple but as water used is limited it is difficult to keep pit-latrines clean

Replication potential: Design readily available; all materials locally available; it is not possible to up-grade the toilet system

Reliability: Considered reliable in the absence of other alternatives. Function of the system is usually guaranteed until the pit is full.

Convenience: Toilet located outside the house; Potential odour, insect and hygiene hazards if system is not cleaned regularly; due of soil infiltration there is danger of groundwater contamination; emptying and/or relocation of pit poses health hazards

PRO:

- **Very low investment and O & M costs**
- **Construction requires no experts**
- **Reliable**

CONTRA:

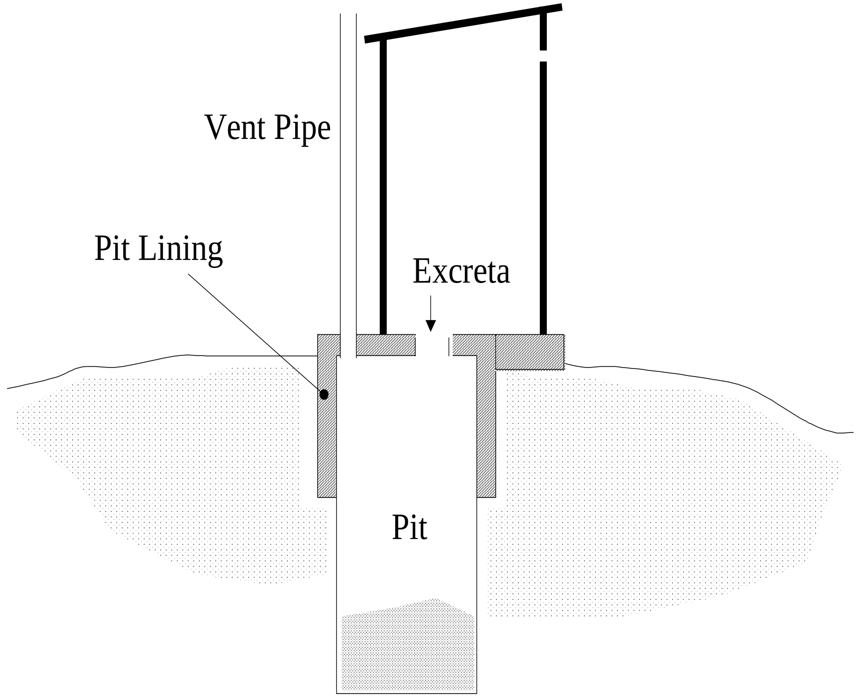
- **Difficult to keep toilet clean and hygienic**
- **Odour and insect nuisances are common**
- **System functions only if water use is strictly minimized**
- **Manual desludging poses health hazard**
- **Relocation of individual leach-pits difficult in densely populated urban areas**

Ventilated improved pit latrine, VIP

Description:

The design is nearly the same as a normal pit latrine – made of a latrine superstructure, a pit cover slab and a hole for defecation. Different is only the ventilation pipe, provided with a durable fly screen on the top. If properly designed and used, i.e. supplied with a dark interior, the ventilation can reduce flies and odour. If fly screen fails convenience and health will be undermined. Dry anal cleansing is advantageous to minimise water content. No sullage treatment is included. Relocation of latrine is usual after the pit is full.

A variation of the system includes two pits. Only one pit is used at a time. Once a pit is full, the content is left to decompose while the other pit is being used. By the time the second pit is full the odourless and decomposed content of the first pit is removed.



Ventilated improved pit latrine, VIP

Capacity: One unit can serve one or several households. Space for relocation and/or desludging of pit required

Costs: Very low investment costs - among the cheapest systems; maintenance requires re-location or emptying of pits

Self-help compatibility: Toilet can be constructed without expert inputs;

Operation & Maintenance: Simple, but it proves difficult to keep system clean and hygienic as water use is strictly limited.

Replication potential: Design readily available; all materials locally available; not possible to up-grade system

Reliability: Considered reliable in the absence of other alternatives. Function of the system is usually guaranteed until the pit is full.

Convenience: Toilet located outside the house; due to ventilation reduced insect and odour nuisances; due of soil infiltration there is danger of groundwater contamination; emptying and/or relocation of pit poses health hazards

PRO:

- **Very low investment and O&M costs**
- **Construction requires no experts**
- **Reliable**
- **Compared to simple pit latrine reduced odour and insect nuisances**

CONTRA:

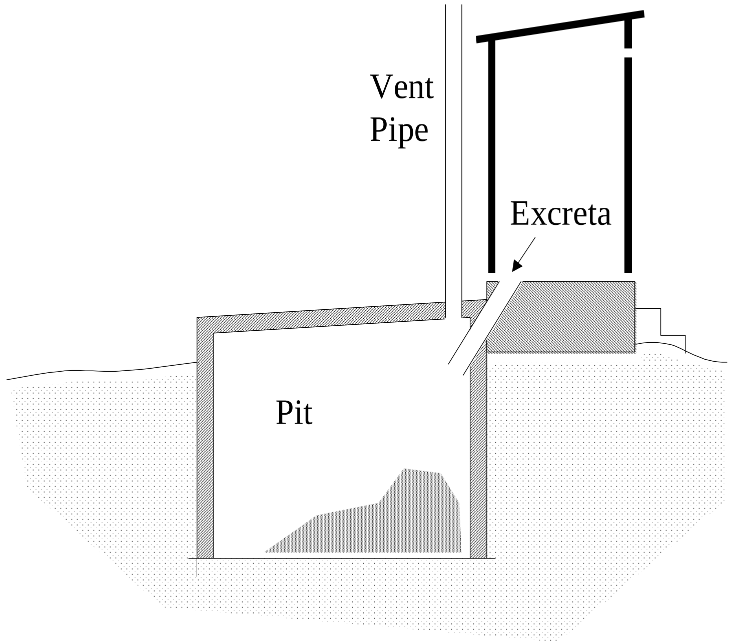
- **Difficult to keep toilet clean and hygienic**
- **System only functions if water use strictly minimized**
- **Manual de-sludging poses health hazard**
- **Relocation of individual leach-pits difficult in densely populated urban areas**

Composting latrine

Description:

The composting latrine consists of a squatting plate which is placed over a watertight fault that is usually constructed above soil. The fault is usually ventilated through a pipe. To support the composting process it is necessary to add organic material to faeces such as straw and vegetable waste. Different techniques can be applied to reduce the water content thus, guarantee optimal aerobic conditions. Composting latrines are only suitable for communities using dry cleansing material. No sullage treatment is included

Another popular type of compost toilet used two faults which are alternately in use. During one fault is used the content of the other is dewatered through evaporation and decomposed through micro-organisms. After a certain time the odourless and partially disinfected compost can be removed without harm and the vault can be used again.



Composting latrine

Capacity: One unit can serve one or several households; sufficient dry organic materials should be available to keep up composting processes; space for compost removal is required

Costs: Low construction costs; maintenance costs can be minimized through utilization of compost as organic fertilizer

Self-help compatibility: Toilets can be constructed without experts, but users should fully understand and appreciate the system

Operation & Maintenance: Dry anal cleansing practices required as moisture content of compost must be kept at 70 %; cleaning of toilets difficult as water use is limited; dry organic materials need to be added regularly into pit; regular removal of compost necessary

Replication potential: High self help potential. System can be easily implemented by communities or local authorities.

Reliability: Reliable if moisture content of 70 % is maintained; if content is too wet, composting processes collapse and anaerobic fouling processes develop

Convenience: Toilet is located outside the house; system is convenient in rural areas where composting is practiced traditionally; system not suitable for wet anal cleansing practices .

PRO:

- **Low construction cost**
- **Construction requires no experts**
- **Cost recovery through organic fertilizer use**
- **No negative effect on aquatic environment**

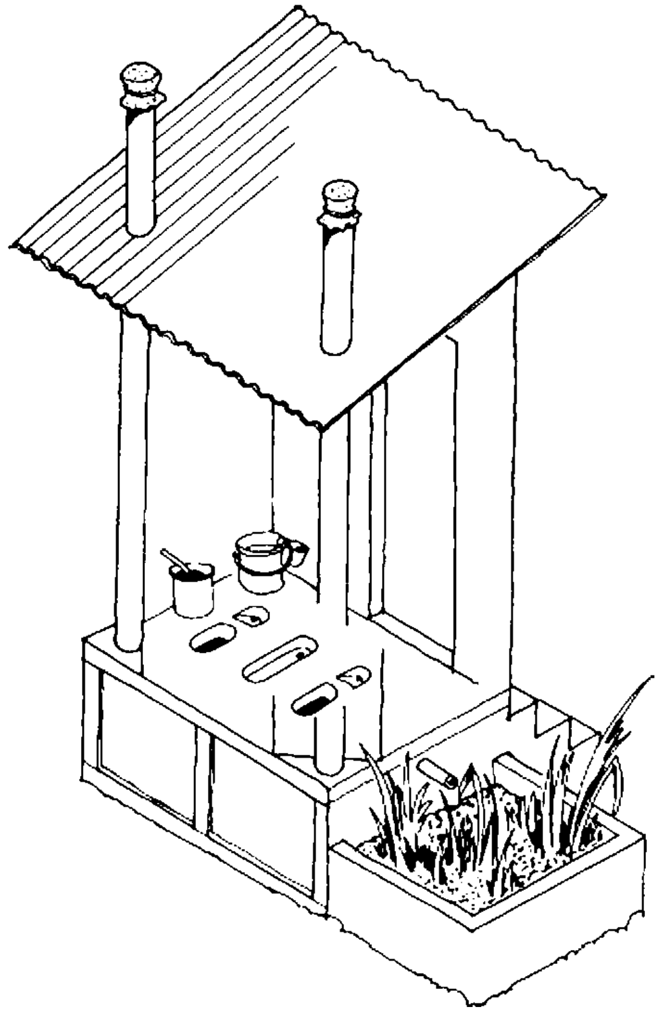
CONTRA:

- Only suitable for dry anal cleansing practices
- Difficult to maintain toilet clean and hygienic
- Difficult to keep moisture content at 70 %
- Compost removal from pits difficult in urban areas

Eco-Toilet 1: Traditional Double-Vault Toilet

Description:

Chambers are covered with a squatting slab. Over each vault there is a drop hole for faeces and a funnel for urine. Anal cleansing is carried out over a trough located between the two vaults. Urine and the water used for anal cleaning flow into the planted evapo-transpiaration bed. Vaults are lined with straw or dried organic matter before use to absorb moisture and provide organic carbon. After defecation, a handful of ashes is sprinkled over the faeces to absorb moisture and reduce fly and odour nuisance. After one vault is full it is closed and left for decomposition and the second vault used. After one year the odourless and partially disinfected substrate is be removed and the vault is again ready for use. The evapo-transpiration bed requires very little maintenance. Plants are cut back, chopped into small peaces and after drying added to the processing vault. Good experiences with the system have been reported in South India – also in combination with wet anal cleansing and under humid climate. The traditional Vietnamese double vault toilet works in the same way but only in combination with dry anal cleansing and urine utilization for agriculture purposes.



Eco-Toilet 1: Traditional Double-Vault Toilet

Capacity: One unit can serve one or several households. Suitable for rural areas where compost can be utilized and organic material is available.

Costs: Low, but slightly more expensive than a compost. Users are responsible for all aspects of O & M

Self-Help Compatibility: Toilets can be constructed without experts, but users should fully understand and appreciate the system

Operation & Maintenance: Operation and maintenance based on availability/use of organic materials/decomposed feaces; use of decomposed faeces must be compatible with existing sanitation culture

Replication potential: System can be easily replicated by communities or local authorities.

Reliability: Reliable if low moisture content is kept

Convenience: Toilet is located outside the house; system is convenient in rural areas where composting is practiced traditionally; system not suitable for wet anal cleansing practices .

PRO:

- **Low construction cost**
- **Construction requires no experts**
- **Cost recovery through organic fertilizer use**
- **No negative effect on aquatic environment**

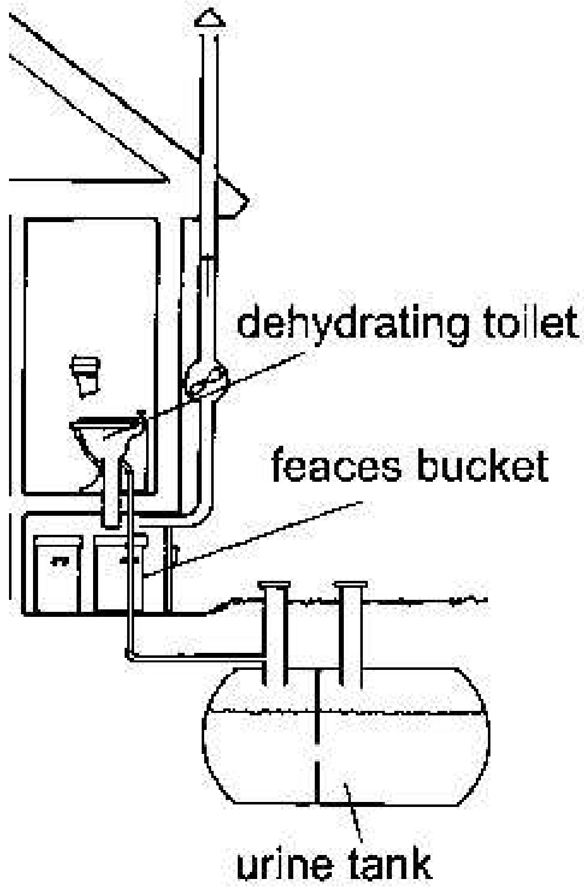
CONTRA:

- Only suitable for rural areas
- Difficult to maintain toilet clean and hygienic
- Difficult to keep optimal moisture content

Eco Toilet 2: Modern Double Vault Toilet

Description:

Through a urine diversion toilet urine is flushed with 0,1 l water into a air tight urine tank for storage. After the tank is full the urine can be utilized in agriculture. Faeces and toilet paper drops into a insulated vault where it is collected by a plastic container. The vault is aerated by a fan. After the container is full it is put aside and an empty container is placed under the toilet. The full container is left in the vault for decomposition for about 6 months. The dehydrated content can than be further treated in a compost bin. The described system is a well-tested sanitation system suitable for indoor use in modern western bathrooms.



Eco Toilet 2: Modern Double Vault Toilet

Capacity: One unit can serve one or several households. More suitable for rural or suburban areas where urine and faeces can be utilized.

Costs: High investment for pre-fabricated appliances. Users are responsible for all aspects of O & M

Self-Help Compatibility: Imported parts and expert plumbing services required;.users should fully understand and appreciate the system

Operation & Maintenance: Operation and maintenance based on availability/use of organic materials/decomposed feaces; use of decomposed faeces must be compatible with existing sanitation culture

Replication potential: Low replication potential as appliances have be imported; expert plumbing required during implementation; individual system only

Reliability: Reliable if dry anal cleansing is practised; electric fan required for aeration of vault

Convenience: Convenient in-house location possible; System only suitable if faeces can be re-used as organic fertilizer; system dependent on dry anal cleansing practices; no pollution of aquatic environment

PRO:

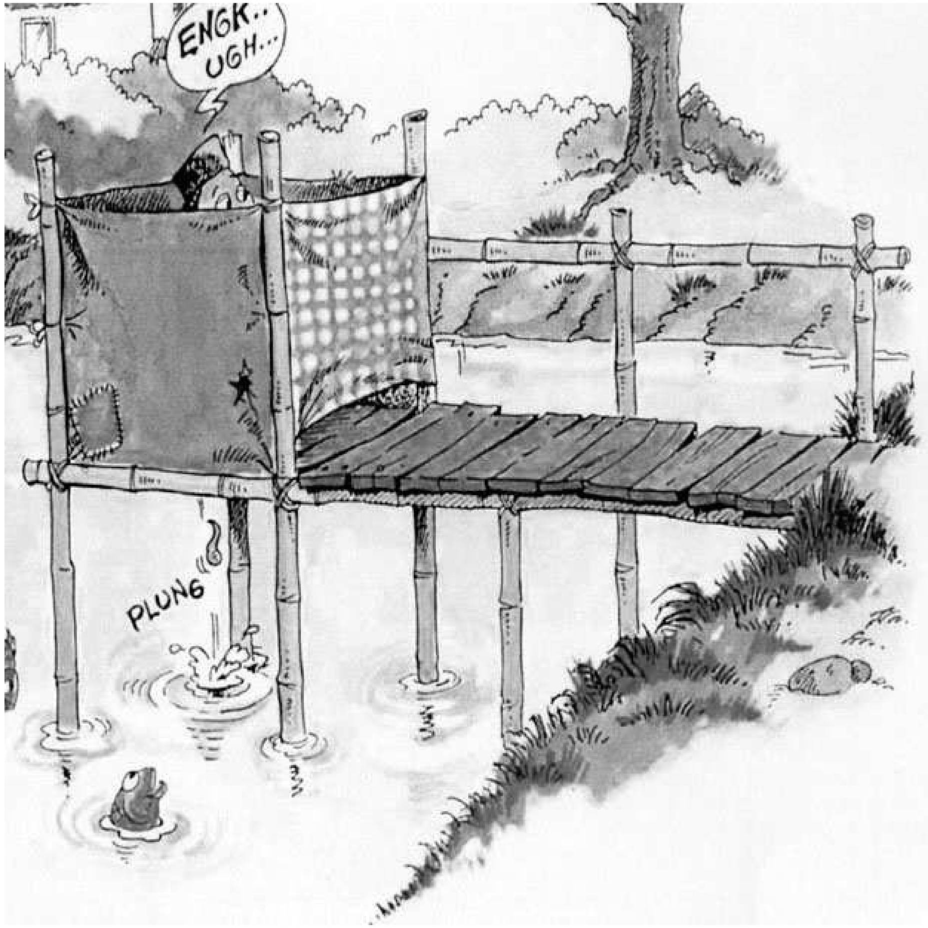
- **Environment friendly, individual high-tech toilet**

CONTRA:

- **Suitable for rural and semi-urban areas only**
- **High investment costs**
- **Imported parts and experts required**
- **DIY system installation not possible**
- **Proper function of urine separation only possible in combination with dry anal cleansing**
- **Bad odours if aeration fan brakes down**

Water-reliant Toilets

Overhung latrine



Description: An overhung latrine is usually built from bamboo or wood, which is sited above the surface of water bodies (e.g. rivers ponds or lakes). Excreta fall directly into the water where they are decomposed. Usually it is a public facility which serves an entire or part of a community.

Overhung latrine

Capacity: Ideally practised by communities in scarcely populated rural areas; depending on effluent inflow, large fresh water-body is required

Costs: Very low investment and operation costs; maintenance costs low as required materials often available free-of-charge

Self-help compatibility: No expert staff needed for construction and maintenance;

Operation & Maintenance: Supporting wooden parts of superstructure need to be replaced regularly

Replication potential: Materials locally available and often free of charge; system can be easily implemented by individuals or communities; up-grading of system not possible

Reliability: Reliable if superstructure is maintained

Convenience: Inconvenient, as superstructure is usually located away from settlements; Hazardous to public health in case receiving water body is too small or/and used as clean water source.

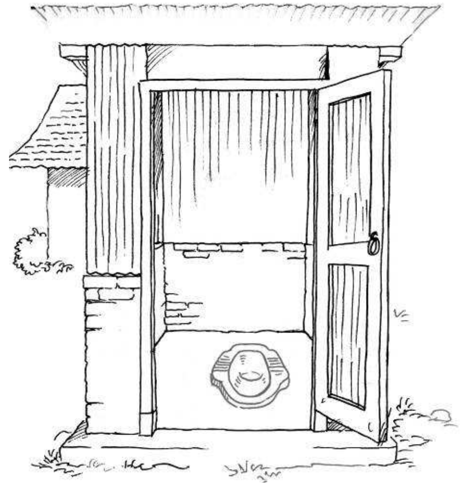
PRO:

- **Very low investment and O & M costs**
- **No expert staff needed for construction**
- **High-self help compatibility**

CONTRA:

- **Only acceptable in scarcely populated areas**
- **Potential contamination of water body**
- **Inconvenient as latrine located outside settlements**
- **Water body cannot be used as clean water source**

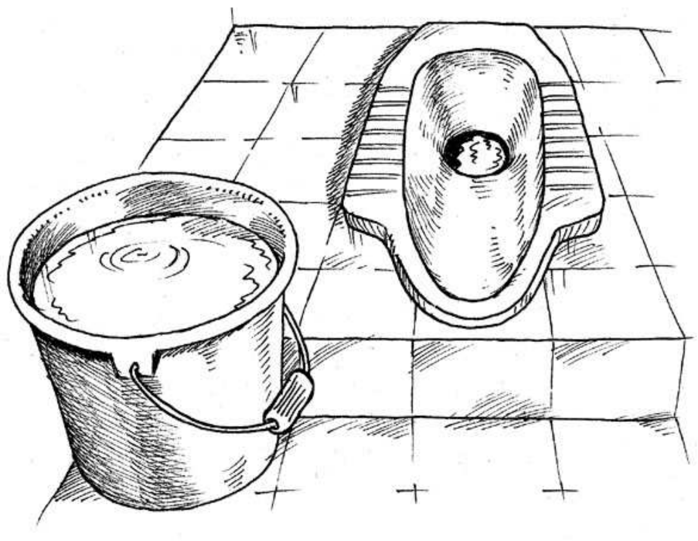
Pour-flush toilet



Description:
The majority of manual pour-flush toilets commonly used in Indonesia are of the squatting type. Cistern based pour-flush toilets can be only found in high-income households.
Pour-flush toilets can be located within the house, attached to it or as a free standing unit in the yard.

The pour-flush toilets incorporates a water seal against odours and insects. Excreta are flushed away with water poured into the pan with a scoop.

Where water is required for anal cleansing, pour-flush toilets are particularly suitable because the same water can be used for flushing. As no complex mechanical devices are needed for operation, the toilets are robust and will rarely require repair. Since water is available near and in the toilet, cleaning is very easy.



Pour-flush toilet

Capacity: Pour-flush toilets are the most commonly used toilets in urban households as well as in community sanitation centres

Costs: Low investment and maintenance costs; Cost of superstructure depends on comfort required as well as availability of in-kind labour and local material prices; operation and regular cleaning = maintenance

Self-help compatibility: Design readily available; only local craftsmen required for construction;

Operation & Maintenance: Easy operation and maintenance if regular water supply is provided

Replication potential: Know-how for installation of devices and required hardware is readily available; upgrading possible;

Reliability: Reliable and clean system

Convenience: Pour-flush toilets can be constructed inside and outside the house; clean and hygienic system; water consumption reduced if water is used for anal cleansing.

