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Decentralised Waste Water Treatment

Tasks, function and selection of small-scale purification plants

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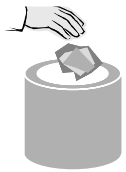
Sub-tasks of waste water purification

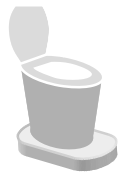
Overview of processes

Rainwater

Household waste water



Toilet waste



Grey water | Black water

Preliminary treatment

- Wastewater pond
- Pre-composting tank (Rottebehälter)
- Single-chamber settlement tank
- Multi-chamber settlement tank
- Single-chamber slurry pit
- Multi-chamber slurry pit
- Filter sack

Purification process

- Wastewater pond
- Infiltration trench, filter bed
- Filter chamber
- Sediment filter
- Plant beds
- Percolating filter
- Biological contactor system
- Small-scale activation system
- SBR process

Post-treatment, recycling

- Lamella separator
- Composting bed
- Polishing pond
- Sand filter
- Underground trickle system
- Drip trough (trickle area)
- Seepage trench, soak-away
- Cistern
- Underground irrigation
- Liquid manure trench, agricultural recycling

Return to water cycle

Sub-tasks of waste water purification

The entire purification process for domestic waste water can be divided into individual sub-stages or sub-tasks, regardless of the size of a water treatment plant:

Waste water purification: sub-tasks

- Separating out of coarse materials
  - → Refuse
- Separating out of sand
- Separating out of solid materials
  - → Primary sludge

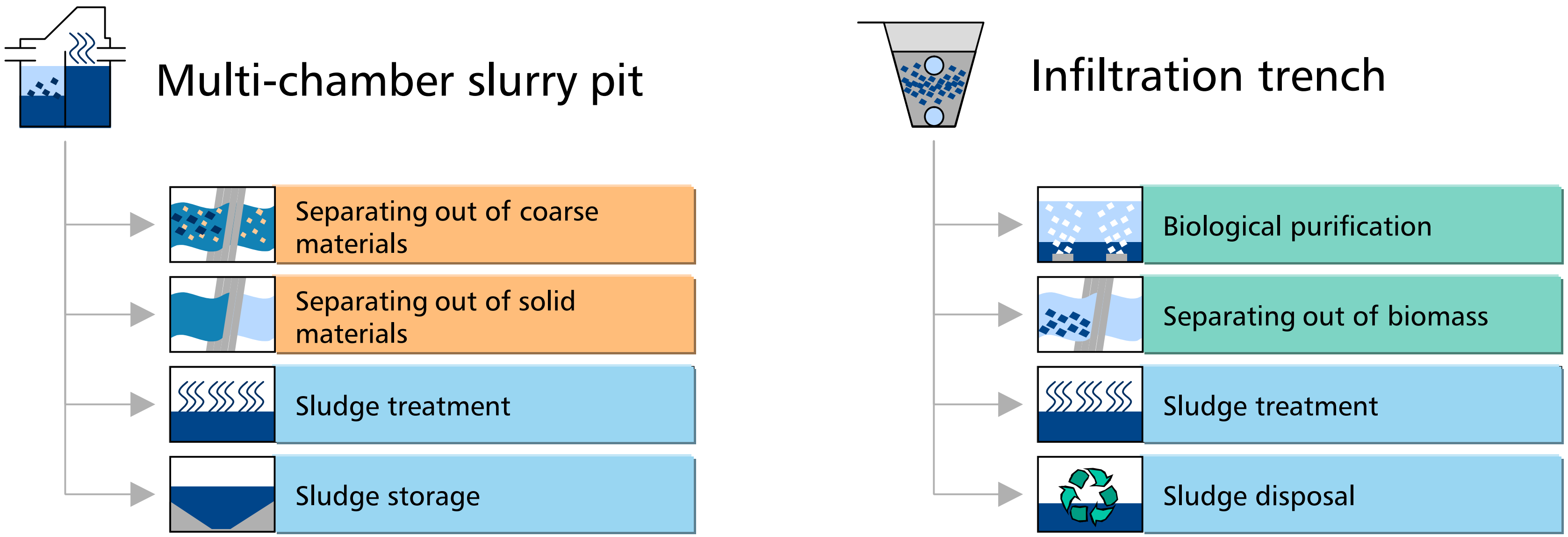
- Biological purification
  - Organic carbon compounds are converted into biomass → secondary sludge
- Separating out of biomass
- Elimination of nitrogen
- Elimination of phosphorous

- Sludge treatment
- Sludge storage
- Sludge disposal
- Post-treatment of outflow

Sub-tasks of waste water purification

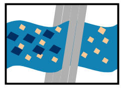
1. General

Since it would be impossible to perform all the required sub-tasks in one single stage or in one single system component, each and every water treatment plant consists of the appropriate combination of individual components. A percolating filter, for example, is not a water purification system in itself: it is only a component which, when combined with other components such as a multi-chamber settlement tank, a sedimentation tank, sludge storage tank etc., constitutes a water purification system. Frequently, several sub-stages are found in one single component.



Sub-tasks of waste water purification

2. Separating out of coarse materials



Coarse materials found in untreated waste water include paper, disposable nappies and other hygiene products, food remains and kitchen waste, razor blades, curlers, plastic bags, cotton buds, plasters and so on: in other words, mainly materials which could in fact be disposed of with the rest of the household rubbish and need not end up in the waste water.

With small-scale purification plants it has been shown that - unlike with large-scale plants - local residents can be encouraged by means of appropriate education of the public to dispose of these materials along with normal refuse and not to flush them down the toilet. Experience has also shown, however, that all coarse materials cannot be prevented from ending up in the waste water. These have to be separated out to prevent blockages and other malfunctions in the water treatment plant. However, the dividing line between coarse materials and the primary solid materials described in section 6.3.4 (Separation of solid materials) is flexible and cannot be clearly defined.

The separating out of coarse materials is usually achieved by the settling of sedimentation and floating in multi-chamber settlement tanks and multi-chamber slurry pits. One special component is the filter sack. When activation tanks are used without preliminary treatment, secured refuse baskets and specially designed scum baffles are used.

Sub-tasks of waste water purification

3. Separating out of sand

Sand and small stones get into domestic waste water through the washing of vegetables, dusting, vacuuming, boot-cleaning and similar activities. Sand also gets into the sewage network through ventilation holes in manhole covers. Poorly maintained rainwater inlets, which are the main cause of sand in urban mixed-sewage systems, are not an issue in small-scale purification plants because with this kind of system the collection of waste water always follows the separation process. As a result, the amount of sand in small-scale treatment plants is small and there is usually no need for a dedicated structure for separating out sand. Sand is simply filtered out together with other solid materials.

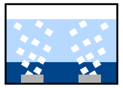
4. Separating out of solid materials

Solid materials are all those particulate materials which are not categorised as coarse materials or sand, which can be separated out within a few hours by settling or floating in still water. This includes ground-up paper, solid faecal elements and other particles which get into the waste water as a result of householders washing dishes, cleaning or having baths or showers. It is vital that solids be removed in a separate process if the treatment plant contains components which must be protected against silting up, e.g. percolating filters, rotating biological contactors (RBCs), biological contactors and in particular all 'natural' treatment stages, such as infiltration trenches and plant beds. When using activation tanks, there is no need to separate out solid materials first.

The components used for separation are multi-chamber settlement tanks and multi-chamber slurry pits. Another possibility, mentioned previously, is the filter sack. This allows some materials which are categorised as solids to be separated out in addition to coarse materials.

Sub-tasks of waste water purification

5. Biological purification



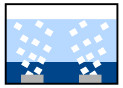
Approximately two thirds of the organic carbon compounds found in untreated waste water which can be detected using the 5-day BOD parameter are present either in solution or in highly distributed form. They cannot therefore be removed using physical methods, but can only be removed using a 'biological cleaning' process. The basic principle underpinning all biological processes is that dissolved organic matter is mostly converted into bacterial biomass by the metabolic activity of aerobic microorganisms in the presence of free dissolved oxygen, biomass which is then separated from purified waste water using physical methods. A proportion of the organic matter is used by the microorganisms to cover their requirements for CO_2 and H_2O. A key precondition for the success of this process is the presence of free dissolved oxygen.

Infiltration trenches, filter beds, filter chambers, sediment filters and plant beds are known as 'semi-natural' or 'natural' processes because they allow oxygenation without the use of pumps, fans or similar mechanical devices and therefore without the use of external energy.