PRO:

- Most common toilet system in Indonesia
- Low investment and O & M costs
- Construction requires no experts
- Location of superstructure flexible
- Reliable
- Convenient, clean and hygienic if regular water supply provided

CONTRA:

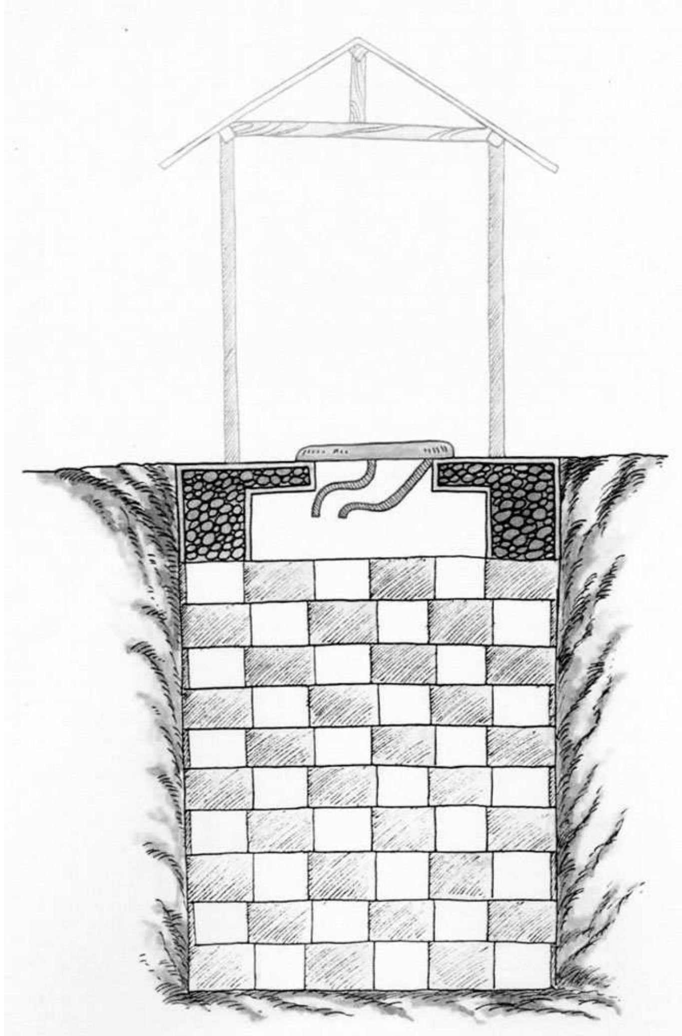
- Regular water supply needed
- More expensive than basic dry systems
- Collection and treatment system for effluent required

Pour-flush toilet with leach pit

Description:

Single leach pits are made of a latrine superstructure, a WC pan with water seal and a collection pipe 100 mm in diameter laid at an gradient of at least 1 in 20 if the pit is off-set. The pipe discharges water in a pit made from water pervious brick work. For desludging, it is easier to locate the pit off-set and not directly under the superstructure. Water necessary for flushing is about 0,5 – 2 l. Therefore, the system fits better to wet anal cleansing. Desludging is required every 3 – 5 years. Equipment for emptying should be available. High volumes of sullage discharged into the pit can cause spill over during rainy season.

In double leach pits, two pits are used alternately. During one pit is used the content of the other is being left to decompose so that decomposed faeces can be removed manually in a more hygienic manner.



Pour-flush with leach pit

Capacity: One unit can serve one or several households; only suitable for densely populated areas if groundwater level is deep and if wells are located outside infiltration area.

Costs: Low investment and maintenance costs

Self-help compatibility: Design readily available; no specific technical know-how needed for construction;

Operation and Maintenance: Toilets are easy to clean if regular water supply available; manual desluging unfavorable in urban areas; re-location of leach pits nearly impossible in densely built areas

Replication potential: High self help potential. System can be easily implemented by communities; system up-grading possible, e.g. connection to new collection/treatment components possible

Reliability: Reliable

Convenience: Toilet use convenient; emptying/re-location of leach pits difficult und potentially unhygienic in urban areas; risk of groundwater and well contamination;

PRO:

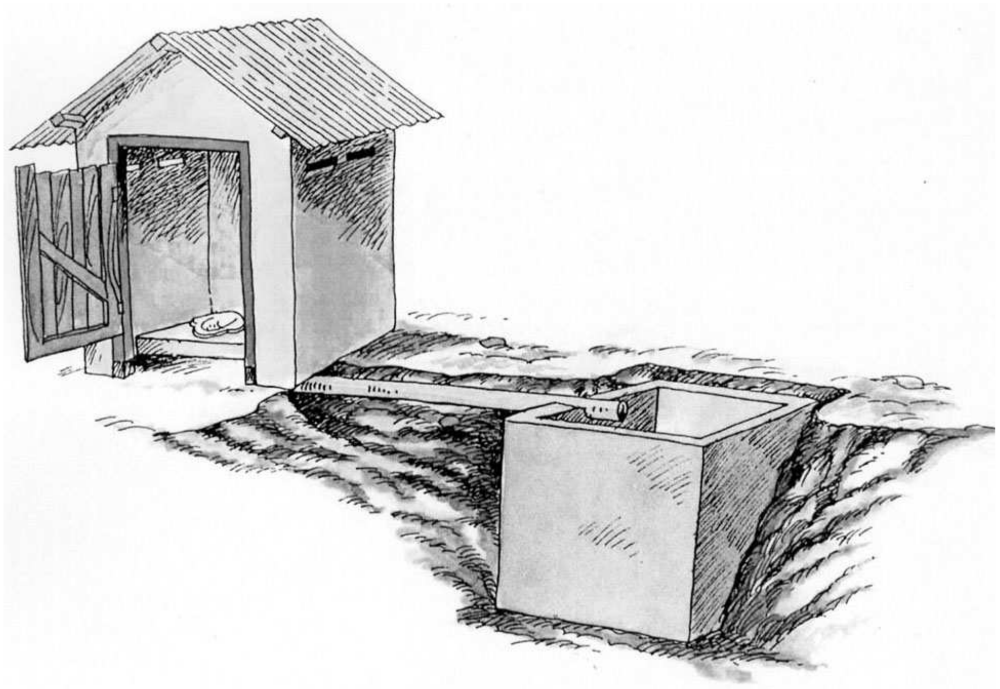
- **Low investment and O & M costs**
- **No experts needed for construction**
- **Convenient, clean and hygienic toilet option**
- **Possible to up-grade system**

CONTRA:

- **Potential groundwater and well contamination**
- **Manual desludging of single pit system poses health hazard**
- **Relocation of individual leach-pits very difficult in densely populated urban areas**

Pour-flush with individual septic tank

Description:



Individual septic tanks are made from a latrine superstructure, a WC pan with water seal, a pipe 100 mm in diameter, laid at an gradient of at least 1in 20. The pipe discharges water in a water-tight tank located off-set . In the tank, contaminants are removed from the sewage by either settling or by flotation. Wastewater from the clarified layer flow to the outlet. The remaining organic pollutants are decomposed through anaerobic digestion. Water necessary for flushing is about 0,5 – 2 l. System fits better to wet anal cleansing. Sullage can also be discharged into adequately designed tanks. Desludging is required every 3 – 5 years. Equipment for emptying should be available.

Pour-flush with individual septic tank

Capacity: System can be used on individual, - shared or community basis. As septic-tank is constructed underground, suitable for densely populated areas;

Costs: Medium investment costs; low operation and maintenance costs

Self-help compatibility: Good self-help compatibility as only local craftsman required for supervision;

Operation & Maintenance: daily cleaning has to done to keep up basic hygiene; mechanical de-sludging can be executed on self-help basis or via service provider by vacuum truck

Replication potential: Standardized designs available; know-how and materials readily available; system up-grading possible

Reliability: Reliable

Convenience: Convenient, clean, hygienic individual toilet system; connected septic tank reduces organic load of wastewater

PRO:

- Low O & M costs
- Operation and maintenance is simple
- Later system up-grading possible
- Convenient and environment-friendly system

CONTRA:

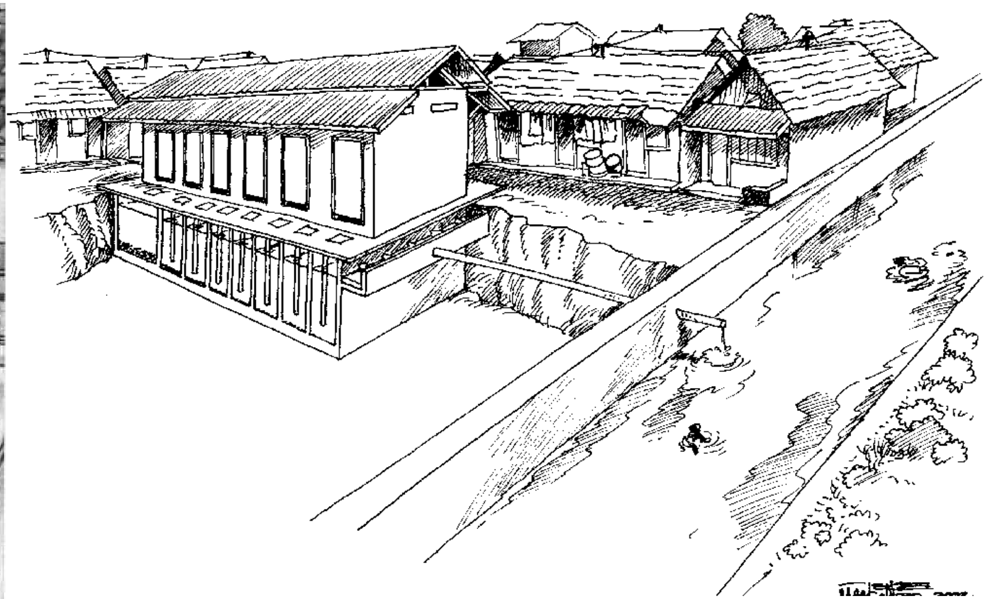
- Relatively high investment costs
- Skilled craftsmen needed for construction
- Regular desluging of septic tank required

Pour-flush Community Toilet Block

Description:

Community toilet blocks consist usually of a number of toilet compartments. A large variety of available superstructure options can also include bathrooms, public water-points and facilities for laundry.

Each toilet should not be shared by more than 6 households or 25 persons. Integrated concepts can also include set-on or set-off treatment options such as septic tanks or baffled reactors. Community toilets are a suitable CBS option in settlements where majority of households have no toilets. For the convenience of residents, communal toilet blocks should be located close to houses. Past experiences have shown that proper maintenance and operation of community toilets are major obstacles for its sustainability. User fees are a “must” to finance routine operation and maintenance services which ought to be carried out by permanent or part-time O & M staff employed by community groups or private service provider.



Evaluation Sheet

PF- Community Toilet Block

Capacity: Depending on the number of toilet compartments, CTBs can serve 20 to 100 households; community toilets should be located strategically within settlements; treatment and discharge components should be adapted to expected effluent volume.

Costs: Investment costs depend on availability of permanent clean water supply and specific design of superstructure; price of land needed for construction is major cost component in urban areas; operation & maintenance costs include provision of water, electricity, cleaning services & materials as well as replacement of heavily used parts of the superstructure parts; user fees must be collected to cover O & M costs

Self-help compatibility: Part of construction work can be carried out semi/un-skilled labourers; daily supervision by craftsmen required; competent community organization or service provider needed to manage facilities

Operation & Maintenance: Regular attendant needed for daily cleaning and collection of user fees; use of cheap materials and sloppy construction work increases maintenance costs significantly;

Replication potential: Basic MCK designs, materials, and technical know-how readily available; possible to up-grade collection, treatment and discharge components later if required

Reliability: Reliable, if operation and maintenance requirements are met

Convenience: Provision of basic sanitation services; convenience depends on location, cleanliness and appliances of superstructure

PRO:

- **System provides basic sanitation facilities**
- **Low per capita costs if water and land available**
- **Convenient for residents of very densely populated areas**
- **Up-grading of system possible**

CONTRA:

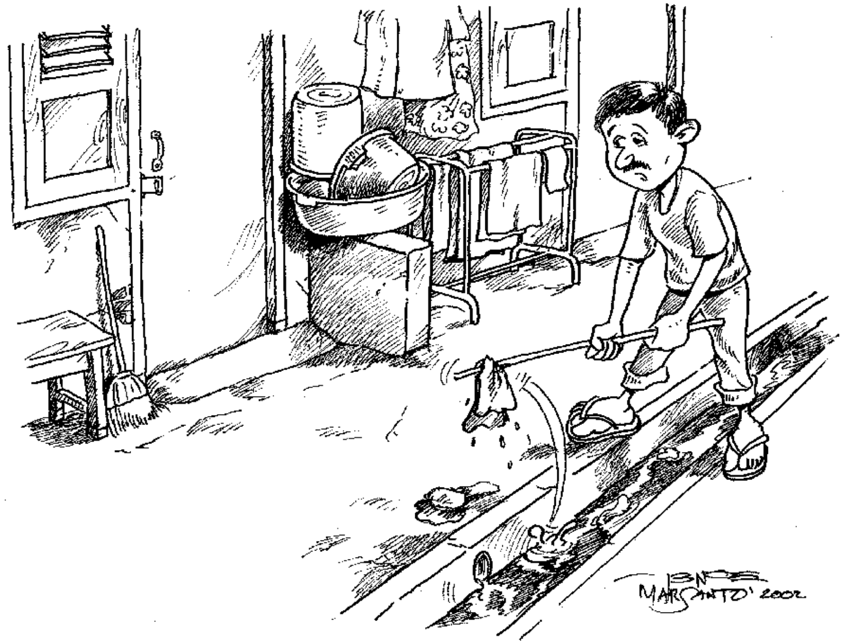
- **Potentially high investment costs due to high land prices and provision of permanent water supply**
- **Professional supervision required for construction**
- **O & M requirements can only be met by well organized community groups or private service providers**

COLLECTION SYSTEMS

Drains

Open rainwater drains

Description:



A system with open ditches for the discharge of rainwater exist in most urban areas in Indonesia. The ditches usually drain-off rainwater into rivers or sometimes into agricultural irrigation canals. Unauthorised discharge of domestic waste into the system is quite common. Where no wastewater infrastructure exists, drainage of sullage through the system could be a possible temporary solution.

Open rainwater drains

Capacity: Practiced within smaller and larger urban areas influenced by tide level of sea; prone to flooding or clogging in rainy season

Costs: Low investment costs if rainwater drains already exist, otherwise high investment needed for labour and materials; permanent cleaning services required for propper maintenance

Self-help potential: No experts needed for construction and supervision;

Operation & Maintenance: As open drains need to be cleaned regularly, solid waste collection system needed on community level

Replication potential: Simple design; all construction materials readily available. Difficult to up-grade system at later stage

Reliability: Open drains are prone to blockage caused by garbage and solids

Convenience: Wastewater not effectively removed and treated; breeding ground for insects/pests; smelly; openly running wastewater in densely populated area poses public health hazard

PRO:

- **Low-cost drain-off solution if drains already exist**
- **Simple to construct**

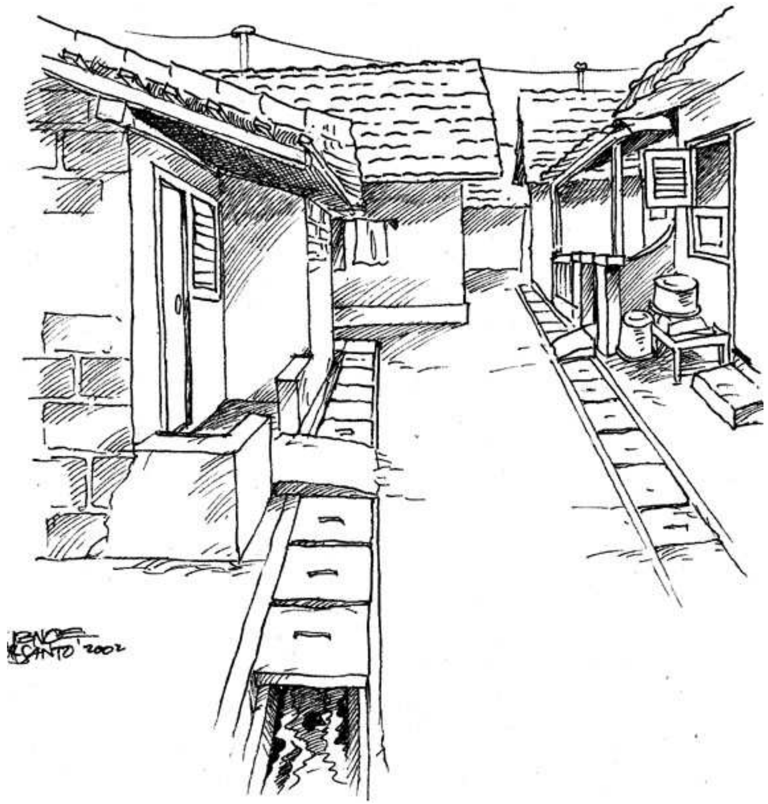
CONTRA:

- **New construction is expensive**
- **Cleaning service required to remove solids**
- **Blockages can cause spill-over and flooding**
- **Foul odours prevalent**
- **Open wastewater drains pose public health hazard if located in densely populated areas**

Covered rainwater drains

Description:

Nowadays in many urban areas, roadside drains are used to discharge sewage. Covered rain water drains are often used to collect wastewater in areas which lack conventional sewerage systems. Drains are covered by concrete slabs to prevent blockages by litter and humans from getting in contact with their contents. In order to allow rain water to enter the system, periodic inlets in the drain covers are required. Theoretically, connected treatment plants would have to be designed for the purification of combined flows - rainwater and domestic wastewater – which requires a very high treatment capacity and investment.



Covered rainwater drains

Capacity: Applied in small and large urban settlements with high ground-water or sea-tide levels.

Costs: Low investment costs for modification if covered drains already exist, otherwise high investment needed. Regular cleaning services required for maintenance; broken covers need to be replaced

Self-help potential: No experts needed for construction and supervision;

Operation & Maintenance: Covered drains must be cleaned and maintained regularly by residents; blockages often more difficult to locate than in open system

Replication potential: Simple design; all construction materials readily available. System cannot be extended or up-graded;

Reliability: If broken covers not replaced, system is prone to clogging/blockage caused by garbage and solids

Convenience: Wastewater is not effectively removed and treated; potential breeding ground for insects and rodents;

PRO:

- **Cheap drain-off solution if infrastructure already exist**
- **No experts needed for construction**
- **All materials needed locally available**

CONTRA:

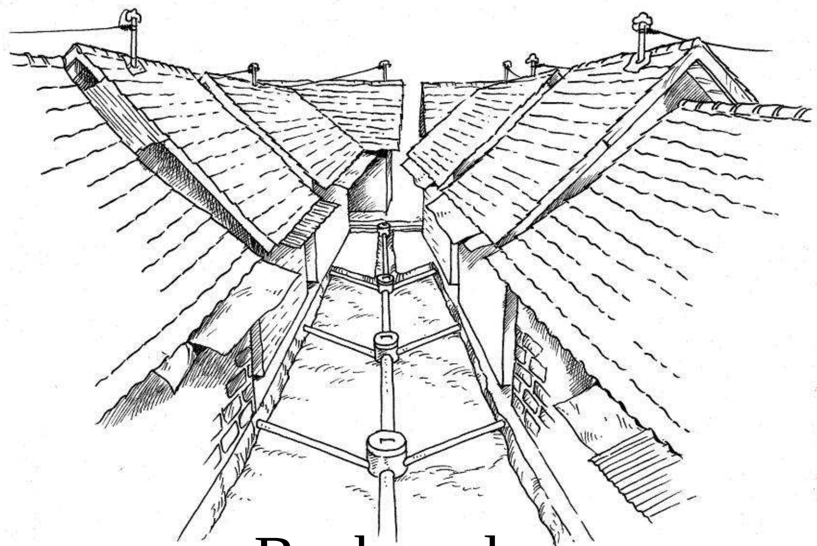
- **Expensive if newly built**
- **Service provider or efficient community organization required for maintenance work**
- **Blockages due to silting and solid waste disposal**
- **System can become potential public health hazard faeces are discharged in drains without any pre-treatment**

Shallow Sewerage

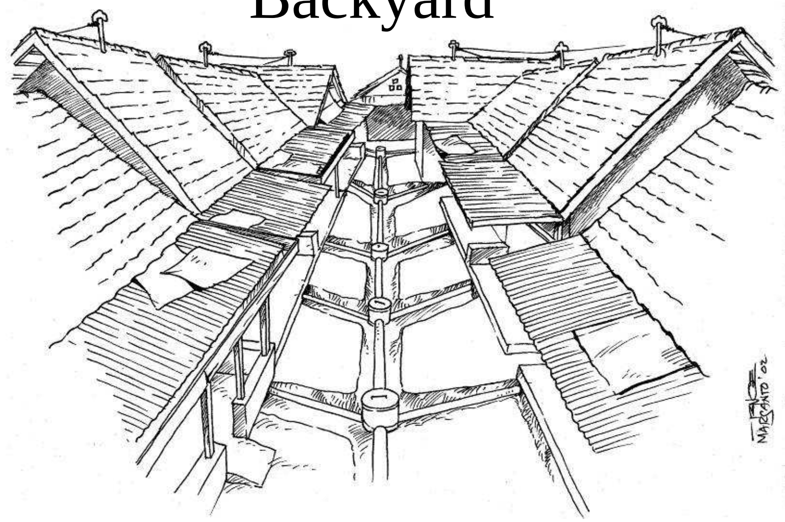
Condominial gravity sewerage

Description:

Condominial sewerage is usually based on a PVC piping sytem. The minimum diameter of the system is 100 mm. Pipes are usually laid at a flat gradient and routed through private land either through front-yards, back-yards (in-block) or sidewalks. Therefore, the required tyre load capacity can be less compared to in-road construction. Consequently, it is possible to lay the pipes at a shallow depth. For backyard and frontyard systems a minimum cover of 20 cm is necessary. A sidewalk system cover should be 40 cm. Another advantage of backyard sewers is the reduced piping length, thus reduced cost. Further, shallow condominial sewerage do not require large expensive manholes. Simple inspection chambers (each 20 m) and junction boxes at sewer connection points are usually sufficient.



Backyard



Front Yard

Condominial gravity sewer

Capacity: As collection system suitable for neighbourhoods, communities and cities if high connection rate can be achieved.

Costs: Medium investment costs due to “minimal design”. Cost reduction depends on ability to cut technical input such as size of pipes and trenches and control/inspection chambers; high connection rate required; permanent staff to be employed for cleaning/maintaining collection system;

Self-help compatibility: As lay-out of sewerage network needs approval all residents, extensive planning needed; Construction design and supervision requires expert; construction and maintenance work can be done by semi/un-skilled labourers. Users should understand and support the system to avoid clogging.

Operation & Maintenance: Private/public service provider or efficient community institution needed to clean and maintain collection component; instant removal of blockages, regular cleaning/desludging of inspection chambers required.

Replication potential: Required elevation, pipe diameters and depths are partly standardized; materials required readily available; service organisation required for operation and maintenance; system can be up-graded

Reliability: Reliable. however, drastic cost saving measures could cause the system to be prone to clogging.