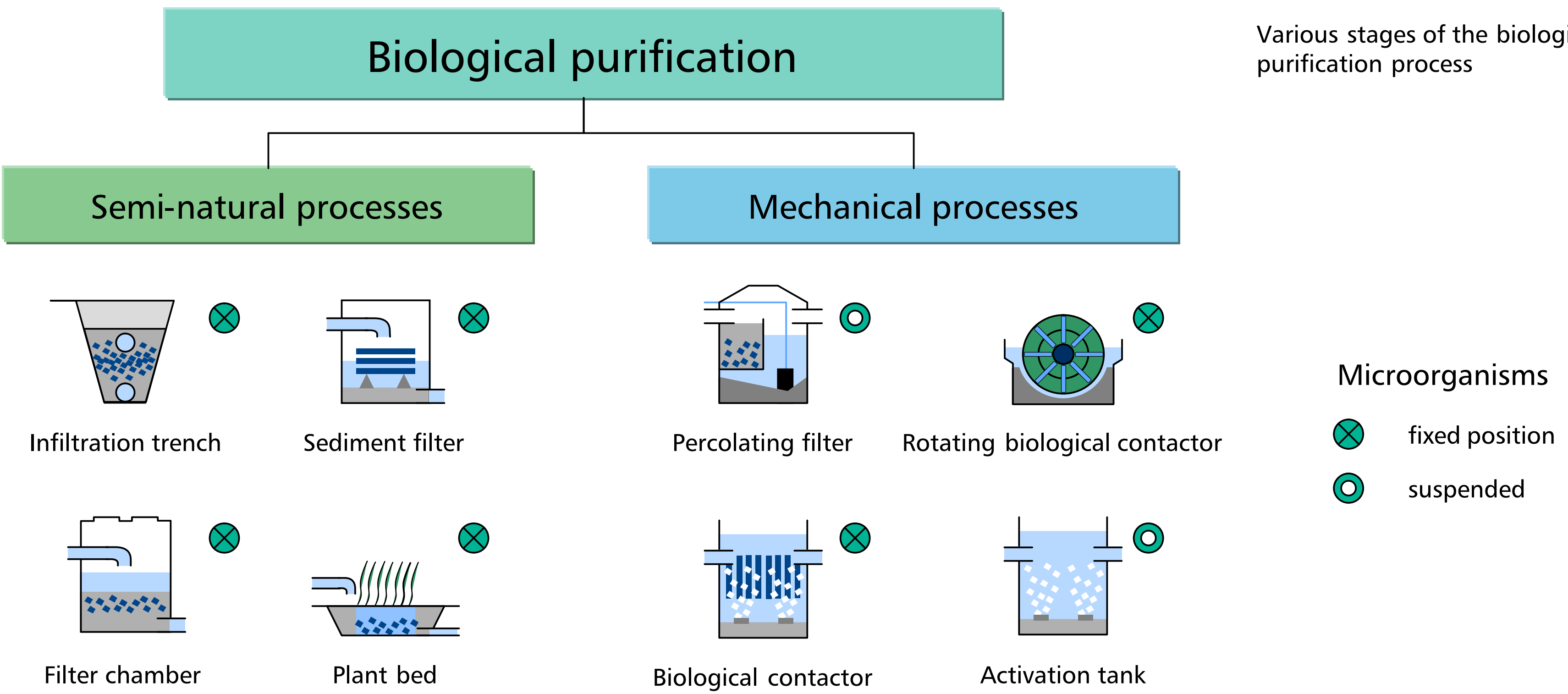
Percolating filters, rotating biological contactors, biological contactors and activation tanks are known as 'mechanical' or 'artificial' processes, for which machines are needed for oxygenation.

Another differentiating criterion is whether the microorganisms are present as a fixed growth on growth surfaces (biofilm) or are suspended in the water, i.e. can move freely. In all natural processes and when using percolating filters the microorganisms settle on the growth areas, while in the activation tank they are suspended and free to move about. Rotation biological contactors and biological contactors feature both fixed and suspended organisms.

Sub-tasks of waste water purification

...Biological purification 

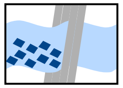
In the case of all biological purification components, the biomass created by bacterial growth (excess sludge or secondary sludge) must be removed on a regular basis, unless it is continually broken down within the component itself - as is the case with infiltration trenches and plant beds.



Various stages of the biological purification process

Sub-tasks of waste water purification

6. Separating out the biomass

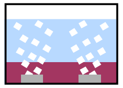


The bacterial biomass which performs the biological purification is usually separated out from the purified waste water in a downstream sedimentation tank by means of sedimentation. Clarifying by means of sedimentation can also be performed using a lamella separator. Activation tanks, which are operated using a damming process with discontinuous aeration, contribute to both the biological purification of the water and the separating out of the biomass through sedimentation, alternating periodically.

In the case of 'natural' biological purification processes (filter chamber / plant bed), biomass is separated out in the structure itself by the filtering effect of the construction material used. The continuous eating by the higher organisms (protozoa, grubs, insect larvae etc.) offsets the growth of biomass, which means that under the right conditions a balance is achieved between the amount of existing biomass and the amount broken down, preventing the filter material from becoming overgrown and blocked. If this balance is not achieved, blocked material may have to be replaced.

Sub-tasks of waste water purification

7. Oxidation of nitrogen (nitrification)



The nitrogen found in untreated household waste water comes mainly from human excrement. In the form of ammonium-nitrogen (NH_{4}-N) it produces a nitrate (NO_3^-), causing unwanted oxygen consumptionin the discharge system. In Germany this fact is tolerated in the case of small-scale purification plants, while in Austria the oxidation of nitrogen (nitrification) must take place in the purification system, even in the case of purification systems for individual homes, and not in the receiving water after it has been discharged.

Although the oxidation of ammonium-nitrogen is not a desired feature of small waste water treatment systems, it often arises 'by itself' as a result of the design regulations imposed on small-scale plants. Favourable conditions exist for nitrifiers in activation tanks, for example. This can be of significance in terms of the process.

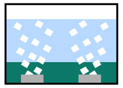
The oxidation of nitrogen is performed by special microorganisms (nitrifiers) according to the summary reaction equation: $NH_4^+ + 2O_2 \rightarrow NO_3^- + 2H^+ + H_2O$ + energy. As the equation shows, H^+ions are formed during the nitrification process. In soft drinking water with a low acid buffer capacity (carbonate hardness < 10 °dH), this can lead to a lowering of the pH with serious disruption to the biological purification processes. There are small-scale activation systems for which normal operation as a purification system is only possible through the regular addition of alkaline agents, e.g. 'lime hydrate' (calcium hydroxide $Ca(OH)_2$).

8. Elimination of oxidised nitrogen (denitrification)

Nitrogen which has been oxidised into a nitrate (NO_3^-) is used amongst other things as a plant fertiliser and can lead to excessive growth of algae. This is tolerated in small purification plants.

Sub-tasks of waste water purification

9. Elimination of phosphorous



In domestic waste water, phosphorous comes mainly from human excrement. The phosphorisation caused by detergents containing phosphate, which at one time was a key issue, has now lost much of its relevance. In water, phosphorous is a more effective fertiliser than nitrate and therefore promotes the growth of algae. This is tolerated in small purification plants.

10. Sludge treatment

The sludge which accumulates during the treatment of waste water, i.e.

§ the precipitate solid material from the untreated waste water (primary sludge) and

§ the continuous growth of biomass produced during biological purification (secondary sludge)

must be treated in such a way that its ability to decompose is largely eliminated before it is disposed of.

We talk about sludge being 'stabilised'. Stabilisation can be achieved aerobically or anaerobically.

In anaerobic sludge stabilisation, also known as sludge decomposition, the sludge is allowed to decay in the absence of oxygen with the help of various groups of bacteria, to such a degree that when utilised on agricultural land, the influx of air soon creates aerobic conditions and most of the odour which is still present at this stage disappears within a few days. At normal temperatures, anaerobic sludge stabilisation takes a very long time and can only be guaranteed in multi-chamber slurry pits which are evacuated approximately every 2 years. In multi-chamber settlement tanks with an evacuation interval of ≤1 year as recommended by DIN 4261, the sludge is not stabilised, merely stored.

Sub-tasks of waste water purification

... Sludge treatment

The principle of the aerobic sludge stabilisation process is that the microorganisms in the effluent sludge are kept in a constant state of 'hunger' in the presence of oxygen, forcing them to use virtually all the reserve, storage and other reusable materials available to them as food. Using this aerobic process, the sludge is stabilised such that when it is disposed of no further decomposition takes place and no odours develop. Because of design regulations, activation tanks for small-scale purification plants are consistently subjected to such low demands that the desired state of hunger of the microorganisms is created, allowing biological purification and stabilisation of the sludge to take place simultaneously in the activation tank.

'Natural' purification processes which use various types of soil filters as biological stages of purification are a peculiarity insofar as the only sludge which accumulates in these systems is primary sludge, with no secondary sludge. The primary sludge is stabilised anaerobically in the upstream multi-chamber slurry pit.

11. Sludge storage

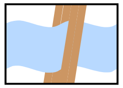
Because there are long intervals between the removal of sludge from small-scale purification plants, sufficient storage capacity is essential. Particularly large storage volumes allowing an accumulation time of at least six months are required if the sludge is to be used directly for agricultural purposes. This is because effluent sludge cannot be used on agricultural land in winter or during the growing season.