Convenience: Convenient, as foul wastewaters are carried away from residential areas. Ad hoc service & maintenance approach might lead to total system failure

PRO:

- **Huge cost savings compared to conventional sewerage system**
- **Community able to actively participate during planning and construction**
- **Underground pipe system provides effective sanitation barrier**
- **Convenient for user as foul waters are carried away from residential areas**

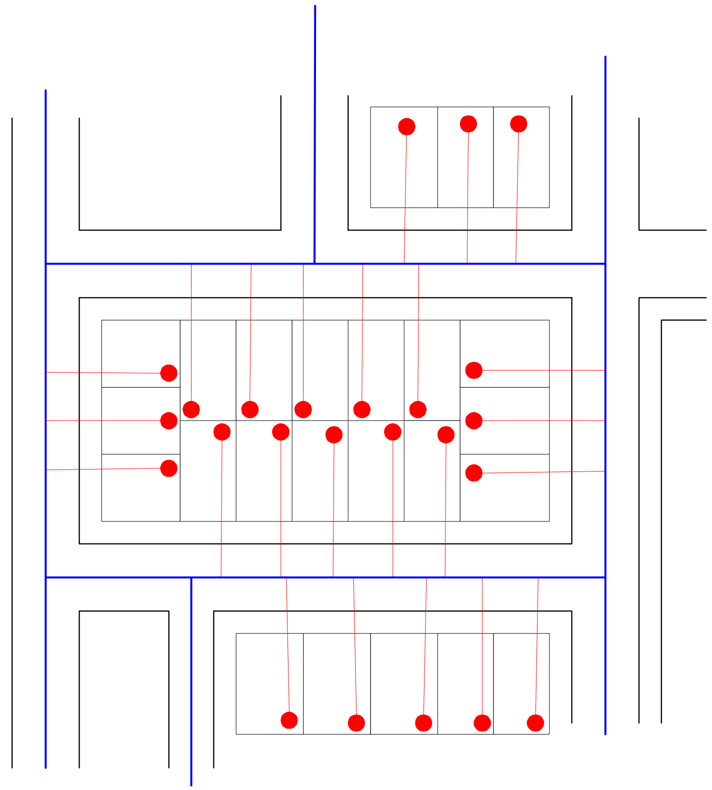
CONTRA:

- **Intensive planning phase required**
- **Effective and efficient operation & maintenance institutions required**
- **Faulty use of system combined with ad-hoc maintenance approach can lead to total system failure**

Simplified gravity sewerage

Description:

Simplified sewerage works like conventional sewerage. Domestic wastewater flows in a system of underground pipes, located under streets and lanes, to a treatment facility. Pipes are usually made from plastic or concrete. Design criteria for construction are far less typical compared to a conventional sewerage. Pipes diameter are smaller, the pipes are usually laid at a flatter gradient and a shallow depth. The system can also be equipped with less inspection manholes. Design criteria are selected to just comply with minimum hydraulic requirements. As a result of costs are saved but there is an increased probability of malfunction.



Simplified gravity sewerage

Capacity: Like condominial collection system, suitable for neighbourhoods, communities and cities if high connection rate can be achieved.

Costs: Cost savings are possible through the "minimal design" compared to a conventional system. Cost reduction depends on ability to cut technical input. As excavation work carried out on public roads, costlier than condominial system

Self-help compatibility: Design and regular supervision of sewerage network needs to done by expert staff; all construction and maintenance work can be done by semi/un-skilled labourers. Users should understand and support the system to minimise malfunction.

Operation & Maintenance: Private/public service provider or efficient community institution needed pre-condition for maintenance; instant removal of blockages, regular cleaning/desludging of inspection chambers required.

Replication potential: Required elevation, pipe diameters and depths are partly standardized. All materials required readily available.Professional service organisation required for operation and maintenance. System can be up-graded and extended.

Reliability: Reliable. however, drastic cost saving measures and inflow of solids could cause system clogging.

Convenience: Convenient, as foul wastewaters are carried away from residential areas. Ad hoc service & maintenance approach might lead to total system failure

PRO:

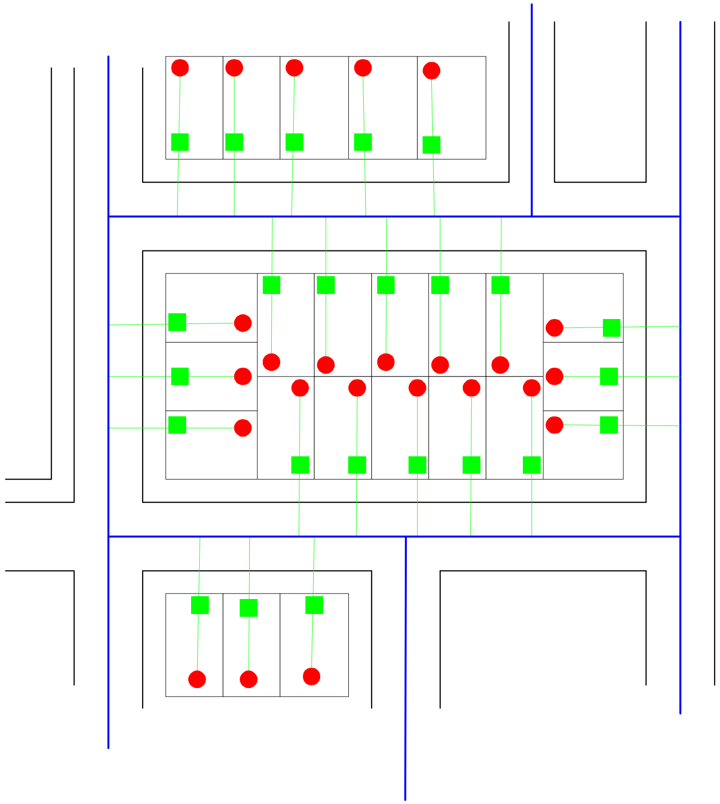
- **Cost savings compared to conventional sewerage system**
- **Community able to actively participate during planning and construction**
- **Underground pipe system provides effective sanitation barrier**
- **Convenient for user as foul waters are carried away from residential areas**

CONTRA:

- **Intensive planning phase required**
- **As sewerage system constructed under public roads/lanes, high cost for excavation**
- **System needs to be planned by experts**
- **Effective and efficient operation & maintenance required**
- **Faulty use of system combined with ad-hoc maintenance approach can lead to total system failure**

Settled sewerage

Description:



The system receives the effluent from individual or shared household septic tanks. Hence, coarse solids are removed and only the liquid part of sewage enters the sewerage system. In principle, the design of settled sewerage is similar to that of condominial/simplified gravity sewerage. However, since no self-cleansing flow-velocity is required, pipes with smaller diameter can be laid at much flatter gradients. Contrary to simplified sewerage systems, clogging and blockage of pipes is very unlikely due to pre-treatment in STs, effectively reducing maintenance work of the piping system. Design and layout of piping network can be easily adapted to local settlement structure and requirements.

Settled sewerage

Capacity: Suitable for densely populated urban settlements; minimum number of connections required; earthwork in public areas required

Costs: Low-medium investment costs if high population density and high number of connections, settling tanks exist or 3 to 4 households share one settler. Construction cost reduced if pipe diameters (3-4''), pipe depths (50 cm) and septic-tank volumes are minimized; operation and maintenance requires regular desludging of settlers and inspection of pipe system

Self-help compatibility: Design and regular construction supervision of sewerage network needs to done by expert staff; all construction and maintenance work can be done by semi/un-skilled labourers. Users should understand and support the system to minimise malfunction.

Operation & Maintenance: Regular desludging of settlers required; risk of blockage and clogging minimized

Reapplication potential: Required elevation gradients, pipe diameters and depths are partly standardized. All materials required readily available. System can be up-graded and extended.

Reliability: Reliable through pre-treatment. Effectiveness of settled sewerage reduced if settlers not cleaned/desludged regularly and if coarse materials (silt, sand) enter pipe system.

Convenience: Reduction of foul solids as well as BOD. Piping system acts effectively as sanitation barrier

PRO:

- **Suitable for densely populated settlements**
- **Low operation & maintenance costs**
- **Efficient wastewater pre-treatment**
- **Save and reliable system**
- **Sewerage piping provides effective sanitation barrier**

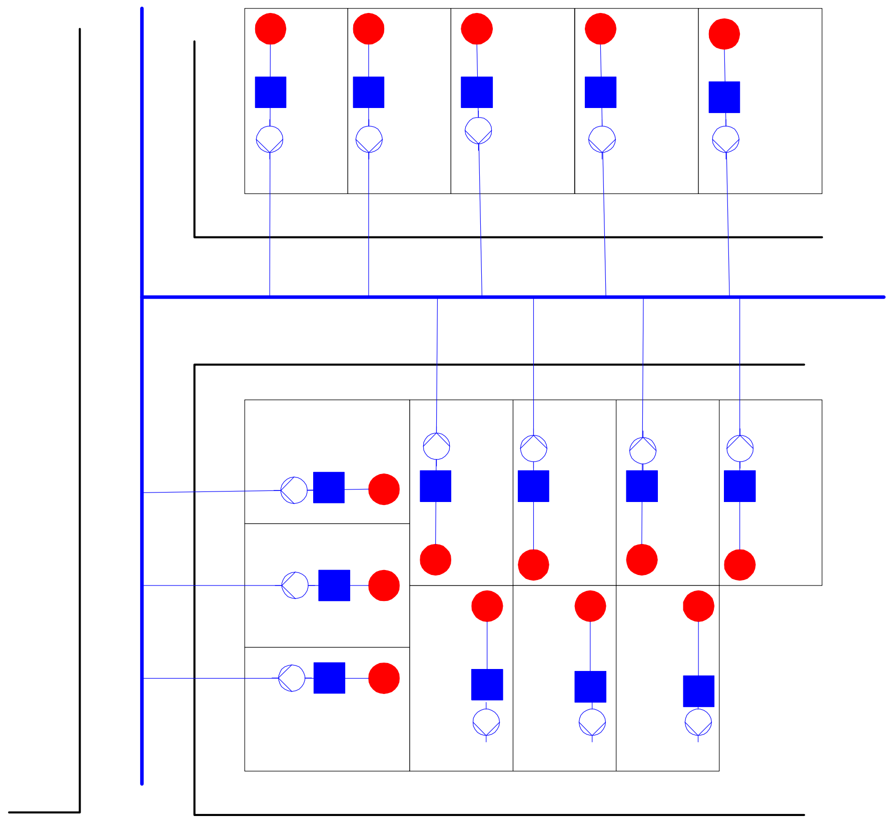
CONTRA:

- **Costly if septic tanks not shared by households**
- **High connection-rate required to reduce costs**
- **Permission of authorities needed if piping system constructed in public areas**
- **Operation & maintenance requires well organized community self-help institutions**
- **Expert design and supervision required**

Settled pumped sewerage

Description:

The system receives the effluent from individual septic tanks, where most settable solids are removed, therefore only the liquid part of sewage enters the sewer system. In principle, the design of settled pumped sewerage systems is similar to that of settled sewerage systems with exception that effluent from septic tanks or interceptors due to unfavourable elevation has to be pumped into the main sewer system. Since only settled sewage enters the sewerage system, pipes with smaller diameter can be laid at much flat gradients. Contrary to condominial and simplified sewerage, clogging is very unlikely. Permanent electricity supply and professional maintenance services are required for sustainable operation.



Settled pumped sewerage

Capacity: Suitable for densely populated, mountainous urban settlements; minimum number of connections required; earthwork in public areas required

Costs: Due to pumpsets and electricity, higher investment, operation and maintenance costs compared to settled sewerage collection system; regular desludging and inspection of pipe systems required;

Self-help compatibility: Design and construction supervision of sewerage network requires expert staff; skilled staff needed for construction (pumps) as well as maintenance work (pumps); users should understand and support the system to minimise malfunction.

Operation & Maintenance: Regular desludging of settlers required; risk of blockage and clogging minimized; power cuts and pump failure leads to system breakdown

Replication potential: Required elevation gradients, pipe diameters and depths are partly standardized. All materials required readily available. System can be up-graded and extended.

Reliability: Reliable, if professional service and maintenance organization responsible for operation

Convenience & efficiency: Reduction of solids as well as BOD (40%)

Reliability: Reliable through pre-treatment. Effectiveness of settled sewerage reduced if settlers not cleaned/desludged regularly , coarse materials (silt, sand) enter pipe system and if pumps break down.

Convenience: Reduction of foul solids as well as BOD. Piping system acts effectively as sanitation barrier

PRO:

- **Suitable for densely populated hilly settlements**
- **Efficient wastewater pre-treatment**
- **Sewerage piping provides effective sanitation barrier**

CONTRA:

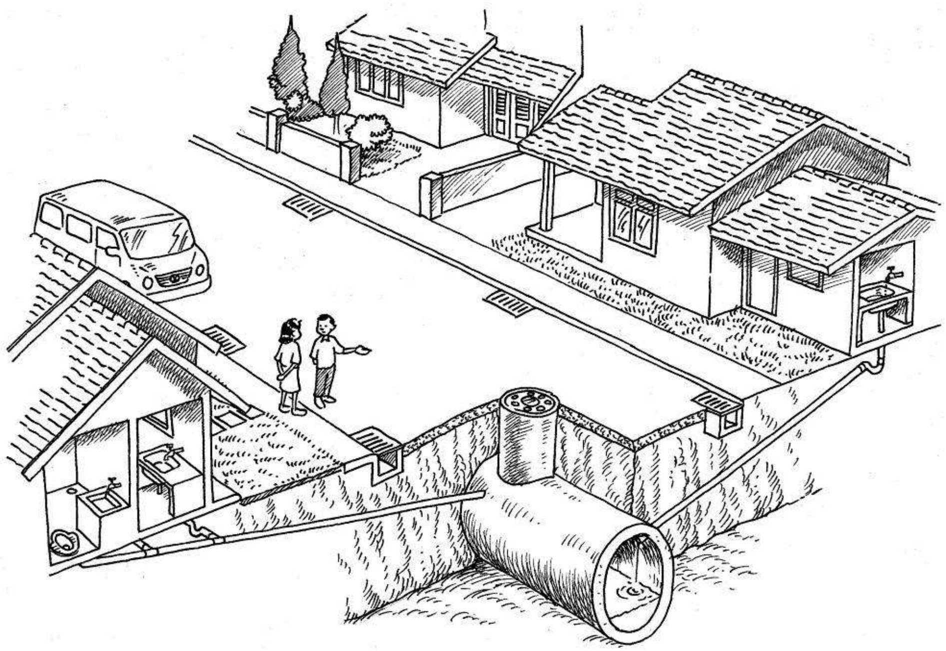
- **Costly if septic tanks not shared by households**
- **High operation & maintenance costs**
- **High connection-rate required to reduce costs**
- **Permission of authorities needed if piping system constructed in public areas**
- **Operation and maintenance requires professional service provider**
- **Expert design and supervision required**

Conventional Sewerage

Conventional gravity sewerage

Description:

Domestic wastewater flows in a system of concrete pipes to a treatment facility. The minimum diameter of a conventional system is usually 200 mm (D) to allow cleaning of the system. A minimum velocity of 0,5 m/s is necessary to avoid solids deposit. The maximum velocity should not exceed 6 - 8 m/s. The necessary gradient of the pipes depends mainly on the diameter. In a first step the gradient (I_S) can be estimated through the equation I_S=1/ D. A sewerage consists of house connections to a reticulation sewer system which is usually built as an in-road sewer. The sewerage is equipped with inspection manholes at least each 70 m. In Europe pipes are usually laid in a depth of 1,5 – 2,0 m to guarantee load rating suitable for normal traffic as well as for protection against frost.



Conventional gravity sewerage

Capacity: Usually applied to drain-off domestic wastewater in urban areas with high population density to a central treatment facility. Not implemented on neighbourhood or community levels.

Costs: High investment costs due to large-scale design;

Self-help compatibility: Planning, construction as well as operation and maintenance have to be carried out by experts and professional service providers.

Operation & Maintenance: Professional public/private service providers required

Replication potential: Designs and materials readily available; system can be implemented on a professional basis by experts only; System can be up-graded and connected to central treatment facility

Reliability: Reliable due to large-scale design if proper designed and operated

Convinience: Convenient

PRO:

- **Highly reliable**
- **Convenient**

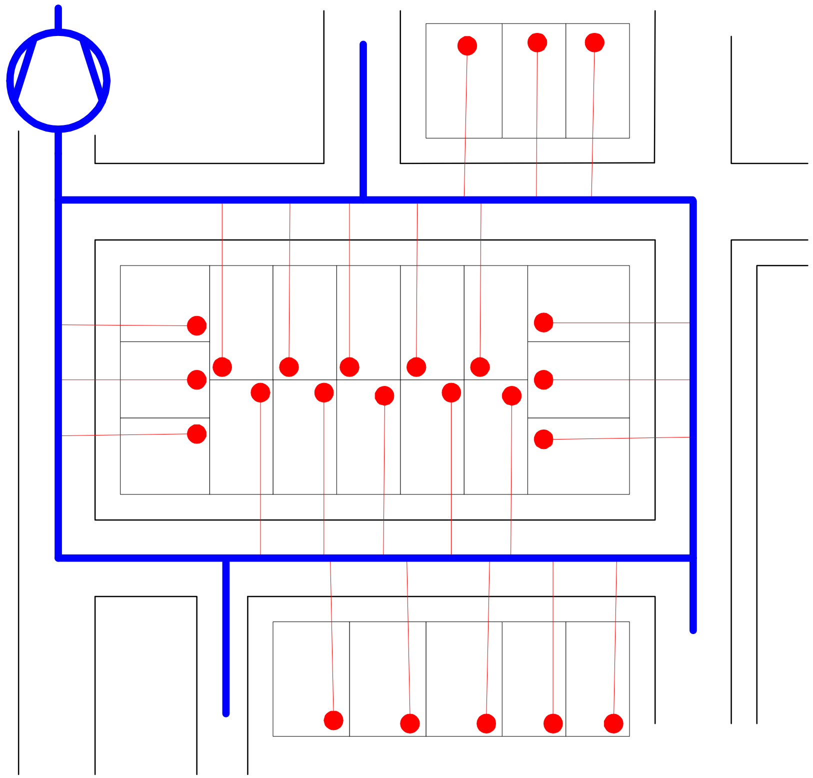
CONTRA:

- **Not suitable for application on community level**
- **Very high investment cost, due to large-scale design**

Vacuum sewerage

Description:

Vacuum sewers are made of a pipe network consisting of high-grade plastic pipes. The wastewater flow is not caused by gravity but by vacuum generated through pumps. The advantages of the system are: small pipe diameters, laying pipes at no gradients and at shallow depth. On the other hand the system is expensive, and high sophisticated.



Vacuum sewerage

Capacity: Usually applied to drain-off domestic wastewater to a treatment facility in urban areas where topography is unfavourable. Not implemented on neighbourhood level

Costs: Due to use of sophisticated technology (e.g. air-tight pipes, powerful compressors) very high investment costs; high operation and maintenance costs

Self-help compatibility: System implementation by specialized contractors only; operation and maintenance has to be carried out by highly skilled professional service providers

Operation & Maintenance: Only by highly skilled professional service providers

Replication potential: Little self help potential System is usually implemented on a professional basis by experts.

Reliability: Prone to clogging if charged with coarse materials.

Convenience: Convenient

PRO:

- **Suitable for densely populated hilly settlements**
- **Convenient**

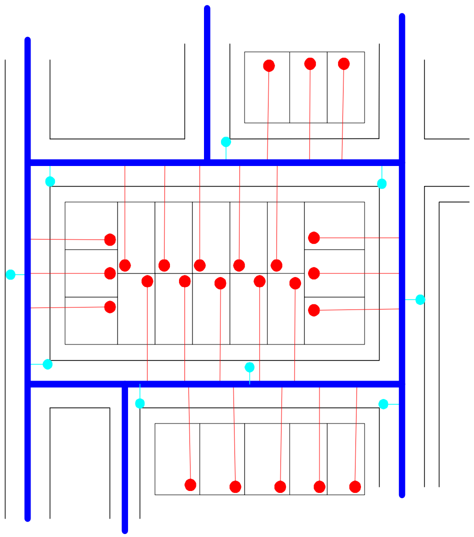
CONTRA:

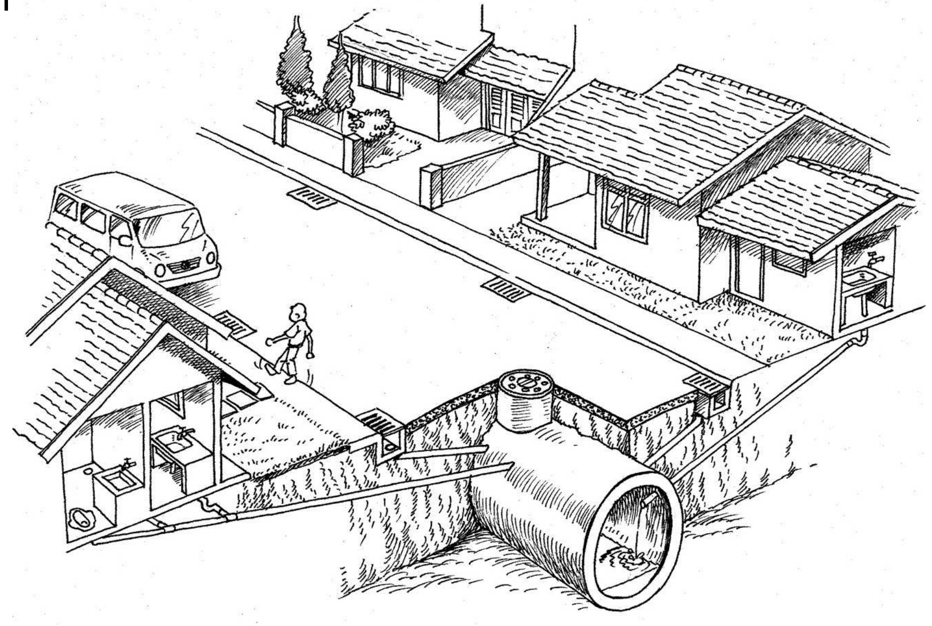
- **Not suitable for application on community level**
- **Very high investment, operation and maintenance costs**
- **Coarse materials can lead to blockage of collection system**
- **Construction as well as operation and maintenance require expert contractors and professional service providers**

Combined gravity sewerage

Description:

Domestic wastewater is drained-off together with rainwater in a system of underground concrete pipes to a treatment facility. Compared to a conventional sewerage,, much bigger pipe diameters are required for the mixed flow. The diameter of a combined system is in the range of 300 until 1.200 mm (D). Flow velocity is usually between 0,5 and 8 m/s. The necessary gradient (I_S) can be estimated through the equation I_S=1/D. The combined sewer consists of house connections to a reticulation sewer system and inspection manholes at least each 70 m. Further inlets for rainwater from roof and street run-off are necessary. The sewerage is usually build as an in-road system. In Europe, pipes are usually laid in a depth of 1,5 – 2,0 m





Combined gravity sewerage

Capacity: Usually applied to drain-off mixed flows in urban areas with high population density. Reapplication potential usually limited to areas with moderate precipitation.Not implemented on neighbourhood level

Costs: The design is determined through the peak flow during precipitation, e.g. investment costs higher than for conventional sewerage collection

Self-help compatibility: No self-help potential. Operation and maintenance have to be carried out by experts.