Sub-tasks of waste water purification

... Sludge storage

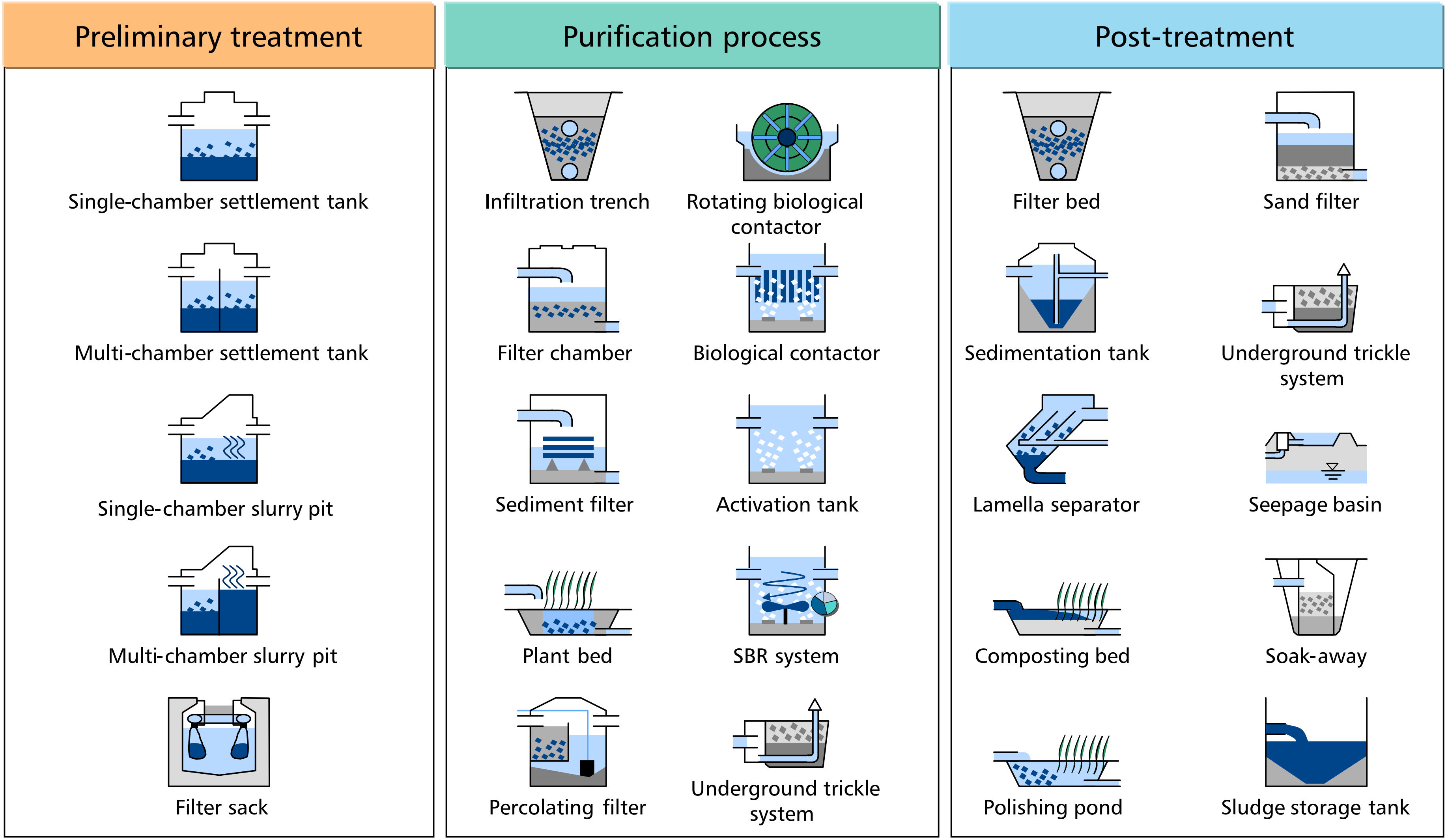
In mechanical small-scale purification systems, the secondary sludge which accumulates during biological stages of purification is transported periodically to the upstream multi-chamber pit. If this is a multi-chamber slurry system, it serves simultaneously as a sludge storage facility. Assuming that the sludge is to be stored in the multi-chamber settlement tank, the tank volume should be enlarged to 'sludge storage supplement' level. If there is no preliminary treatment stage with sufficient sludge storage capacity, a separate sludge storage tank will need to be built. There are also 'enlarged' activation tanks, a special case in which the tank also performs the function of the sludge storage tank.

12. Post-treatment



Before being reintroduced into sensitive waters, additional outflow enhancement measures can be applied. Polishing ponds and downstream sand filters are possible options. These structures also serve to moderate outflow volumes. A polishing pond can also function as a storage facility if the treated waste water is to be used for irrigation purposes.