Operation & Maintenance: Professional public/private service providers required

Replication potential: Construction materials readily available. System can be implemented on a professional basis only. System needs to be connected to central treatment facility

Reliability: Usually reliable, but during unexpected strong precipitation overload can occur which may lead to public health or environmental hazards

Convenience: Convenient

PRO:

- **Convenient**

CONTRA:

- **Not suitable for application on community level**
- **Very high investment costs because of large-scale design**
- **The capacity of an attached treatment unit is determined by the peak of flow during precipitation. Therefore, big units are required.**
- **Only applicable in areas with moderate precipitation**
- **Only applicable on a professional level**

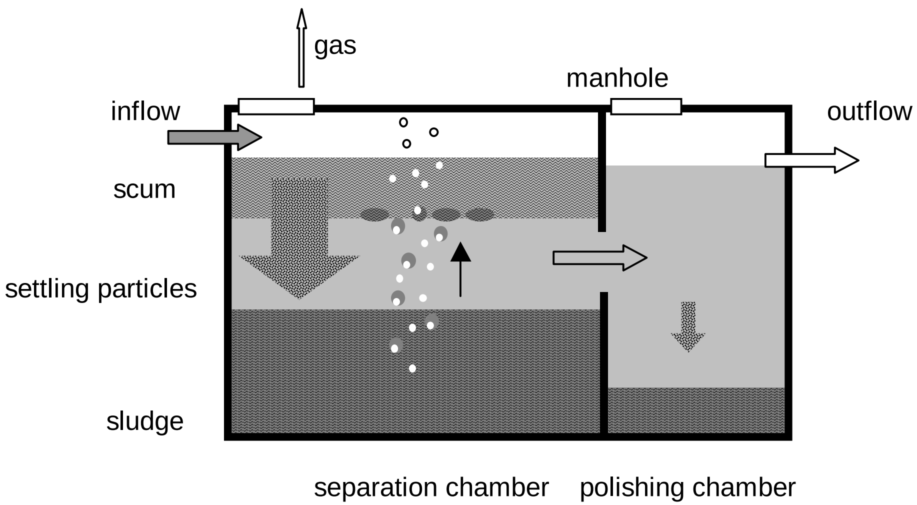
TREATMENT SYSTEMS

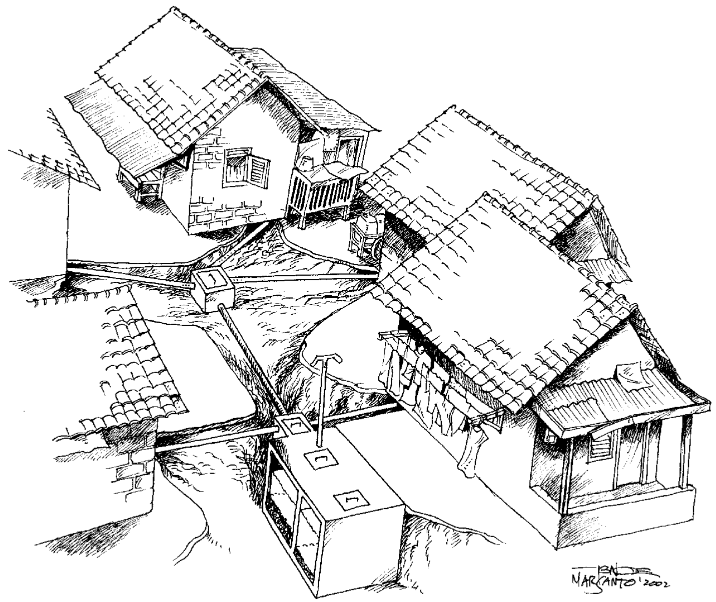
Main Treatment Systems

Community septic tank

Description:

Different designs are applied for septic tanks. It can be distinguished between single compartment septic tanks (aqua privy) and multiple compartment septic tanks. Wastewater flows through a submerged inflow-pipe into a watertight tank, which is located underground. Within the tank two main treatment processes take place. First, solids are removed from the sewage by either settling (heavy particles) or by flotation (e.g. oils and fats). The wastewater from the clarified layer flows to the outlet. The remaining organic pollutants are decomposed by micro-organisms. Through the digestion process an excessive accumulation of sludge can be avoided. However, regular annual desludging of septic tanks is recommended





Community septic tank

Capacity: Large scale septic tanks provide minimum wastewater treatment facilities for household influents. Due to the underground construction, land use is very limited. STs can be constructed under roads or other public areas.

Costs: Construction costs are low; Manual or vacuum desludging required periodically.

Self-help compatibility: Design and lay-out prepared by CE. Construction can be carried out by semi/unskilled labourers; supervision by mason needed; manual desludging can be carried out by communities

Operation & Maintenance: O & M activities consist of desludging and removal of floating debris such as coarse materials and grease; regular O & M activities require well-organized community organization or public/private service provider.

Replication potential: Standardized designs and SOPs available for different sizes of STs; all required construction materials are readily available; variety of number of collection treatment and disposal options can be linked to ST.

Reliability: Reliable, if desluging carried out routinely; ST is resistant against shock-loads

Efficiency: Reduction of BOD about 30 - 40 %; very moderate reduction of infectious organisms;

PRO:

- Suitable for small settlements and house clusters
- Little space required due to underground construction
- Very low investment costs
- Very low operation and maintenance costs
- No experts required for construction
- Standarized designs and SOPs available
- Simple operation and maintenance

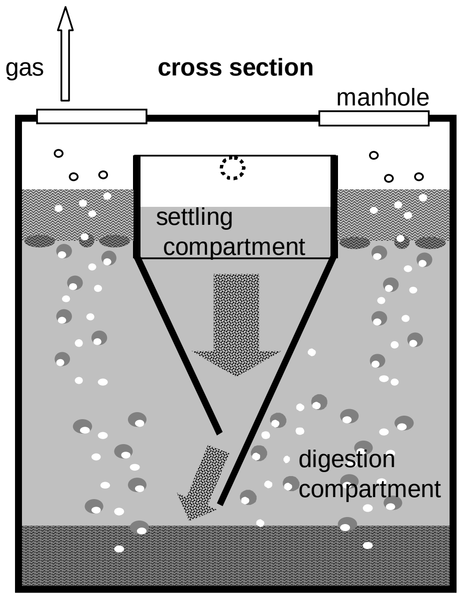
CONTRA:

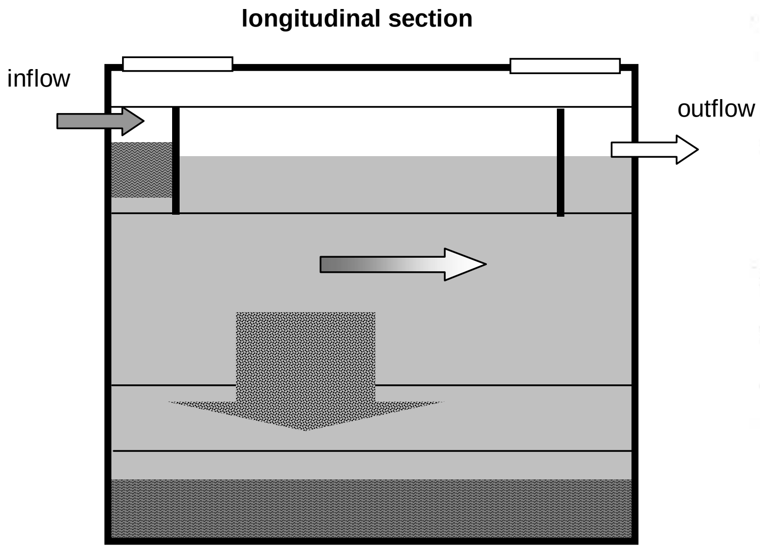
- Very low treatment efficiency
- Additional treatment might be needed
- Inefficient treatment option if not regularly desludged

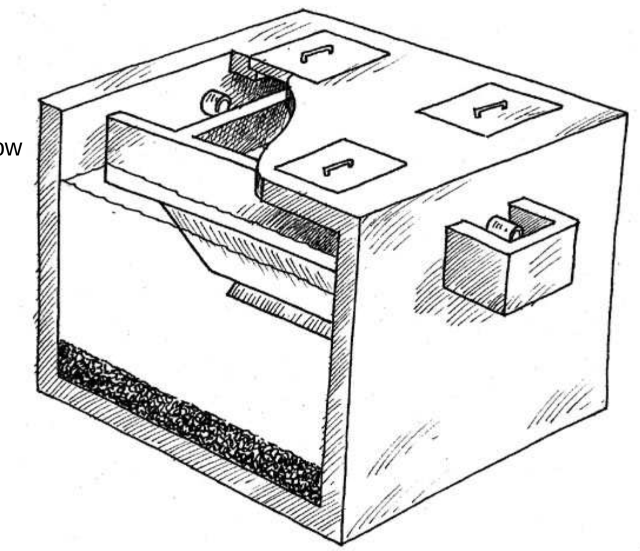
Imhoff tank

Description:

Imhoff-tanks work similar to communal septic tanks. Very effective sedimentation of solids occurs in the upper settling compartments. Sludge sinks through the slot to the bottom of the settling compartment into the lower tank, where it is decomposed. This process generates biogas which, is deflected by the baffles to the gas vent channels to prevent it from disturbing the settling process.







Imhoff tank

Capacity: Imhoff tanks provide minimum wastewater treatment facilities for household influents. Sedimentation of coarse particles is very effective. Due to the underground construction, land use is very limited. An Imhoff tank can be constructed under roads or other public areas.

Costs: Construction costs are slightly higher than ST; Manual or vacuum desludging required more often than for ST

Self-help compatibility: Design and lay-out prepared by CE. Construction can be carried out local craftsmen; supervision by CE needed; manual desludging can be carried out by communities

Operation & Maintenance: O & M activities consist of desludging and removal of floating debris such as coarse materials and grease; regular O & M activities require well-organized community organization or public/private service provider

Replication potential: Standardized designs and SOPs available for different sizes of ITs; all required construction materials are readily available; variety of number of collection treatment and disposal options can linked to ST.

Reliability: Reliable if desluging carried out routinely; IT is resistant against shock-loads

Efficiency: Reduction of BOD about 30 - 40 %; very moderate reduction of infectious organisms;

PRO:

- **Suitable for small settlements and house clusters**
- **Little space required due to underground construction**
- **Low investment costs**
- **Very low operation and maintenance costs**
- **Standarized designs and SOPs available**
- **Simple operation and maintenance**
- **Efficient sedimentation of coarse particles**

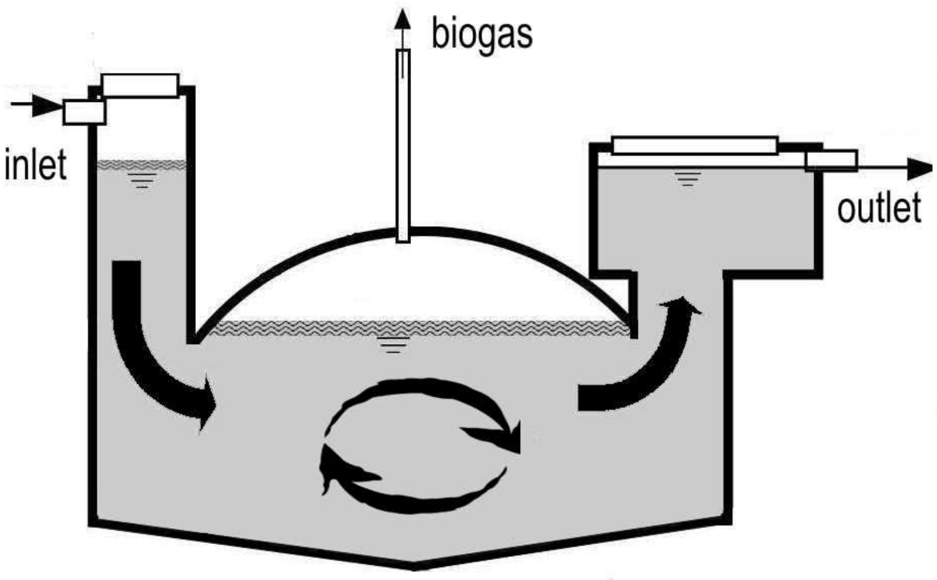
CONTRA:

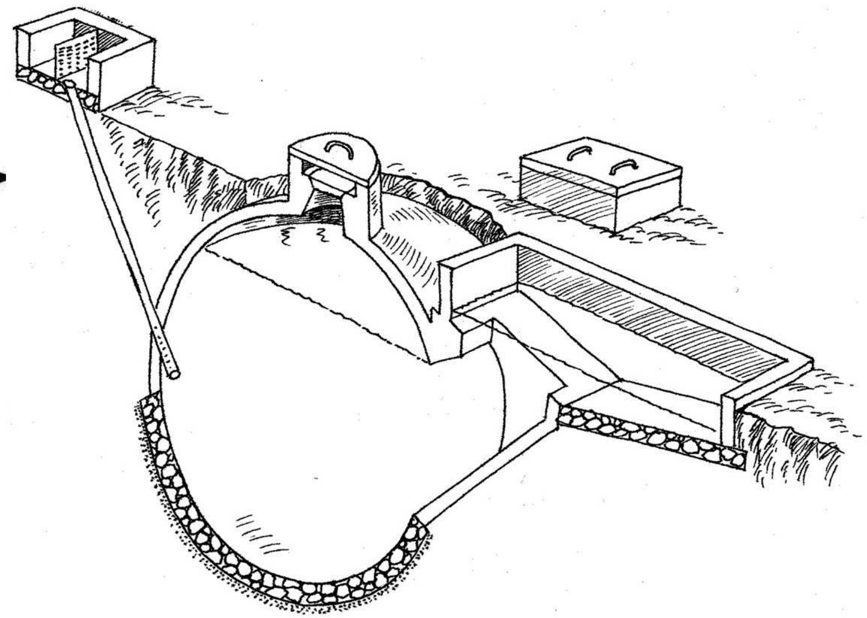
- **Very low treatment efficiency**
- **Short desludging intervals**
- **Additional treatment might be needed**
- **Inefficient treatment option if not regularly desludged**

Anaerobic reactor, fully mixed

Description:

The fixed-dome, fully mixed anaerobic reactor is mainly used for digestion of highly loaded organic wastewater. Usually solids are not separated through settling so de-sludging is only rarely required. Recommended retention time lies between 15 and 30 days. The effluent is still high loaded but partly disinfected and odourless. Efficient treatment of low loaded wastewater is difficult with the technique therefore it is mainly applied for blackwater and highly polluted organic wastewater from home industries located in urban settlements. The dome shaped reactor must be plastered gas tight.





Anaerobic reactor, fully mixed

Capacity: System is applied as pre-treatment for highly loaded organic wastewater and for black-water with BOD contents of up to 10000 mg/l. Digester volumes of up to 150 cbm allow inflows of up to 10 cbm/day. Underground construction minimizes land use

Costs: Construction costs are low; only locally available materials required; utensils for gas use locally available; no moving parts and technical energy required; no de-sludgeing required due to baffle-less design and principle of continuous flow; cleansing of gas utensils necessary

Self-help compatibility: Design and supervision of BG reactor needs to carried out by expert staff; gas-tight plaster and brick work require experienced masons;

Operation & Maintenance: Coarse and fibrous materials need to be removed from inflow screen; clay seal of lid has to be in water all times; well-organized community group required

Replication potential: Standardized designs and SOPs available for different sizes of ABR. All required construction materials are readily available. A number of treatment options can be directly connected to the fully mixed reactor.

Reliability: Reliable if construction is gas-tight; reactor is resistant against shock-loads

Efficiency: Reduction of BOD about 50-60 %; high retention time reduces infectious organisms effectively; effluent is nearly odourless as methan gas is extracted;

PRO:

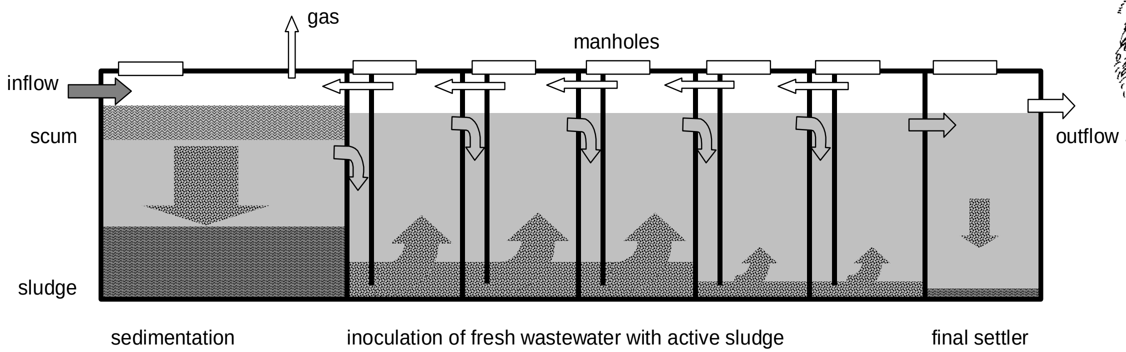
- **Effective, low-cost pre treatment for highly polluted organic wastewater**
- **Low construction and maintenance costs**
- **Limited space requirement**
- **Effluent nearly odo urless**
- **Additional benefits through biogas utilization**

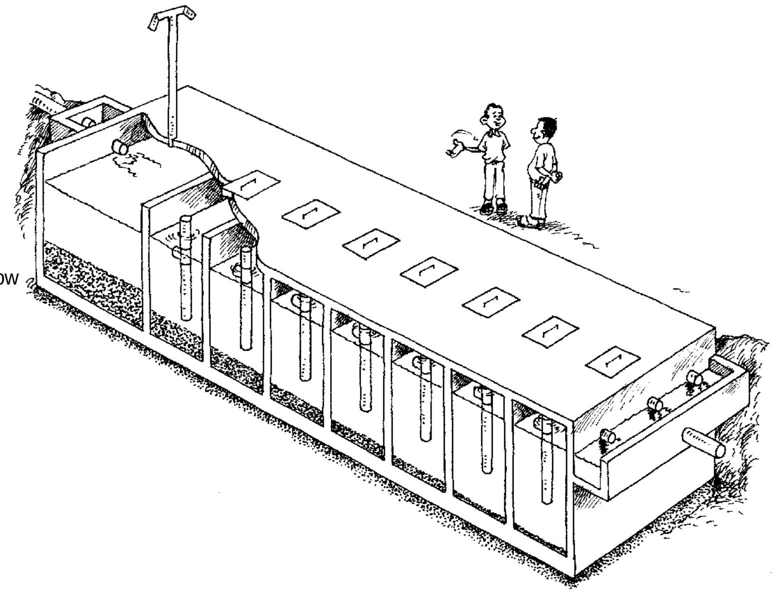
CONTRA:

- **Pre-treatment solution for highly polluted organic wastewater only**
- **Expert staff required for design, supervision and construction**

Anaerobic baffled reactor

Description: In baffled reactors, a number of mechanical and anaerobic cleansing processes are applied in sequence: The reactor consists of different chambers (connected in series) in which the wastewater flows up-stream. On the bottom of each chamber activated sludge is located. During inflow into the chamber wastewater is intensively mixed up with the sludge and wastewater pollutants are decomposed. In the first chambers the easily degradable substances are removed. In the following chambers, substances which are more hard to degrade are removed. The more chambers are applied the higher the performance. The design shown below includes an integrated sedimentation chamber for pre-treatment.





Evaluation Sheet

Anaerobic baffled reactor

Capacity: The ABR treatment component can be efficiently designed for a daily inflow of up to 1000 qbm community WW. Due to the underground construction, land use is very limited. An ABR can be constructed under roads or other public areas.

Costs: Construction costs are low, no filter materials required Neither moving parts nor technical energy needed for operation of ABR. Manual or vacuum desludging required annually.

Self-help compatibility: Design and supervision of ABR treatment component needs to carried out by expert staff; foundation and plastering work should be done by experienced masons (water tightness); large part of the construction work can be carried out by semi/un-skilled labourers; manual desludging can be carried out by communities

Operation & Maintenance: O & M activities consist of desludging and removal of accumulated floating debris such as coarse materials and grease from the sedimentation chamber; regular O & M activities require well-organized community organization or public/private service provider

Replication potential: Standardized designs and SOPs available for different sizes of ABR. All required construction materials are readily available. A number of post-treatment options can be added to the ABR.

Reliability: Reliable if construction is water-tight, settler integrated as pre-treatment and desluging carried out; ABR is resistant against shock-loads

Efficiency: Reduction of BOD about 75 - 90 %; only moderate reduction of infectious organisms;

PRO:

- **Suitable for smaller an larger settlements**
- **Little space required due to underground construction**
- **Low investment costs**
- **Very low operation and maintenance costs**
- **Standarized designs and SOPs available**
- **Simple operation and maintenance**
- **High treatment efficiency**

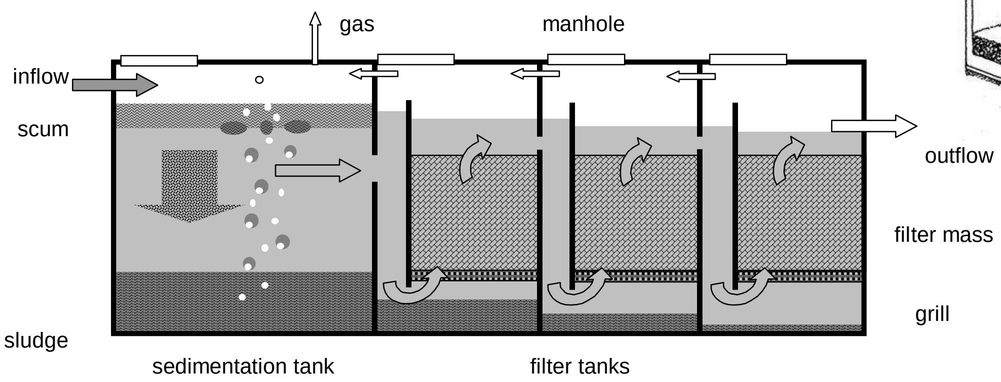
CONTRA:

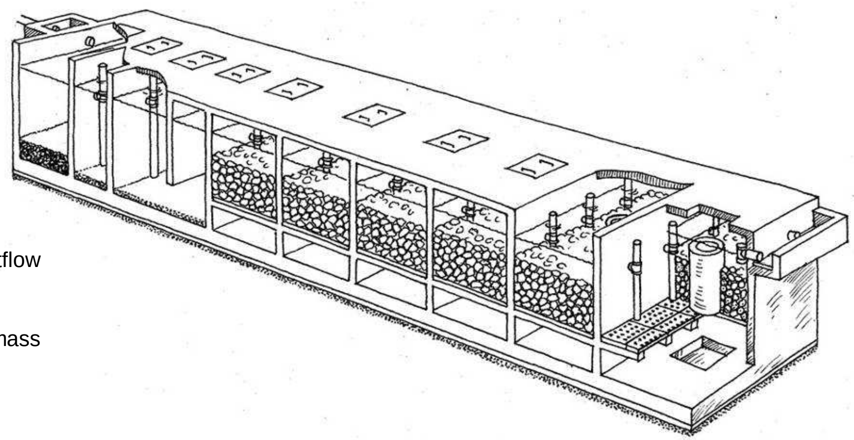
- **Experts required for design and supervision**
- **Master mason required for high-quality plastering work**
- **Well-organized CBO or service provider needed for O & M**

Anaerobic filter

Description:

Anaerobic filter reactors are fixed bed reactors. Biological cleansing processes rely on anaerobic organisms which settle on the surface of filter material and degrade inflowing organic wastewater pollutants. The system is operated continuously via upstream and downstream processes. Rocks, gravel, slag or plastic contact beds can be used as filter materials. To avoid plugging, pre-treatment through sedimentation is necessary. The system below already includes pre-treatment through an integrated sedimentation chamber where coarse solids are precipitated and partly digested.