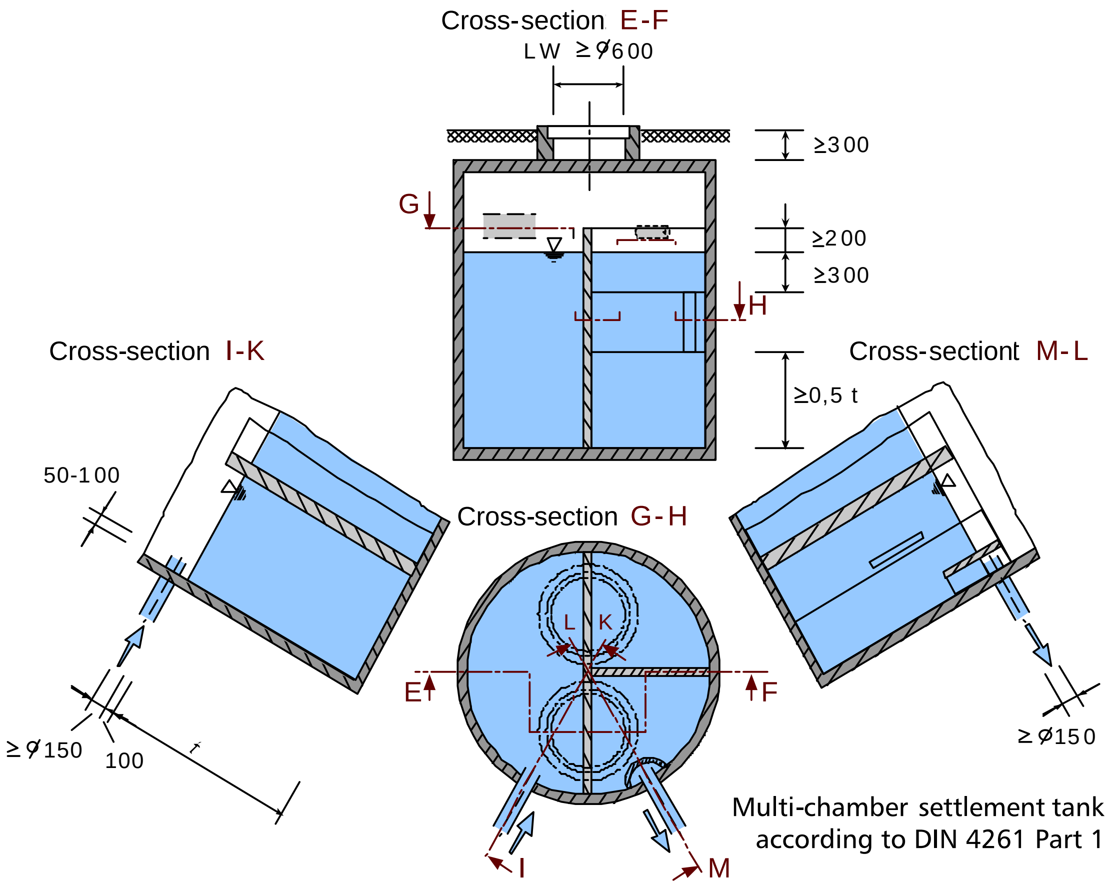
Components of a small-scale purification plant



1. Function and design

In multi-chamber settlement tanks, undissolved material is removed from the waste water by settling to the ground or floating to the surface. Floating sludge is prevented from passing into the outflow of the tank by a scum baffle or similar fixture. At normal usage levels with domestic waste water, the volume produced by the depth of the scum baffle is sufficient to store the floating sludge.

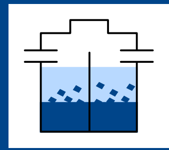
Multi-chamber settlement tanks can be built as two- or three-chamber tanks. The baffles have filter slots in them, and the distance between the base of the tank and the bottom line of these slots must be at least half the depth of the water.



Multi-chamber settlement tank according to DIN 4261 Part 1

Because the waste water spends less time here than in a multi-chamber slurry pit, it is relatively fresh and there is only minimal decomposition. Fluctuating sewage levels in terms of volume and concentration are only equalised and/or buffered to a slight degree.

Multi-chamber settlement tank



2. Rating

Rating and construction in accordance with DIN 4261, Part 1 (Small-scale purification systems); Systems without aeration of waste water; Application, rating and design:

- Usable volume ≥0.3 m^3/ per inhabitant population equivalent), min. 3 m^3, provided that there is an additional sludge storage tank for accumulating secondary sludge,
- If there is not, the volume must be increased by 0.05 m^3 per inhabitant for percolating tanks, rotating biological contactors and biological contactors and by 0.125 m^3 per inhabitant for activation tanks (extra volume for sludge storage),
- For total volumes of up to 4 m^3, two-chamber systems are permissible,
- Usable water depth at least 1.2 m, maximum water depth 1.9 - 3 m depending on size of facility.

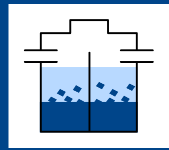
3. Application

Multi-chamber settlement tanks may be used as a preliminary to 'mechanical' purification processes (percolating tanks, rotating biological contactors, biological contactors and activation tanks).

4. Effectiveness

If emptied regularly, multi-chamber settlement tanks have high levels of mechanical cleaning effectiveness. The volume of solid material in the outflow is usually below 0.5 ml/l; coarse materials are consistently removed. As with primary settlement tanks, it is often assumed of large purification plants that reductions of 30% - 35% can be achieved when using using settlement tanks, five-day BOD

Multi-chamber settlement tank



... Effectiveness

Experience has shown, however, that with small two-chamber systems in particular the complex interplay of

- sedimentation and biological processes,
- the decomposition of sludge, formation of gas and therefore disruption of the settling and floating of precipitate sludge and
- the passage back into solution of the products of reaction of anaerobic decomposition

the 5-day BOD reduction can last varying periods of time and any value between 0% and 50% is to be expected. The same applies to the COD.

In all cases the discharged water will be decomposed, can cause nuisance odours and gives off harmful gases. This should be taken into consideration when choosing construction materials and protecting against corrosion.