Evaluation Sheet

Anaerobic filter

Capacity: The AF treatment component can be efficiently designed for a daily inflow of up to 1000 qbm community WW. Due to the underground construction, land use is very limited. AF can be constructed under roads or other public areas.

Costs: Construction costs are low in case filter materials are locally available; neither moving parts nor technical energy needed for operation of AF; manual or vacuum desludging required annually; back-washing of filter materials may be required every five to ten years.

Self-help compatibility: Design and supervision of AF treatment component needs to carried out by expert staff; foundation and plastering work should be done by experienced masons (water tightness); large part of the construction work can be carried out by semi/un-skilled labourers; manual desludging and back-washing of filter can be carried out by communities

Operation & Maintenance: O & M activities consist of desludging and removal of accumulated floating debris such as coarse materials and grease from the sedimentation chamber; regular O & M activities require well-organized community organization or public/private service provider

Replication potential: Standardized designs and SOPs available for different sizes of AF. All required construction materials are readily available. A number of post-treatment options can be added to the AF.

Reliability: Reliable, if construction is water-tight and includes integrated sedimentation; AF is resistant against shock-loads

Efficiency: Reduction of BOD about 75 - 90 %; only moderate reduction of infectious organisms;

PRO:

- **Suitable for smaller an larger settlements**
- **Little space required due to underground construction**
- **Low investment costs**
- **Very low operation and maintenance costs**
- **Standarized designs and SOPs available**
- **Simple operation and maintenance**
- **High treatment efficiency**

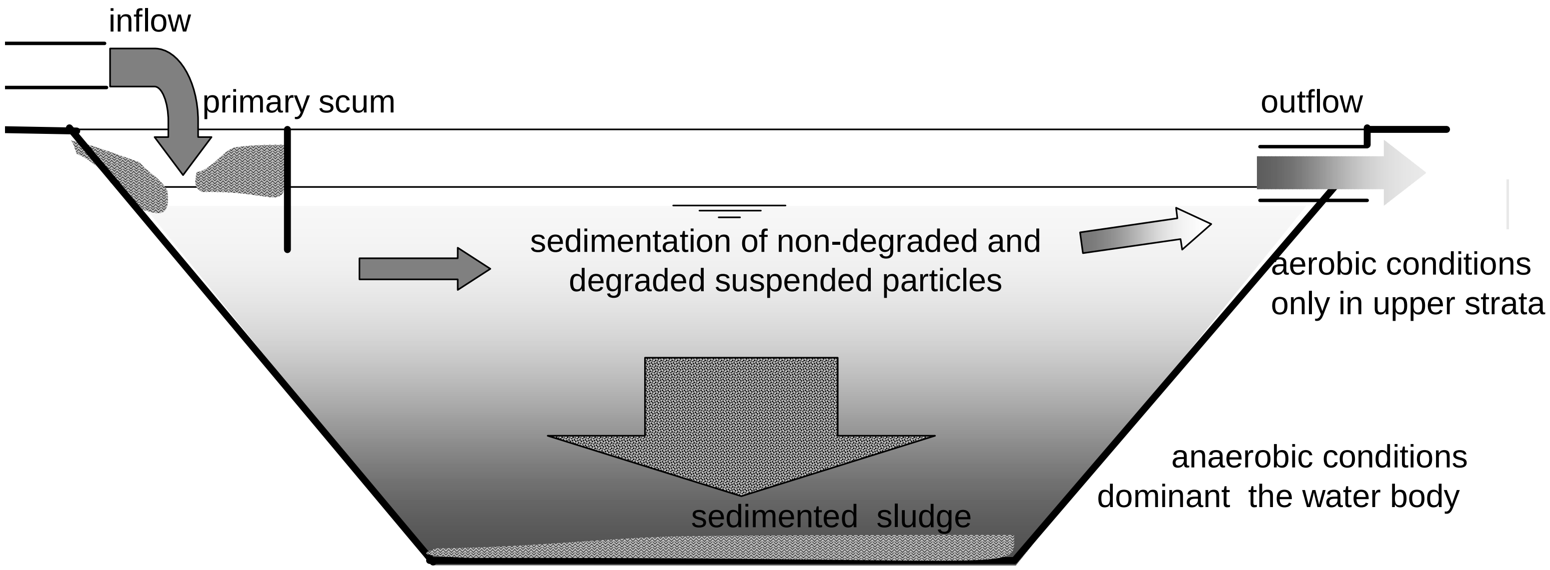
CONTRA:

- **Increased construction cost if filter materials not locally available**
- **Experts required for design and supervision**
- **Master mason required for high-quality plastering work**

Anaerobic lagoon

Description:

Anaerobic lagoons are extremely simple in construction, operation and maintenance. Decomposition processes are similar to the process in nature. The pond is made of 2,5 – 5 m deep earthen basin with an embankment slope of 1:3. Detention time of influent is about 20 – 30 days. An area of 1 - 3 m² is required for treatment of wastewater generated by one person. Dependent on the load, anaerobic ponds must be desludged regularly. It is quite common to use pond systems in series of two or three modules for a full scale treatment. Overload will deteriorate treatment process



Anaerobic lagoon

Capacity: The system is only suitable for communities in rural and suburban areas where space is available. Also suitable for strong loaded wastewater. Not usefull in urban settlements as overload cannot be ruled out

Costs: Investment costs are low where land prices are low. Operation and maintenance costs are very low.

Self-help compatibility: Design prepared by expert; construction can be carried out by unskilled labourers in case expert supervision is provided.

Operation & Maintenance: Floating debris has to be removed from surface and inlet regularly; for desludging, influent must be allowed to by-pass lagoon temporarily; efficient community organization or service provider required

Replication potential: High self help potential. System can only be implemented with the intensive co-operation of experts.

Reliability: Usually reliable; however, if system is overloaded or misused as garbage dump in urban areas, public health hazards arise

Efficiency: Low treatment efficiency. Reduction of BOD is about 50 %. Effluent still infectious.

PRO:

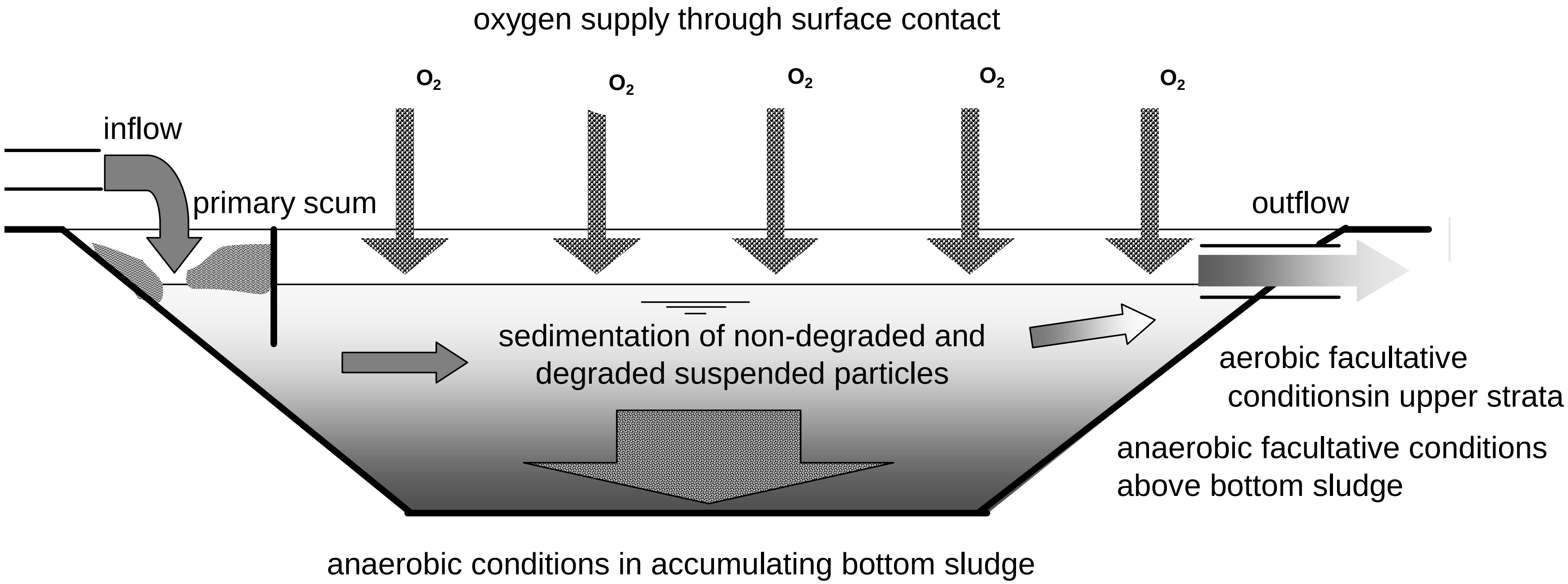
- **Low-cost system suitable for rural and semi-urban communities**
- **High community participation in construction and O & M possible**
- **Simple operation & maintenance**
- **Resistant against shock load and variable inflow volume**

CONTRA:

- **Only applicable where land is available and cheap**
- **Permanent overload leads to breakdown of biological cleansing processes**
- **Misuse of system leads to public health hazard**

Facultative lagoon

Description: Facultative lagoons are extremely simple in construction, operation and maintenance. Decomposition processes are similar to those occurring in the natural cycle. The pond is made of 1,2 – 2,4 m deep earthen basin with an embankment slope of 1:3. Detention time is about 5 – 10 d. An area of 2 until 4 m² is required for treatment of wastewater generated by one person. Dependent on the load, facultative ponds must be desludged regularly. More suitable for low loaded wastewater. For a higher treatment efficiency it is quite common to use pond systems in series of two or three modules for a full scale treatment.



Facultative lagoon

Capacity: The system is only suitable for communities in rural and suburban areas where space is available. Not suitable in densely populated urban areas. More suitable for low loaded wastewater.

Costs: Investment costs are low where land prices are low. Operation and maintenance costs are very low.

Self-help compatibility: Design prepared by expert; construction can be carried out by unskilled labourers in case expert supervision is provided.

Operation & Maintenance: Floating debris has to be removed from surface and inlet regularly; for desludging, influent must be allowed to by-pass lagoon temporarily; efficient community organization or service provider required

Replication potential: High self help potential. System can only be implemented through intensive co-operation with experts.

Reliability: Usually reliable if aerobic conditions in upper layer can be maintained; however, if system is overloaded or misused as garbage dump in urban areas, public health hazards arise

Efficiency: Effluent quality low until middle because of algae content. Reduction of BOD is about 60 - 75%.

PRO:

- **Low-cost system suitable for rural and semi-urban communities**
- **High community participation in construction and O & M possible**
- **Simple operation & maintenance**
- **Resistant against shock load and variable inflow volume**

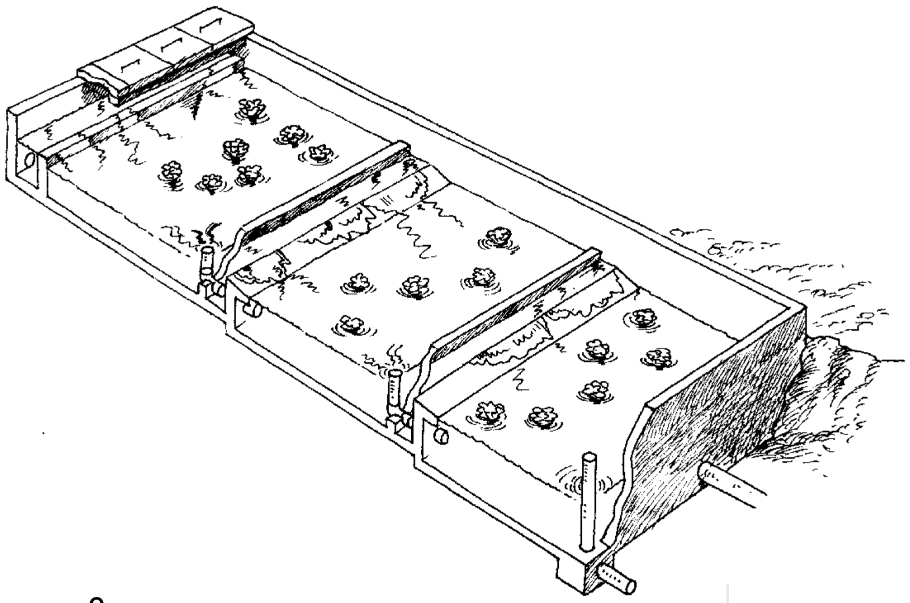
CONTRA:

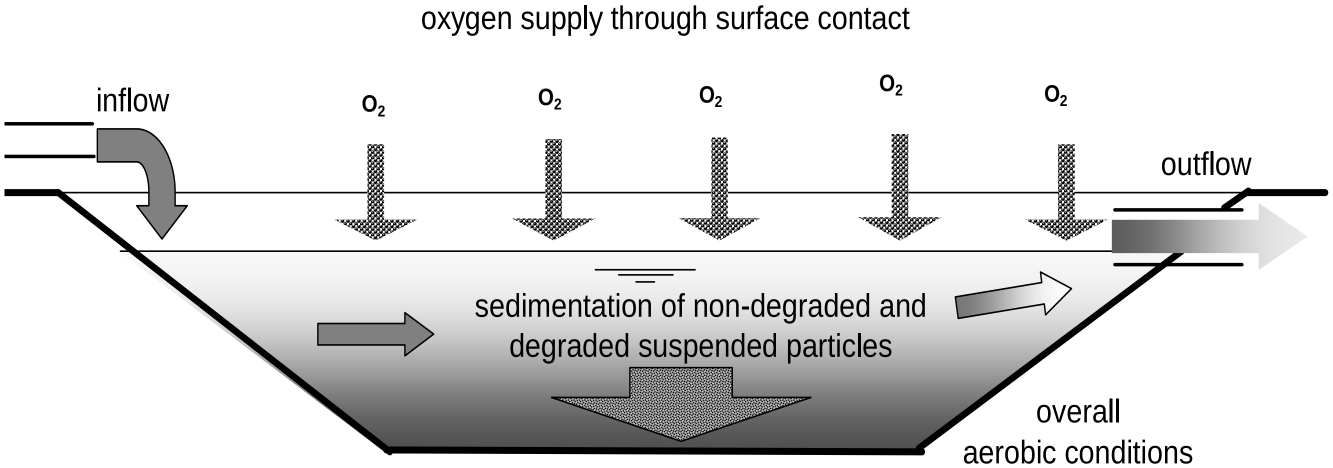
- **Only applicable where land is available and cheap**
- **Permanent overload leads to breakdown of biological cleansing processes**
- **Misuse of system leads to public health hazard**

Aerobic lagoon

Description:

Aerobic lagoons are extremely simple in construction, operation and maintenance. The lagoon is made of 1 – 1,2 m deep earthen basin with an embankment slope of 1:3. Decomposition processes are similar to processes in nature. Shallow basin and a high detention time (10 –15 d) results in high space requirements. An area of 3 until 7 m² is required for treatment of wastewater generated by one person. Dependent on the load, aerobic ponds must be desludged from time to time. The technique is only efficient for low loaded wastewater as sullage or for post-treatment of domestic wastewater It is quite common to use pond systems in series of two or three modules for a full scale treatment.





Aerobic lagoon

Capacity: The system is only suitable as main treatment system for communities in rural areas where space is available. In densely populated urban areas only suitable as post-treatment for low loaded wastewater.

Costs: Investment costs are low where land prices are low. Operation and maintenance costs are low.

Self-help compatibility: Design prepared by expert; construction can be carried out by unskilled labourers in case expert supervision is provided.

Operation & Maintenance: Floating debris has to be removed from surface and inlet regularly; for desludging, influent must be allowed to by-pass lagoon temporarily; efficient community organization or service provider required

Replication potential: High self help potential. System can only be implemented through intensive co-operation with experts.

Reliability: Usually reliable if aerobic conditions are maintained; however, overloaded or misuse of system as results of beak-down of cleansing processes and leads to public health hazards

PRO:

- **Low-cost treatment system for for rural communities**
- **High community participation in construction and O & M possible**
- **Simple operation & maintenance**

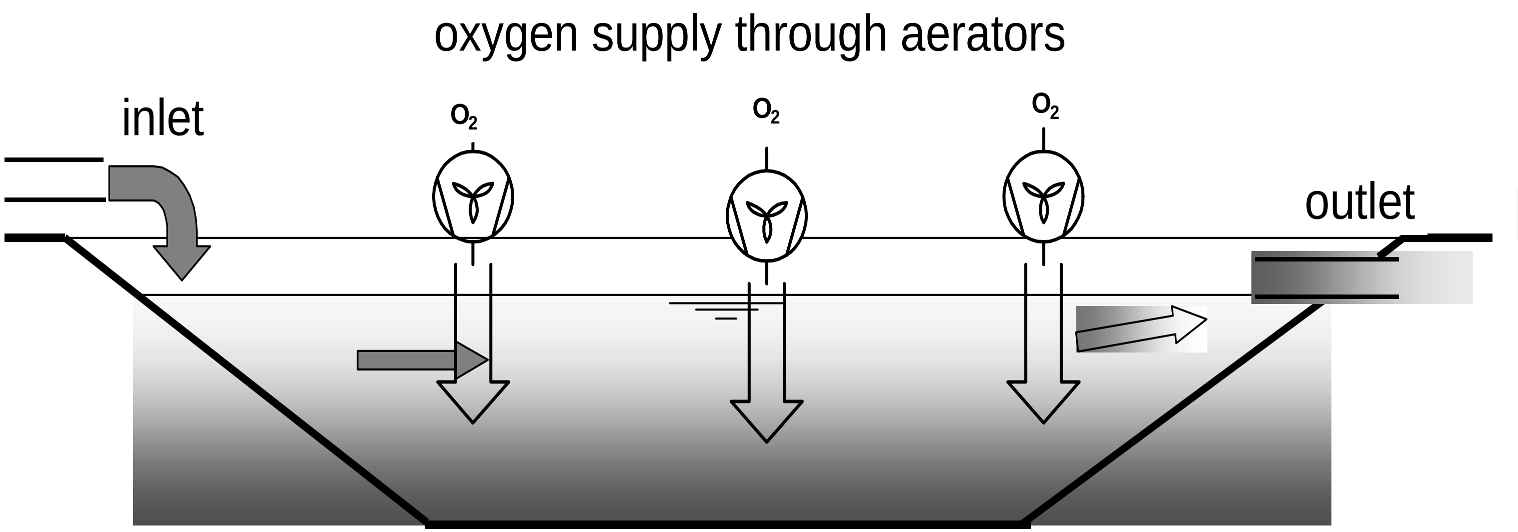
CONTRA:

- **System requires large space**
- **Only useful for low-loaded wastewater**
- **Permanent overload leads to breakdown of biological cleansing processes**
- **Misuse of system leads to public health hazard**

Aerated lagoon

Description:

Provided with mechanical aerators, aerated lagoons are the intermediate system between activated sludge process, and waste stabilization ponds. Aerated lagoons are more simple to operate than activated sludge units and more compact than stabilization ponds. Aeration supports the degradation of organic substances, helps mixing and also gives the possibility of process steering. Usually an attached settling tank or an integrated settling zone is necessary. The sludge from the settling facility has to be removed each 2 to 5 years. Spatial requirement is low with 0,3 – 0,5 m² per person.



Aerated lagoon

Capacity: The system can be used in urban areas for treatment of domestic wastewater. It can be applied for bigger and smaller communities.

Costs: Investment costs are moderate until high. But operation and maintenance is expensive due to high electricity and mechanical part replacement.

Self-help compatibility: Planning and construction supervision carried out by technical experts; community labour contribution during construction possible; permanent skilled staff required for operation

Operation & Maintenance: Floating debris has to be removed from surface and inlet regularly; long desludging intervals; professional service provider required for O & M activities

Replication potential: Materials and mechanical parts not locally available; Co-operation of experts is required for planning, implementation and operation

Reliability: Technique doesn't work in cases of power failure;

Efficiency: High treatment efficiency. Reduction of BOD and infective organisms is about 80 – 95 %.

PRO:

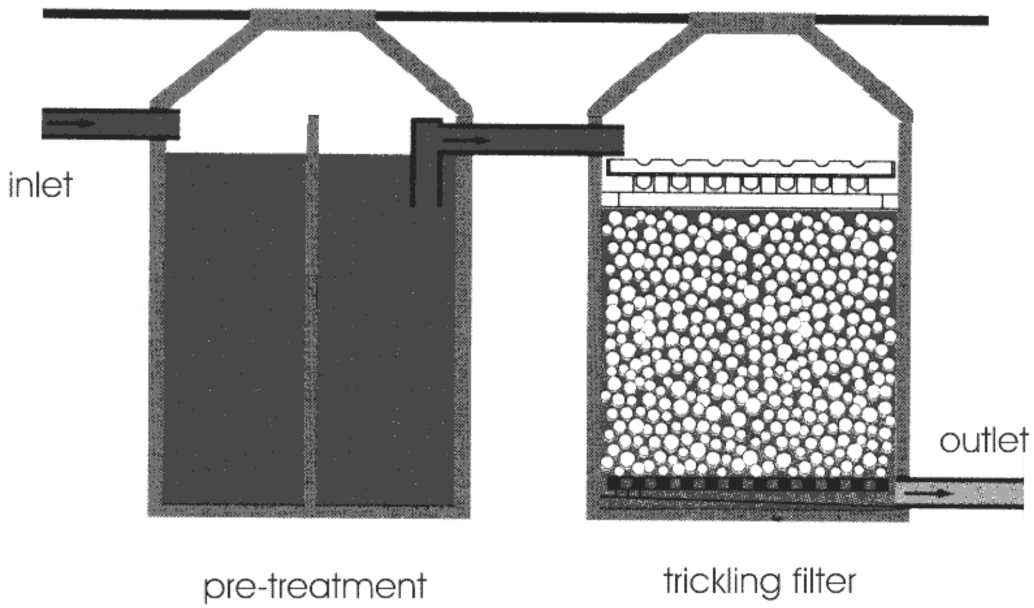
- **Low spatial requirements**
- **Effluent quality usually below 50 mg/l BOD**
- **Resistant against shock load and variable inflow volume**

CONTRA:

- **Expensive treatment system**
- **High operation and maintenance costs**
- **Professional operation and maintenance required**

Trickling filter

Description: A trickling filter is made of a concrete column filled with a coarse carrier material of crushed rock, slag, gravel or plastic modules. Conventionally, the bed is 1 to 3 m deep. Wastewater is distributed evenly on the filter surface and percolates downwards into the filter bed. On the highly permeable bed a bio-film develops. The micro-organisms of the bio-film degrade wastewater pollutants. Aeration of the filter media takes place from the bottom through a spontaneous air flow due to temperature difference. Therefore, sub-soil construction is not common. Usually, the organic and the hydraulic load to the filters should guarantee a balance between the growth of the bio-film and the amount of rinsed-out dead bio-film. Constant hydraulic loading can be maintained through suction level controlled pumps or dosing siphons.



Trickling filter

Capacity: The system is usually applied in urban areas for treatment of domestic wastewater. It can be applied for bigger and smaller communities.

Costs: Medium; investment costs depend on type of filter materials and feeder pumps used; operational costs determined by electricity consumption of feeder pumps

Self-help compatibility: Design, planning and implementation by expert consultants; no community labour contribution possible;feeder pumps required; permanent staff required for operation

Operation & Maintenance: Professional service providers required

Replication potential: Materials not locally available System can only be implemented with the intensive co-operation of experts.

Reliability: Systems does not work during power failurures.

Efficiency: High treatment efficiency. Reduction of BOD and infective organisms is about 80 – 95 %.

PRO:

- System suitable for urban communities
- High treatment efficiency
- Resistant against shock loads

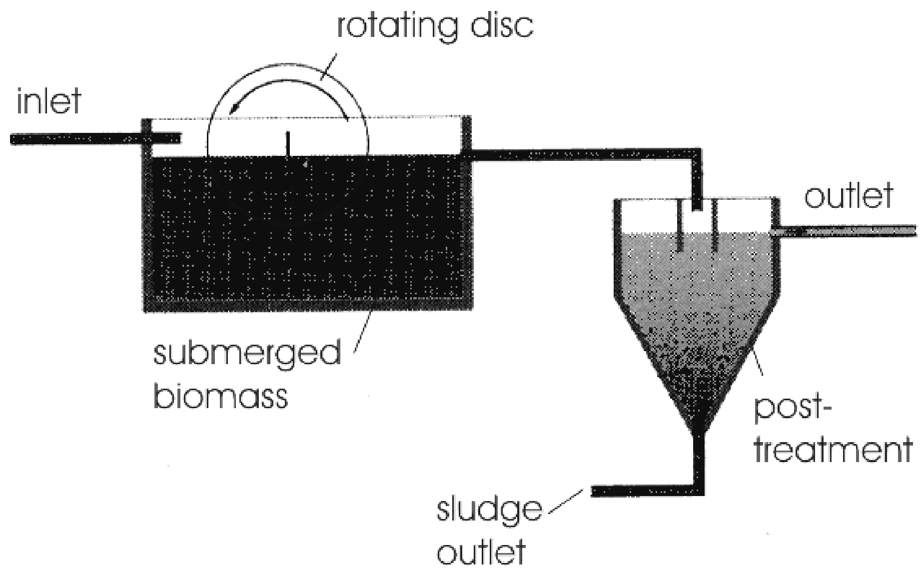
CONTRA:

- Relatively high investment and O & M costs
- Experts required for construction and O & M
- Continuously inflow has to be maintained
- System breakdown during power-cuts and pump failures

Rotating biological contactor, RBC

Description:

Rotating contactors are constructed from a series of closely spaced circular discs which provide a high surface area for the growth of micro-organisms. The discs are submerged about 50 % and rotate slowly in a tank which contains the wastewater to be treated. Discs are covered with aerobic biological film which is alternatively exposed to air, taking up oxygen, and submerged to the wastewater, taking up nutrients. Dead bio-film dropped off automatically from the discs into the wastewater stream. In the tank additionally activated sludge is developing which supports the degradation of wastewater pollutants. The common disc diameter is between 0,6 and 3 m.



Rotating biological contactor, RBC

Capacity: System suitable for treatment of domestic wastewater in urban areas. It can be applied for large and smaller communities.

Costs: Relatively high investment costs. Electricity consumption, replacement of parts and maintenance staff determine O & M costs.

Self-help compatibility: Manufacture and implementation of treatment system by experts; no community contribution for construction/implementation work;

Operation & Maintenance: Operation of system must be supervised by professional operator

Replication potential: Materials and parts not locally available;.system can only be implemented with the intensive co-operation of experts

Reliability: Technique doesn't work in cases of power failure.

Efficiency: High treatment efficiency. Reduction of BOD and infective organisms is about 85 %.

PRO:

- **High purification capacity**
- **Resistant against shock loads**

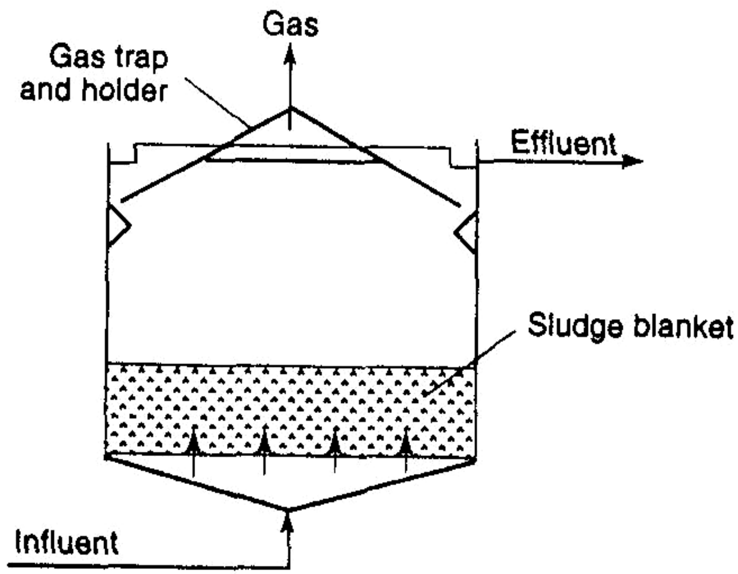
CONTRA:

- **Relatively high investment and O & M costs**
- **If not properly constructed, mechanical problems as shaft/bearing failures and/or media breakage could occur**
- **Continuously electricity supply required**
- **Permanent staff required for operation**

UASB reactor

Description:

UASB reactors consists of a deep tank in which wastewater pours near the bottom and equally distributed over its total area. In the lower part of the reactor a sludge blanket is maintained through which the wastewater is forced to percolate upwards. This results in sedimentation and absorption of organic waste matter and biological conversion to biogas. This gas forms bubbles that escape from the blanket providing the necessary mixing of the sludge mass. In the upper part of the tank, treated wastewater is separated from sludge and biogas in specific gas-liquid-solids separators (GLSS). Excess sludge is removed once every few years. To keep the sludge blanket in suspension, an up-flow velocity of 0,6 – 0,9 m/ h have to be maintained.



UASB reactor

Capacity: The system is suitable for domestic wastewater small and medium settlements and communities.

Costs: Investment is comparable to baffled reactors. For operation usually no costs arise beneath desludging costs and operation of feeding pump.

Self-help compatibility: All materials are locally available; Experts needed for planning and supervision; craftsmen required for construction; community labour contribution limited; Operation difficult for fluctuating inflows.

Operation & Maintenance: Operation of feeder pump requires requires permanent operator; desludging procedures require professional service provider;

Replication potential: All required materials locally and partly standardized design available; Co-operation of experts is required for implementation. A number of post-treatment options can be added

Reliability: Fluctuation of inflow and load can cause unstable fluid bed which can cause collapse of treatment process

Efficiency: Acceptable treatment efficiency only if sludge-blanket is maintained; Reduction of BOD about 75 - 90 %; treatment system not resistant against shock-loads

PRO:

- **Relatively low investment costs**
- **Little space required due to underground construction**
- **High potential treatment efficiency**

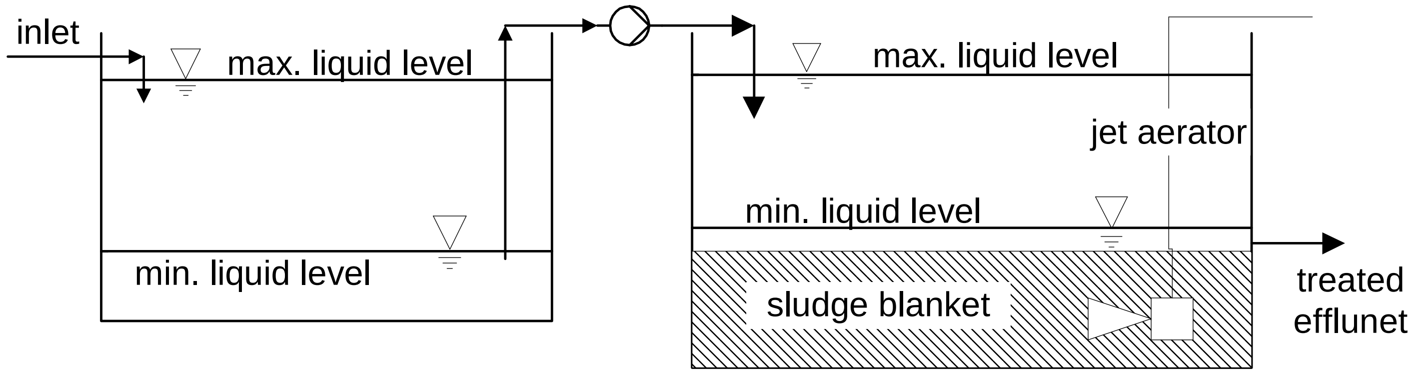
CONTRA:

- **Low community contribution for construction work**
- **Technical energy and feeder pump required**
- **Stable fluidised bed difficult to maintain**
- **Not resistant against shock-loads**

Sequencing batch reactor, SBR

Description:

Within the Sequencing Batch Reactor (SBR) treatment technology, a number of treatment steps are carried out in same reactor. The reactor containing active biomass is charged with influent while aerated. When the feeding stops, the tank operates as a batch fully aerated to allow oxidation of organic matter. Aeration is finally stopped to allow sludge settling. The cycle ends when the treated water is discharged from the top of the tank, while sludge is removed at the bottom. Sedimentation and sludge recycling are not separated. Continuous and discontinuous operation schemes are possible.



Sequencing batch reactor, SBR

Capacity: The system is usually applied in urban areas for treatment of domestic wastewater. It can be applied for bigger and smaller communities.

Costs: Investment is still high but lower than an ASU. Operation expensive due to high electricity consumption and costly parts

Self-help compatibility: Experts required for design, planning, supervision and construction; no labour contribution by communities possible;.

Operation & Maintenance: SBR requires professional operation and maintenance providers;

Replication potential: Materials and parts not locally available; system can only be implemented by specialized consultant firms

Reliability: Technique relies on technical energy and mechanical parts

Efficiency: High treatment efficiency. Reduction of BOD and infective organisms up to 75 – 95 %.

PRO:

- **High purification capacity**
- **Resistant against shock load and variable inflow volume**

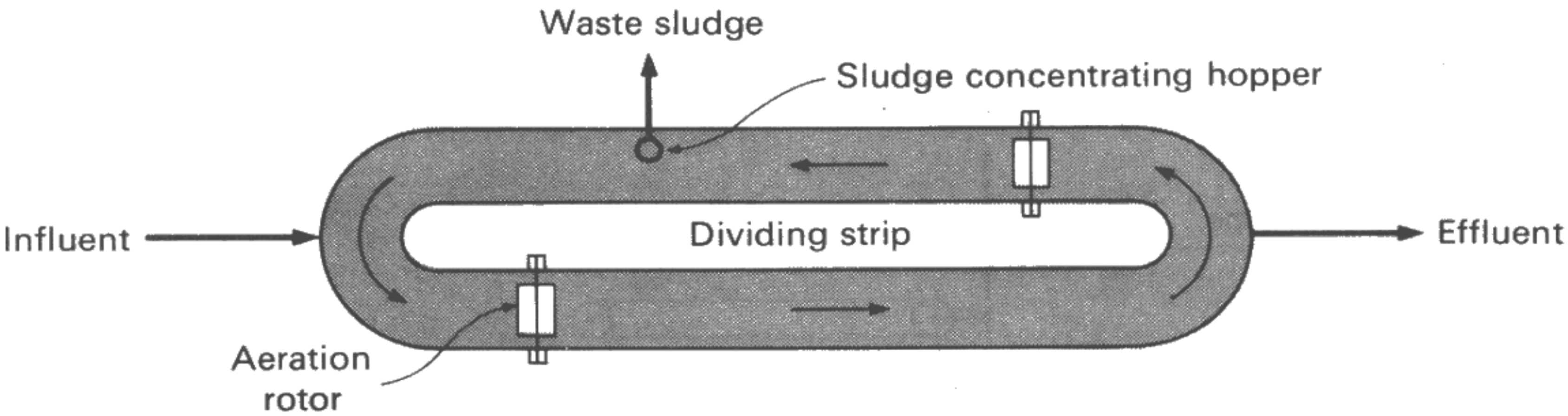
CONTRA:

- **Very expensive implementation and operation**
- **Expert manufacturers and consultants required for implementation**
- **Professional operation and maintenance required**

Oxidation ditch

Description:

The oxidation ditch consists of a ring or oval shaped channel and is equipped with mechanical aeration devices. Screened influent enters the oxidation ditch without primary sedimentation, is aerated and circulates at about 0.25 – 0.35 m/s.Wastewater is mixed with active sludge in a closed loop (carousel) usually made from concrete. Wastewater is aerated and mixed by rotors or cones. Operation can be continuously or intermittent. Pre-treatment is usually not required. Required treatment volume per capita is about 1 m³. Secondary sedimentation tanks are used for most applications.



Oxidation ditch

Capacity: The system is usually applied in urban areas for treatment of domestic wastewater. It can be applied for bigger and smaller communities.

Costs: Investment costs are very high but lower than for an ASU. Maintenance and operation expensive due to need for permanent operator, high electricity consumption and high costs for replacement parts.

Self-help compatibility: Experts needed for planning and construction; communities cannot contribute labour for construction; system operated by permanent staff

Operation & Maintenance: Oxidation ditches require professional operation and maintenance providers;

Replication potential: System parts not locally available; System can only be implemented with the intensive co-operation of experts

Reliability: Technique relies on technical energy and functioning mechanical parts

Efficiency: High treatment efficiency. Reduction of BOD and infective organisms is about 75 – 95 %.

PRO:

- **High purification capacity**
- **Resistant against shock load and variable inflow volume**

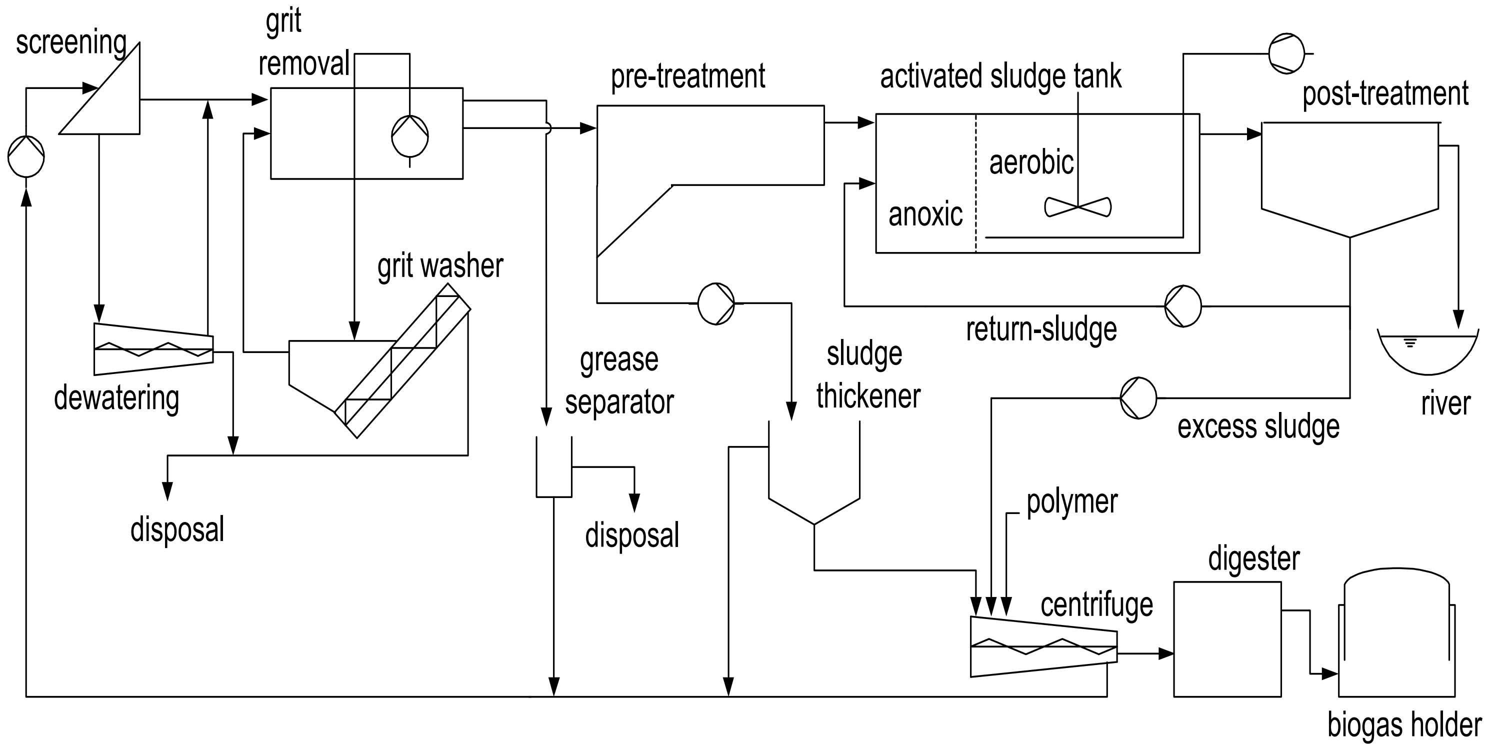
CONTRA:

- **High investment and operation costs**
- **Community cannot be involved in construction**
- **Materials and parts not locally available**
- **Professional operation and maintenance services required**

Activated sludge unit, ASU

Description:

Consists of an aeration concrete tank, in which the wastewater is mixed with recycled sludge containing active aerobic bacteria. The mixed liquid is aerated and the organic pollutants are degraded (partly oxidized and partly integrated into new biomass). In an attached tank, sludge is decanted and returned to the aeration tank. A pre-treatment and a complex process chain for sludge treatment is necessary. Required treatment volume per capita is about 0,5 m³. Most popular wastewater treatment process in industrial countries.



Activated sludge unit, ASU

Capacity: The system is usually applied in densely populated areas for treatment of domestic wastewater; individual treatment units are usually designed 10.000 to 500.000 persons, not for small communities;

Costs: Very high construction and maintenance costs; operation very expensive due to requirement of permanent professional operation, high electricity consumption and costly mechanical parts..

Self-help compatibility: Activated sludge units require professional operation and maintenance providers

Replication potential: System parts not locally available; implementation only possible by experienced consultant firms;

Operation & Maintenance: Oxidation ditches require professional operation and maintenance providers;

Replication potential: No self help potential. System can only be implemented by experts.

Reliability: Technique doesn't work in cases of power failure.

Efficiency: High treatment efficiency. Reduction of BOD and infective organisms is about 85 – 95 %.

PRO:

- **High purification capacity**
- **Resistant against shock-loads**

CONTRA:

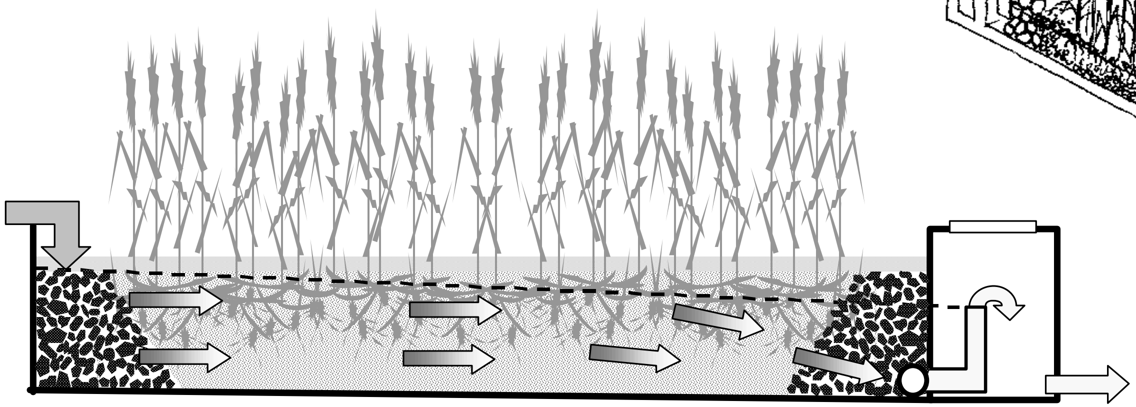
- **Not suitable for application on community level**
- **Very high construction and maintenance costs**
- **Professional consultant firms required for implementation**
- **Professional service providers required for O & M**

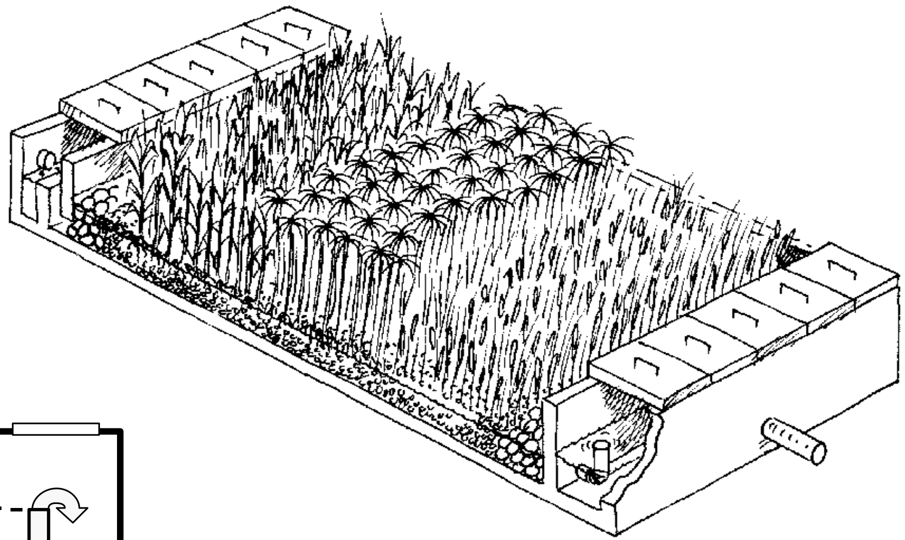
Secondary Treatment Systems

Planted horizontal sand filter

Description:

This secondary treatment system consist of a planted filter body made from gravel or sand with a bottom slope of 0 – 0,5 %. The flow direction in the filter body is mainly horizontal. The filter body is permanently saturated with water, but water level is adjusted 5 cm is below filter surface. The main removal mechanisms are biological conversion, physical filtration and chemical adsorption. The mechanisms of BOD removal are aerobic, anoxic and anaerobic. As coarse particles and solids eliminated within main treatment system and no perforated drainage pipes are used for feeding influent into the filter, filter medium is not prone to clogging.