5. Residual material

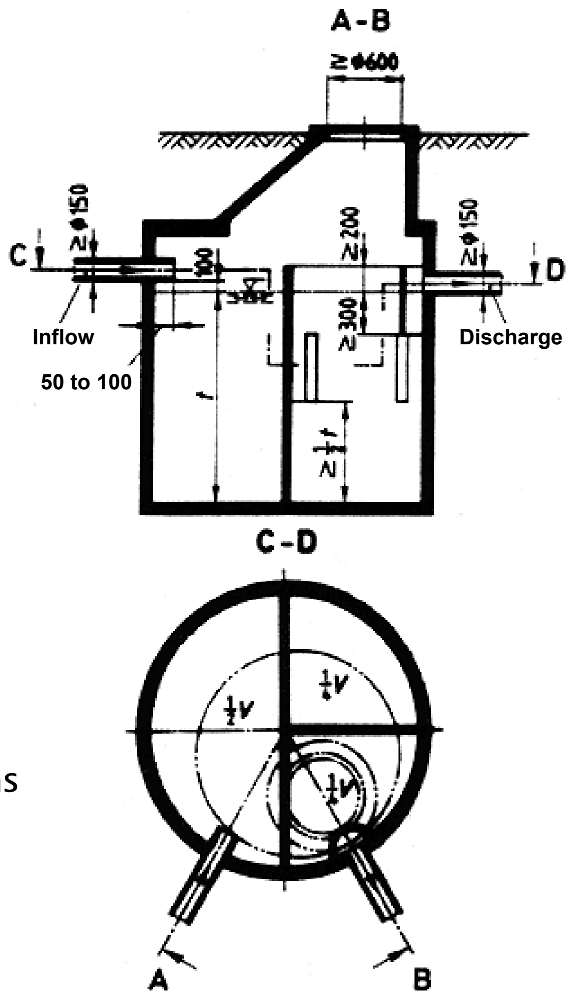
According to DIN 4261, Part 3 (Small-scale purification systems; Systems without aeration of waste water; Operation and maintenance [10], multi-chamber settlement tanks must be evacuated at least once per year . The sludge which accumulates consists of coarse materials, primary sludge and the secondary sludge which results from the downstream aerobic biological purification stage.

It is not fully decomposed (stabilised) and contains non-decayed, visible coarse materials from hygiene products. When all chambers have been completely emptied, the volume of the sludge/water mixture will of course correspond to the total volume of the settlement tank.

Multi-chamber slurry pit

1. Function and design

Multi-chamber slurry pits can be designed as three- or four-chamber systems. Undissolved materials and those which can float are separated out in the same way as in the multi-chamber settlement tank. Due to the large precipitation area, the process of decomposition achieves a more thorough separation of undissolved materials plus the partly anaerobic biological breakdown of undissolved pollutants in the water. The sludge area, which is considerably larger than in a multi-chamber settlement tank, can store much larger volumes of sludge. Most of the sludge will decompose. Due to the larger overall volume, fluctuations in the amount of waste water to be handled can be better balanced out. These additional characteristics of the multi-chamber slurry pit enhance the operational reliability of subsequent biological treatment stages.



Multi-chamber slurry pit
according to DIN 4261 Part 1

2. Rating

In accordance with DIN 4261, Part 1 (Small-scale purification systems; Systems without aeration of waste water; Application; Rating and design:

- Usable volume ≥1.5 m^3 per inhabitant, min. 6 m^3,
- Design always with at least three chambers, volume of first chamber 1/2 of total volume,
- Usable water depth min. 1.2 m, max. water depth 1.9 - 3 m depending on size

Multi-chamber slurry pit

3. Application

Multi-chamber slurry pits are approved without restrictions for use as preliminary purification and sludge storage tanks upstream of all types of aerobic biological purification. They are particularly appropriate for use upstream of 'natural' biological purification components which present an increased risk of blockages (infiltration trenches, plant beds etc).

When dealing with volumes of domestic foul water of up to max. 8 m^3/d, which corresponds to a community of around 50 inhabitants, in accordance with DIN 4261 they are considered only in exceptional cases and only as transitional solutions or as stand-alone purification stages .

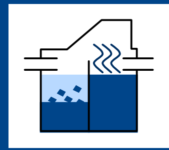
It should be noted that multi-chamber slurry pits also involve decomposition of the waste waster and give off harmful gases.

4. Performance

The disruption to precipitation caused by decomposition in the base sludge occurs in the first chamber of multi-chamber slurry pits in the same way as in settlement tanks. Durch das größere spezifische Volumen der folgenden Kammern wirken sie sich aber kaum auf die Ablaufbeschaffenheit aus. Because of this, and the additional biological partial purification, the purifying effect of multi-chamber slurry pits is considerably higher than that of settlement tanks.

If the system is well-maintained, the mechanical purifying effect is extremely good. The volume of solid material in the outflow is usually significantly below 0.3 ml/l; coarse materials are consistently removed. A 5-day BOD reduction of 30% - 50% is considered feasible. The 5-day BOD concentrations in the outflow are generally between 200 mg/l and 300 mg/l.