Evaluation Sheet

Planted horizontal sand filter

Capacity: The system is suitable as secondary treatment stage for smaller and larger settlements in case sufficient space is available.

Costs: Investment costs are low if land is cheap or land-use is free of charge; phragmites grass and gravel for filter can be readily obtained; use of ornamental water plants will increase costs;

Self-help compatibility: Design and lay-out prepared by expert; Construction can be carried out by semi/unskilled labourers if experienced mason available for supervision (water-tightness of filter-bed required);

Operation & Maintenance: Cutting or thinning of plantation required; washing of filter material recommended every 3-5 years; part-time operation staff or well-organized community group required

Replication potential: Standardized designs and SOPs available for different sizes of HSFs; all required construction materials are readily available; system up-grading possible

Reliability: Reliable, but shock load and flooding of the filter should be avoided.

Efficiency: Reduction of BOD during secondary treatment about 10 - 30 %. Reduction of infective organisms is high.

PRO:

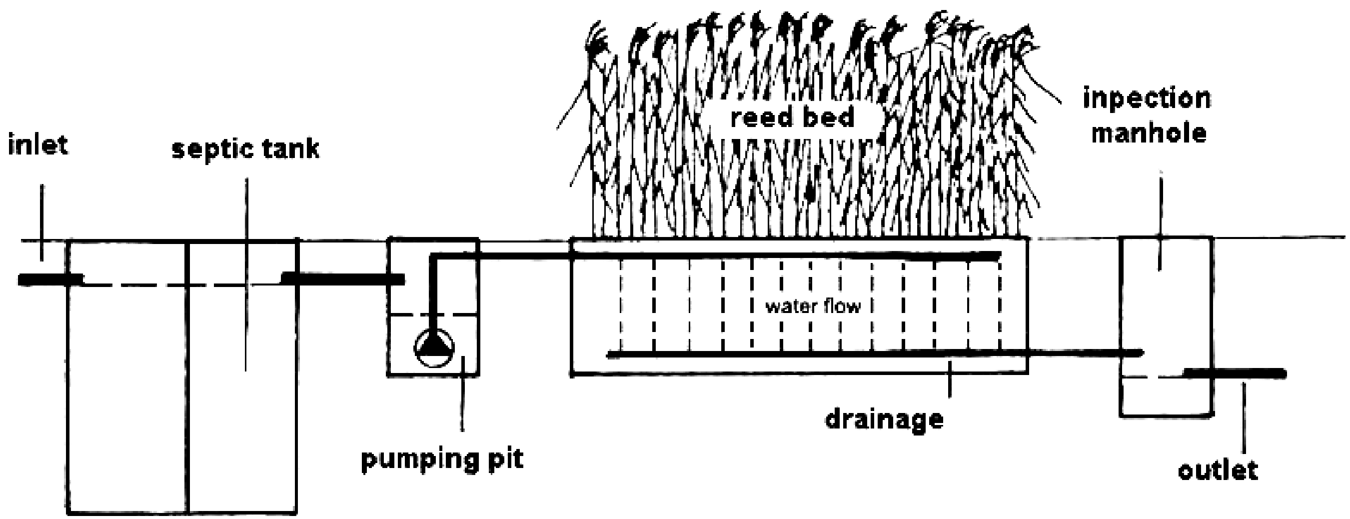
- **Low-cost secondary treatment option**
- **Local mason able to supervise construction**
- **Community can participate in construction**
- **Operation and maintenance is simple**
- **Pleasant landscaping**
- **Good purification effect**

CONTRA:

- **High spatial requirements**
- **Due to high land use not suitable as main treatment component in densely populated settlements**

Planted vertical sand filter

Description: The system consist of a planted filter. The filter body consists of gravel and sand. Usually different grained substrate layers applied. The flow direction in the filter body is vertical. Inflow has to be distributed evenly on the whole surface of the filter, usually through perforated drainage pipes which are covered with a layer of gravel. The filter body is alternating saturated with water but the surface is not submerged. That can be achieved through a batch feed with the help of self priming siphons or if necessary through pumps. The main removal mechanisms are biological conversion, physical filtration and chemical adsorption. The mechanisms of BOD removal are mainly aerobic. Perforated drainage pipes are prone to clogging



Planted vertical sand filter

Capacity: System suitable as secondary treatment option for smaller communities.

Costs: Low spatial requirements reduce cost for land purchase; feeder pumps and electricity are additional cost factors; low cost for filter materials- and plants if locally available; use of feeder pumps increase operational costs

Self-help compatibility: Design prepared by experts; high participation by communities during construction possible; Feeder pumps and electricity supply required;

Operation & Maintenance: Regular cleaning of perforated pipes required; operation & maintenance increased if feeder-pumps are used; depending on filter depth, pumps might be needed for surface discharge;

Replication potential: Materials and parts locally available; Co-operation of experts is required for planning and implementation;

Reliability: Unreliable. Frequent clogging of perforated discharge pipes by unsolved organic particles observed; feeder pumps require permanent electricity supply

Efficiency: Reduction of BOD during secondary treatment about 10 - 30 %. Reduction of infective organisms is high.

PRO:

- **Low spatial requirements**
- **Good purification effect**

CONTRA:

- **Construction is more sophisticated than a horizontal flow system because of required batch-based feed and discharge with pumps systems**
- **Equal distribution of influent on filter surface difficult**
- **Total system failure during power cut and pump failure**

Disposal/Re-use of Effluents & Sludge

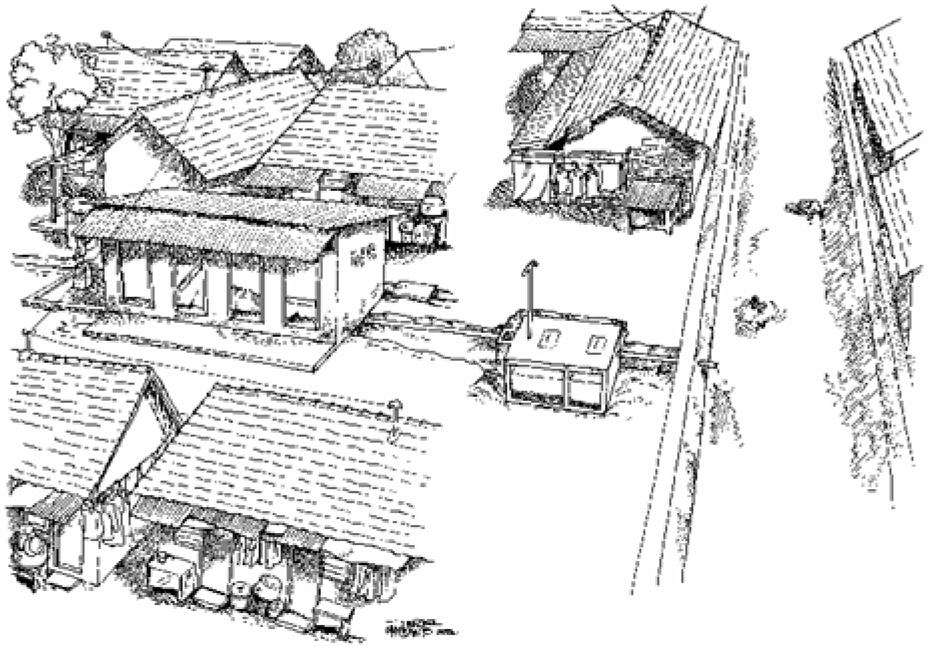
Disposal/re-use of effluents

Discharge into rivers

Description:

The discharge of treated wastewater into rivers is a acceptable way of disposal if special conditions are met. First, it is necessary to ensure that the self-purification capacity of receiving streams is not toppled by an over-load of discharged wastewater. Secondly, efficient pre-treatment must ensure that health of residents who use river-water down stream is not negatively affected.

Water is directly discharged into river through pipes. The discharge of untreated wastewater into rivers can only be accepted under certain conditions and should only be seen as a temporary solution.



Discharge into rivers

Capacity: Applicable everywhere where self cleaning capacity and hydraulic flow is high enough.

Costs: Cost for discharge pipes and labour; cheap, where rivers are close to the treatment facility.

Self-help compatibility: Operation and maintenance is very simple.

Operation & Maintenance: No maintenance required

Replication potential: High self help potential. System can be easily implemented by communities or local authorities.

Reliability: Reliable where rivers not overloaded.

Convenience: Convenient as "0" operation and maintenance required

PRO:

- **Very low-cost disposal option**
- **Implementation can be done by communities**
- **Zero operation and maintenance**

CONTRA:

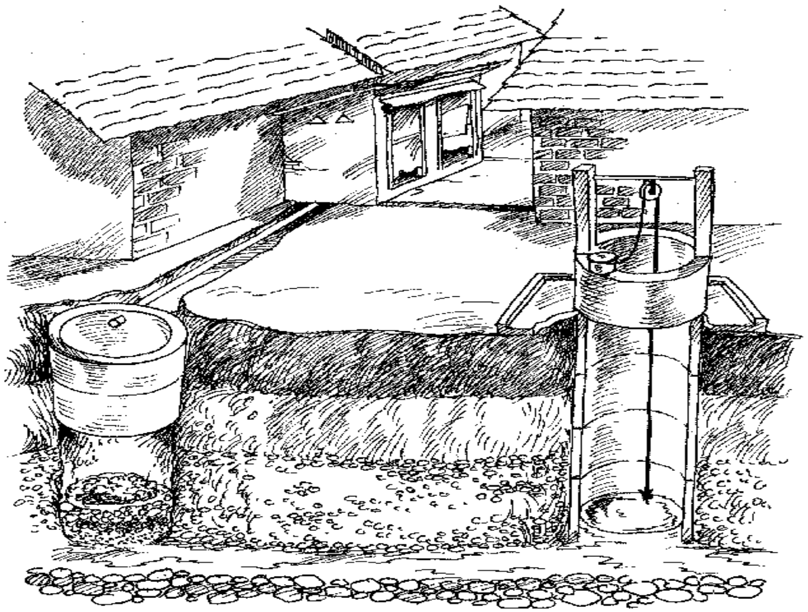
- **Consumption and use of raw river water downstream not recommended**
- **Depending on treatment options and river flow, overload of rivers possible**

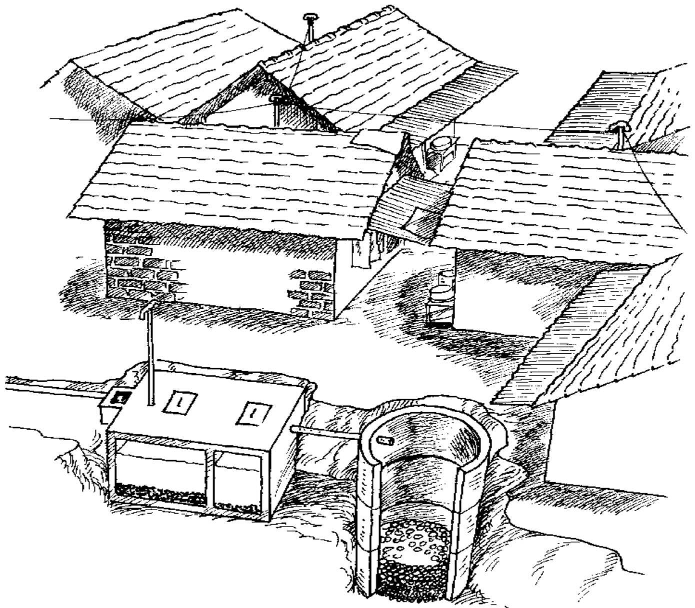
Soil infiltration

Description:

Discharge of treated wastewater through percolation/leach-pits into sub- soil layers is a common practise of wastewater disposal. Depth of the pit is in average 4 m. The depth is usually limited by the groundwater table or rocky underground. Sub-soil layers should be water permeable in order to avoid fast saturation of soils. Soil infiltration of effluents becomes a public health hazard if dug or bore-wells are located less than 10 metres away from infiltration pits as effluents will leach into the catchment water catchment area of the well (see picture on the bottom left).

Infiltration of untreated wastewater into the soil can only be accepted if fresh-water wells are at least 20 metres way, and should be regarded as a temporary solution only.





Soil infiltration

Capacity: Applicable everywhere where soil conditions allow infiltration, groundwater table is deep (+ 2m) and were clean water wells a located at least 20 m away. Should be avoided for high daily volumes of discharged effluents

Costs: Construction usually more expensive than discharge into rivers where rivers are close. No costs for operation and maintenance.

Self-help compatibility: Construction can be carried out by community members. maintenance is very simple.

Operation & Maintenance: "0" operation and maintenance discharge option

Replication potential: System can be implemented by communities

Reliability: Reliable, if restricted to areas with deep groundwater levels

Efficiency: Possible danger of polluting well and groundwater, if efficiency of treatment option is low ; possible spill-over if large volumes of effluents are discharged

PRO:

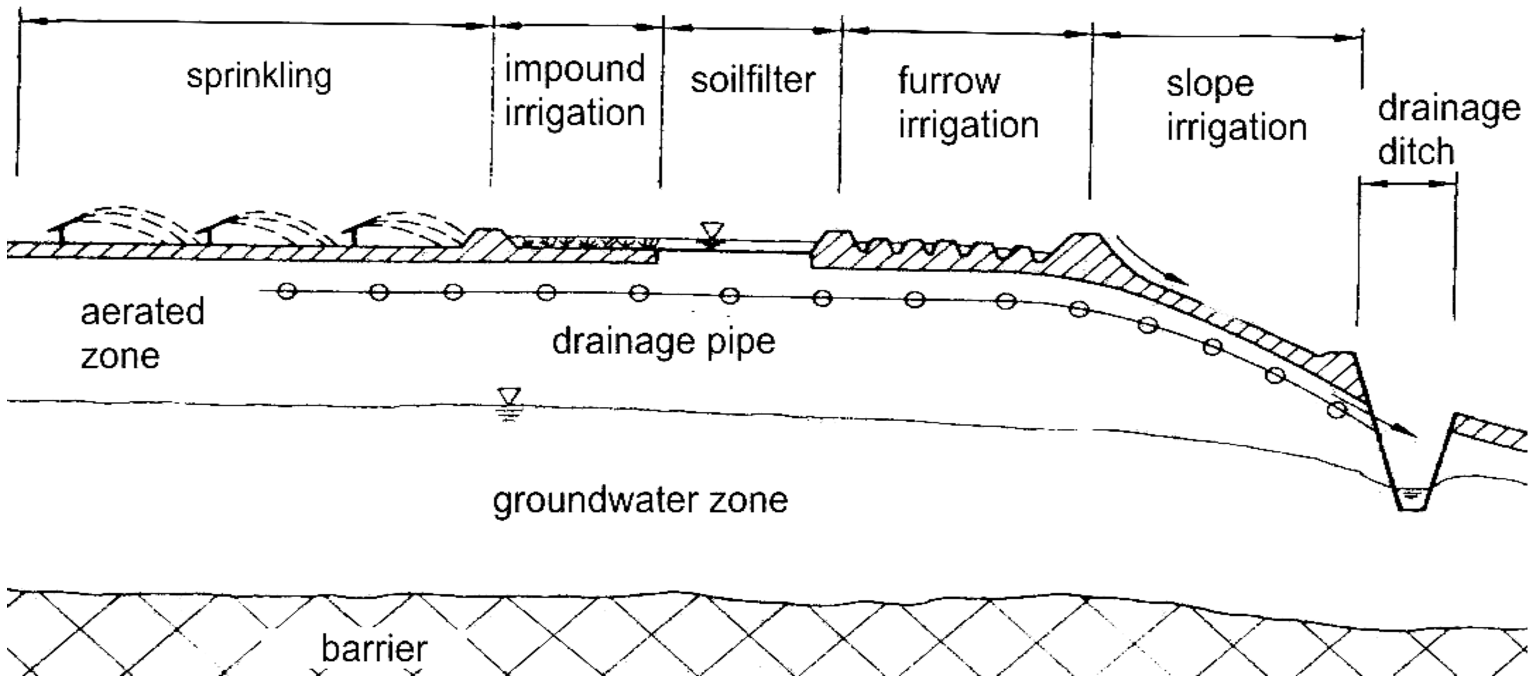
- **Very low-cost disposal option**
- **Implementation can be done by communities**
- **Operation and maintenance very simple**

CONTRA:

- **Only advisable in areas with deep groundwater table and if no wells are nearby**
- **In case option is wrongly applied, discharge option can become public health hazard**

Irrigation

Description: Land treatment and agricultural utilisation of effluents are well-known traditional methods of discharge as well as secondary treatment of wastewater. This technique allows to recycle wastewater contents directly into the nutrient cycle. Different methods applied today depend on existing type and texture of soils, location of groundwater and agricultural land use. Mayor methods applied are shown below.



Irrigation

Capacity: Applicable only in rural areas where space is available. Not applicable within densely populated urban settlements.

Costs: Depending on the technique applied and land prices, treatment can be cost-effective. Pay back function through yield. Technique cannot be applied during rainy season

Self-help compatibility: Often sophisticated irrigation management is required. Users have to be acquainted with the system and its risks.

Operation & Maintenance: Requirements depend on irrigation methods applied; alternative discharge options required during rainy season

Replication potential: High self help potential where irrigation is traditionally practised; co-operation of experts recommended for pollution control.

Reliability: Reliable in regions where irrigation is practised traditionally; due to public health concerns, vegetable and fruit crops should not be irrigated one month before harvest

Efficiency: If proper function can be guaranteed a high performance for organic carbon, nutrients and pathogenic germs can be expected.

PRO:

- **Recycling of nutrients**
- **Reduction of pollution load of rivers**

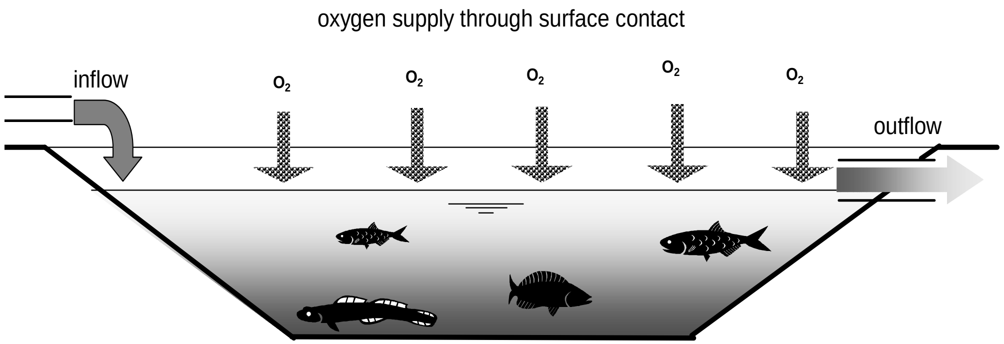
CONTRA:

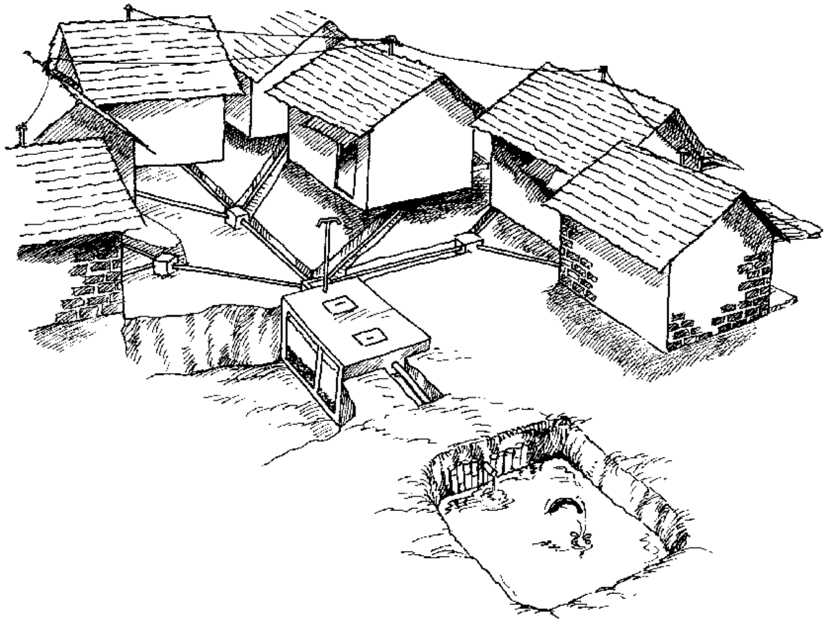
- **Limited to rural and peri-urban areas where large scale horticulture and/or agriculture are practised**
- **Alternative discharge options required during rainy season**

Aquaculture

Description:

With the help of fishponds and aquacultures, pre-treated wastewater can be utilised and nutrients can be recycled into the food-chain. In principle, pre-treated wastewater is let into a pond where the nutrients of effluent are utilized by different species of micro-organisms, plants and fishes. Careful selection of species, especially fishes, is recommended as oxygen demand varies. For a full scale treatment and to maintain optimised conditions for the species it is common to use pond systems in series of two or three modules.





Aquaculture

Capacity: Applicable where space is available within urban settlements. Small and large scale applications possible; pre-treatment determines scope of aquaculture

Costs: Feasibility of effluent re-use option depends on land prices/free land use possibility. Pay-back function through yield.

Self-help compatibility: Sophisticated operation required. Users have to be aware of the system and to be involved.

Operation & Maintenance: Well-organized community groups required which traditionally practise aquaculture

Replication potential: High self help potential where aquacultures has a tradition. But co-operation of experts is recommended for pollution control.

Reliability: Usually reliable but in cases of system over-load hazardous to public health.

Efficiency: Good secondary treatment efficiency;

PRO:

- **Effective re-cycling of nutrients**
- **Relieve rivers through the reduction of direct pollution load**
- **Provision of nutrients and income for residents**

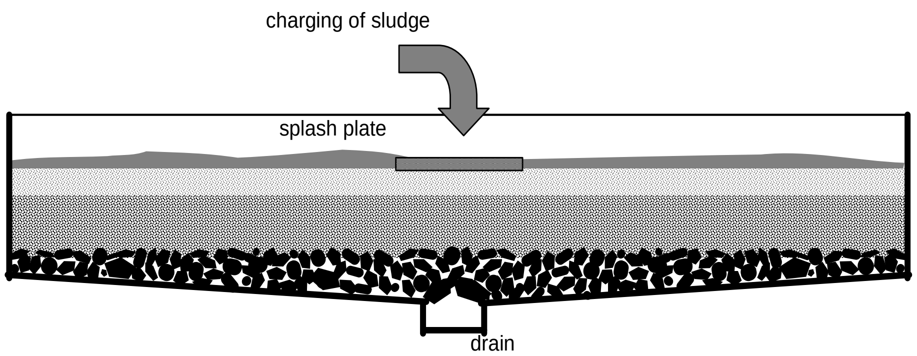
CONTRA:

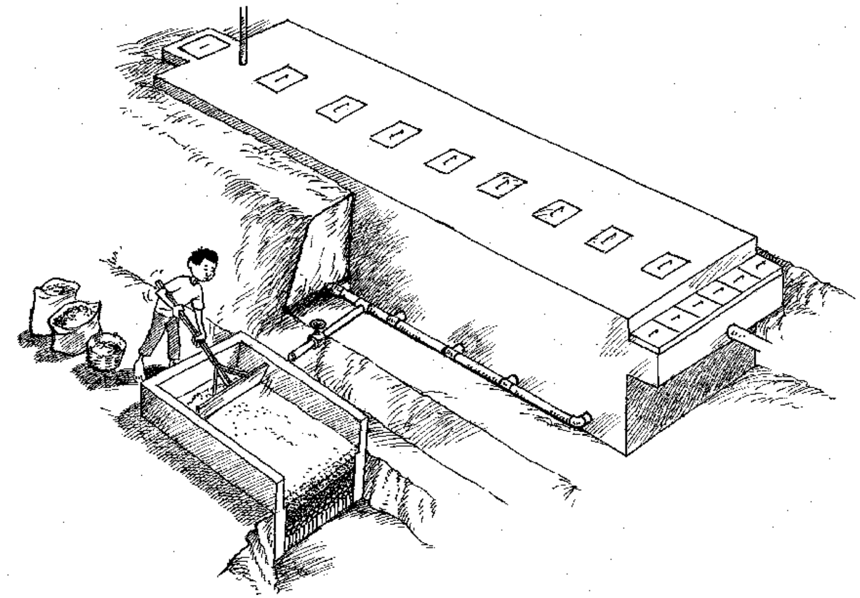
- **Solution limited to efficient pre-treatment land availability of land**
- **Not suitable for areas where aquaculture has no local tradition**
- **Effluent over-load of ponds hazardous to public health human and aquaculture**

Disposal/re-use of sludge

Sludge drying bed

Description: Sludge drying beds are one of the oldest techniques for sludge dewatering. The lowest layer of the bed consists of a drainage stratum made of coarse gravel. Upper layers consist of different sand and gravel with fine grain size at the top. The bed frame is usually made from concrete. Sludge drying beds are filled with a layer of 5 - 20 cm sludge, preferably during the dry season. Drying processes are percolation and evaporation. A yearly charge of up to 1 – 2 m³ sludge per m² bed is possible. After drying water content of sludge is reduced to 35 – 45 %. Sludge is usually removed manually, used for agriculture purposes or sold as compost. Sludge drying beds should be located near the treatment plant.





Sludge drying bed

Capacity: Applicable where space is available near wastewater treatment plants.

Costs: Investment is usually acceptable where land prices are low and filter material is locally available. For operation no costs arise beneath payments for workers. Pay-back function

Self-help compatibility: Manpower is required for operation, maintenance, sludge charging and disposal.

Operation & Maintenance: Well-organized community group required which has experience in organic fertilizer use and preparation. Seepage water has to be collected;

Replication potential: Middle until high self help potential. System can be implemented by communities or local authorities.

Reliability: Reliable if drying is not practised druing rainy season

Efficiency: Dewatered sludge is still infectious; Additional composting of dried sludge in heaps or wind-rows will further stabilise recycled organic materials

PRO:

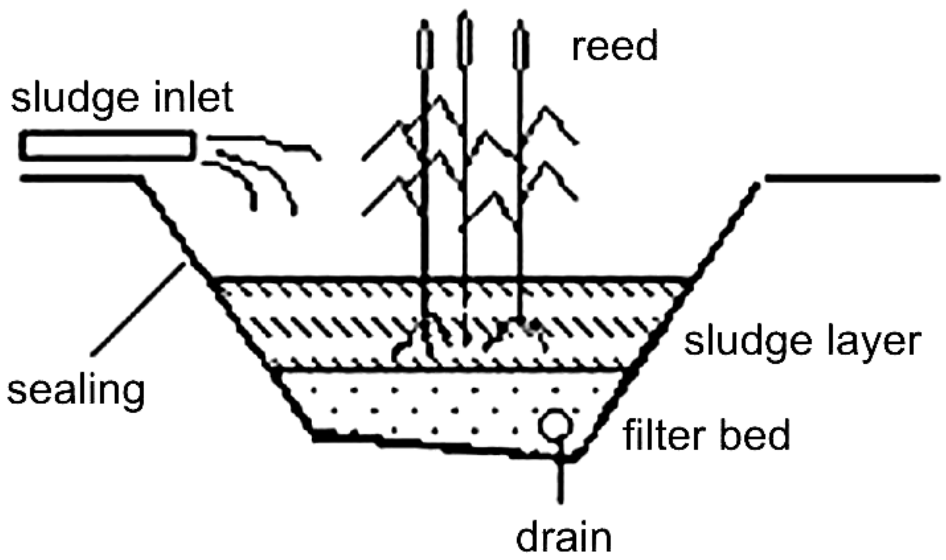
- **Easy to operate**
- **Provision of organic fertilizer or additional income for residents**

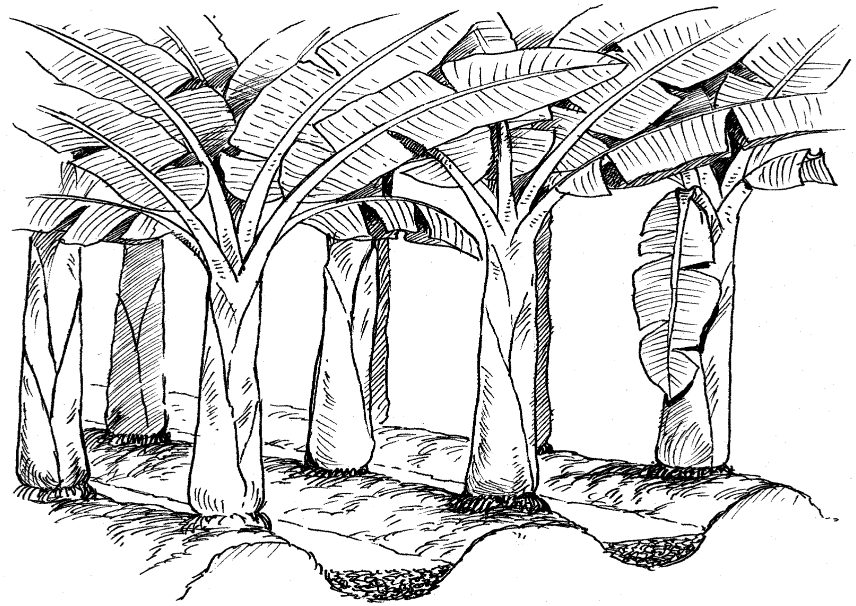
CONTRA:

- **Knowledge about organic fertilizer preparation and use required**
- **Efficient community organization needed**
- **Re-use or treatment of seepage water required**
- **Only applicable during dry seasons**

Reed beds

Description: Reed beds (but also: existing banana and papaya groves or patches of pennisetum grass land) can also be effectively used for sludge conditioning. Theoretically, the lowest layer of the bed consists of a drainage stratum above which different layers of sand and gravel are situated. Practically, a sandy-loam like soil texture will achieve the same results. Beds are planted with species which tolerate high water and nutrients contents. Width of the beds depend on plant species used. Charging is carried out in intervals during the dry season. 1 m² of bed can be charged with a sludge amount of 100-150 litres. Drying efficiency is usually increased through plant transpiration, water drainage is high because of the pathways created by the plant roots. The sludge volume can be reduced about 50% through decomposition. After 5 years of charging, the created substrate can be removed, used for agriculture or sold as organic fertiliser.





Reed beds

Capacity: Applicable in urban communities where horticulture can be practiced near treatment facilities; preferable species are papaya banana and pennisetum varieties

Costs: Investment is low where land-use is free of charge; filter layer consists of a 10 cm sand or sandy-loam layer; operation and maintenance costs are low; pay-back function

Self-help compatibility: Well-organized community organizations with experience in gardening required;.

Operation & Maintenance: Sludge storage pit near treatment facility required; application by buckets or flexible desludging pipe; collection of of dried, de-composed sludge recommended every 2 - 5 years

Replication potential: Possible in communities where urban gardening or horticulture is practised. Consultancy of experts is required for planning.

Reliability: Reliable. Substrate should be applied and removed during dry season.

Efficiency: Efficient and safe method for sludge disposal if space available

PRO:

- **Low-cost sludge disposal solution**
- **Easy to operate and to maintain**
- **Sludge directly used as organic fertilizer**
- **Dried sludge can be sold or used as organic fertilizer**
- **Efficient and safe nutrient recycling**

CONTRA:

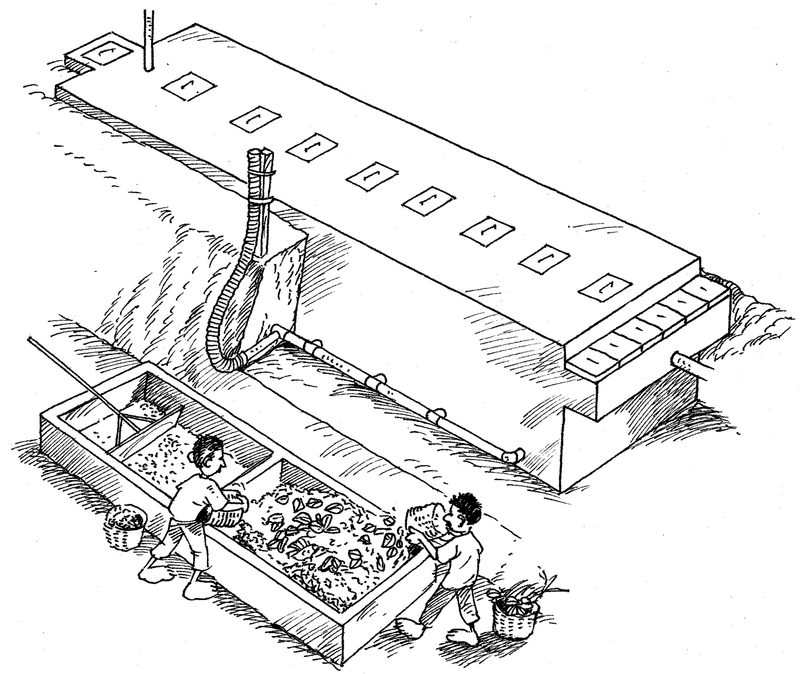
- **Space for gardening required**
- **Only applicable for well-organized community organizations with experience in gardening**
- **Application and removal of sludge only during dry season**

Composting

Description:

A relative simple procedure for sludge composting is to mix digested sludge with chopped and dry organic materials beside the treatment plant, pile up the mixed substrate to heaps or windrows with a minimum height of 1 metre and cover the pile with soil. One turnover after 2 – 3 weeks is sufficient to ensure optimal conditions for composting during 3 to 6 months during dry season. As composting consists of a self-heating process until 60-70 ° C , the final substrate is almost free of pathogens. Organic substrate can be used or sold as organic fertilizer. Composting minimises odour nuisance.

Combining sludge composting with the composting of organic solid-waste found in the community should be considered as an ideal aim.



Composting

Capacity: Applicable in urban settlements where space and organic materials are available.

Costs: Investment for sludge drying and composting pits is low where land prices are low or free-of-charge. O & M has to be provided by community organizations; pay back function

Self-help compatibility: Useful concept for communities which collect organic materials environment; experience of community organizations in organic fertilizer use required;

Operation & Maintenance: O & M requirements higher than for sludge drying processes

Replication potential: Easy to replicate; user training by experts recommended

Reliability: Reliable if performed during dry season

Efficiency: Safe and efficient method if organic materials are collected

PRO:

- **Low-cost disposal/re-use option**
- **Pay-back function**
- **Hygienic organic product**

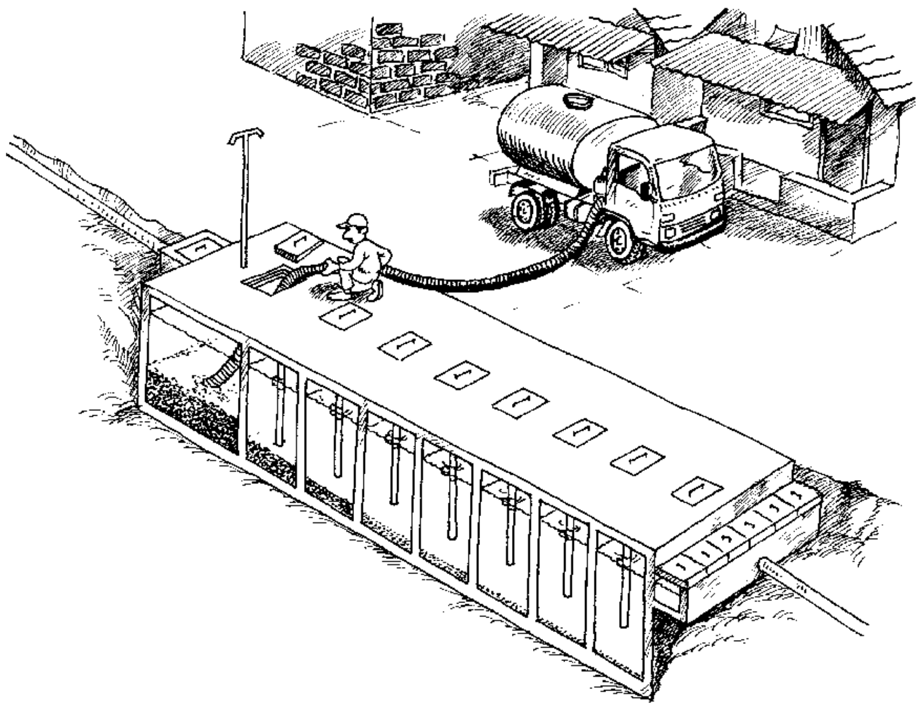
CONTRA:

- **Labour intensive operation**
- **Dry organic materials required**
- **Misuse of compost heaps as garbage dumps possible**

Desludging by vacuum truck

Description:

In cases where sludge is not being processed on-site, it should be collected and disposed by local service providers.In order to utilize vacuum trucks, treatment systems which need regular de-sludging should not be located more than 50 metres (length flexible of de-sludging pipes) from streets which can be accessed by vacuum trucks. The truck's sludge container is connected to a sludge pump and flexible pipe. After the pipe is placed through inspection shafts at the bottom of the treatment systems, the vacuum pump is switched on. During desludging care must be taken that only matured “black” sludge is pumped out.



De-sludging by vacuum truck

Capacity: Capacity of common vacuum trucks is 5 cbm

Costs: Costs for public/private desludging services are low; no other expenses for operation and maintenance required;

Self-help compatibility: Operation is carried out by professional service provider

Operation & Maintenance: Easy, if covers of control shafts of treatment system can be removed and are accessible. No community infrastructure for sludge treatment needed

Replication potential: Depends on availability of de-sludging services in cities. Currently desludging services are operated in most Indonesian municipalities.

Reliability: Reliable as desludging service is required only every +/-12 months

Efficiency: Effective removal of sludge form treatment facilities and settlements; sludge stabilisation and final disposal/re-use is responsibility of municipality

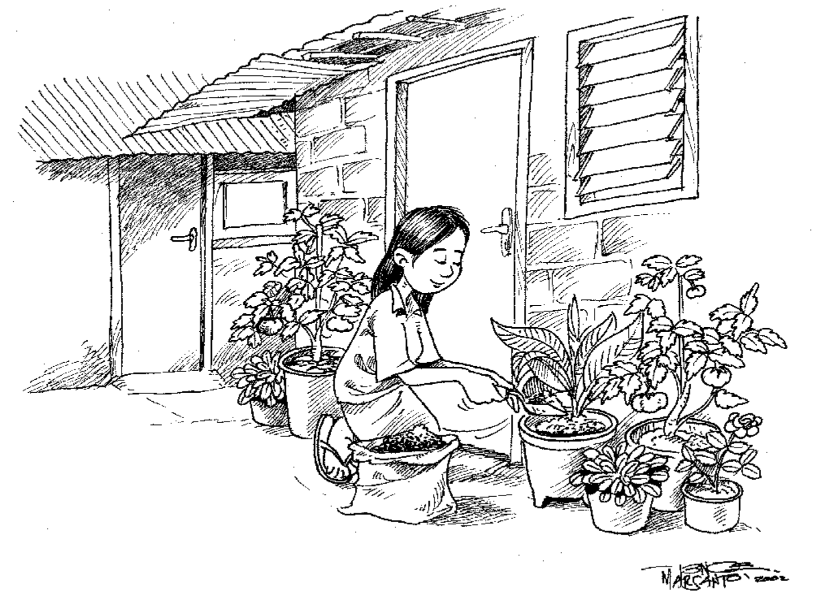
PRO:

- **Low-cost disposal option**
- **“0” operation and maintenance for communities**
- **Efficient removal from sludge from urban settlements**

CONTRA:

- **Service provider needed**
- **Sludge trucks may not be readily available**
- **Potential of un-hygienic final disposal of sludge**

Utilisation as organic fertilizer



Description:

Dried, de-watered or composted sludge can be marketed as compost/organic fertiliser by communities. In this way it is possible for communities to recycle nutrients and to achieve a limited additional income. It is important that dried/composted sludge is fully decomposed/matured in order to get a hygienic and marketable product.

Organic fertilizer preparation should be done during dry-seasons in order to avoid/limit health hazards from sludge handling and to speed up de-watering and composting processes.be avoided during the rainy seasons in order to avoid Different methods can be applied depending on general conditions like soil, groundwater and type of agriculture. In cases agricultural products are used for nutrition monitoring of sludge quality is required.

Utilisation as organic fertilizer

Capacity: On-site use restricted to areas where gardening or horticulture is practised.

Costs: Investment and operational costs are low; pay-back function; community labour required.

Self-help compatibility: Re-use option depends on community labour contribution only. Acceptance of utilisation of processed sludge in agriculture/gardening necessary.

Operation & Maintenance: Well-organized community organizations with experience in organic fertiliser preparation and use required;

Replication potential: Possible in all settlements where small scale gardening and horticulture is practised. System can be implemented by communities or local authorities.

Reliability: Usually reliable but monitoring for harmful substances is proposed from time to time if yield is used for nutrition.

Efficiency: Wherever possible, re-use of sludge is advisable

PRO:

- **Efficient recycling of nutrients**
- **Sale of dried/composted sludge possible if on-site use not possible**

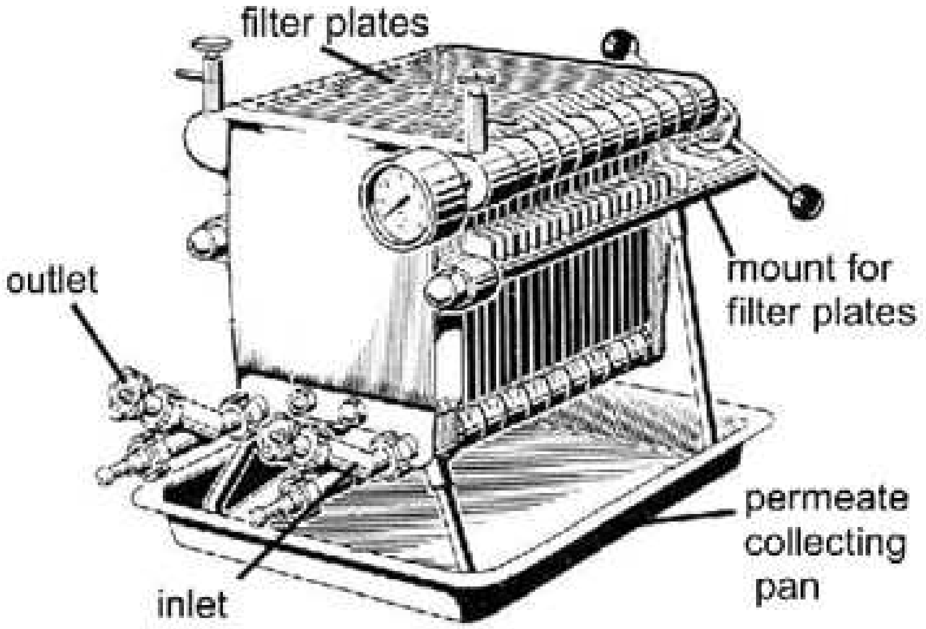
CONTRA:

- **Application of fertilizer restricted to neighbourhoods where gardening/horticulture is practised**
- **Desludging, drying/composting limited to dry seasons only**
- **Commitment of community on long term basis needed**

Mechanical dewatering

Description:

Mechanical dewatering is normally associated with large wastewater treatment plants. The principal methods are belt filter presses, centrifuges and chamber filter presses (as shown on the picture). Water is separated from solids through pressure or centrifugal force. Techniques are usually sophisticated and rarely cost-efficient for smaller systems to be implemented on community level.



Mechanical dewatering

Capacity: Usually applied in bigger and sophisticated wastewater treatment plants. Not used on neighbourhood/community level

Costs: High investment and operational costs costs due to imported technology, spare parts and electricity consumption.

Self-help compatibility: Specialised firms for manufacturing required; operation only by skilled operators;

Operation & Maintenance: Professional operating and maintenance staff required

Replication potential: No self help potential. System can only be implemented by experts.

Reliability: Technique doesn't work in cases of power failure.

Efficiency: Dewatered sludge is still infectious. Further treatment may be necessary.

PRO:

- **High operational capacity**

CONTRA:

- **Only used in large scale treatment plants**
- **High investment, operation and maintenance costs**
- **Only applicable on a professional basis**