Multi-chamber slurry pit



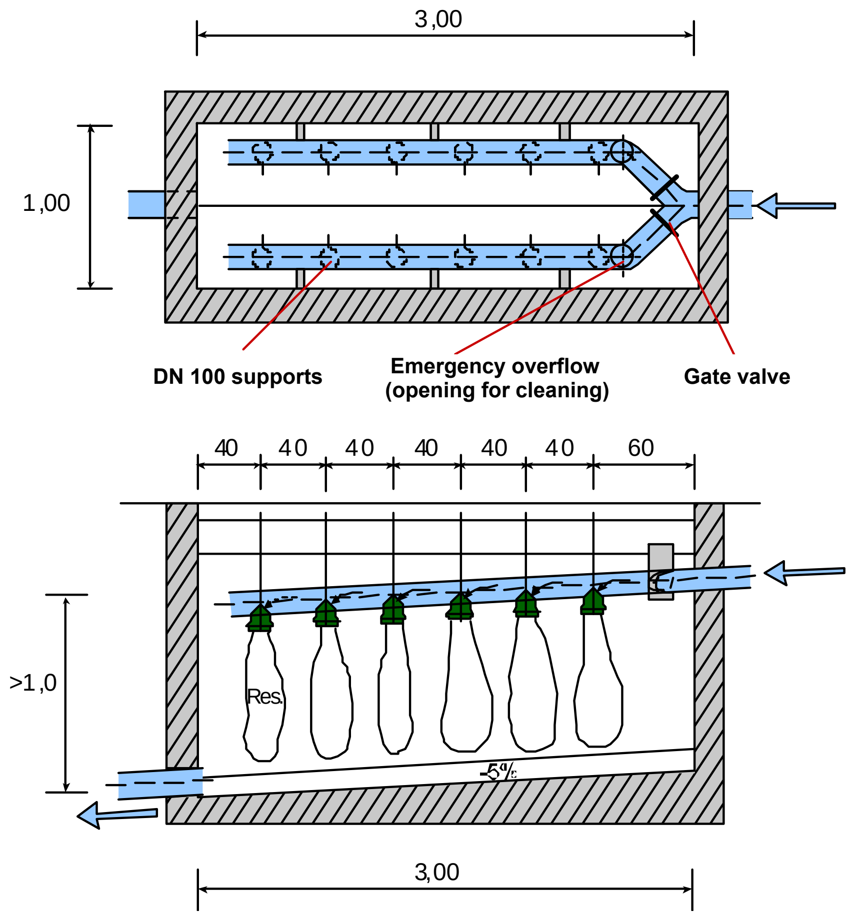
5. Residual material

According to DIN 4261, Part 3 (Small-scale purification systems; Systems without aeration of waste water; Operation and maintenance [10]), multi-chamber slurry pits must be evacuated at least once every two years, i.e. floating sludge must be completely removed and a proportion of the base sludge should be left in place as seeding sludge. The sludge consists of coarse materials and solids (primary sludge) and, in some cases, the secondary sludge from a downstream aerobic biological purification stage. Although it contains non-decayed, visible coarse materials from hygiene products, unlike the sludge from multi-chamber settlement tanks (provided that they are evacuated every two years), most of it will decompose (stabilise).

1. Function and design

The inevitable decomposition of waste water in multi-chamber settlement tanks and the associated disadvantages led to the development of the filter sack system in Austria in 1986. In this process, which is largely unknown in Germany, the untreated waste water flows through non-clogging fabric sacks suspended in the air. Coarse materials are then retained in the sacks. The filtering effect of the fabric is enhanced by the fact that, during operation, a filter of separated materials rapidly forms which produces a high degree of separation of undissolved materials.

The sacks are arranged in underground chambers in two lines such that the sacks in one line are used first and in order. When all the sacks in this line have reached full capacity, the second line is put into operation by the controlling mechanism. After the second line has gone into operation, the filled sacks can be left to drip off under aerobic conditions for an extended period of time. A rate of drainage to 15 - 20% TS as well as a certain composting effect can be observed.



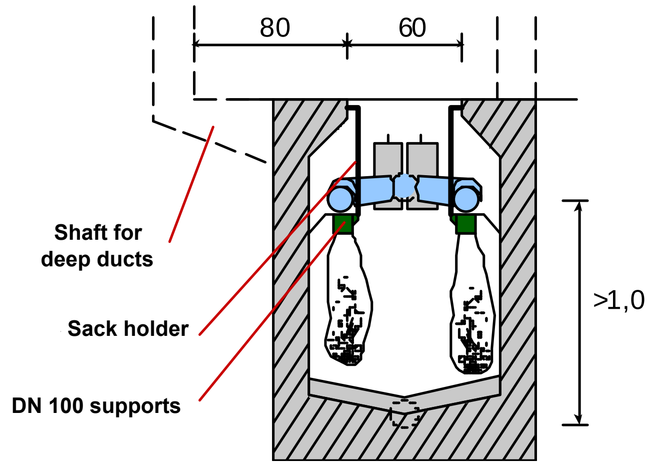
Chamber with filter sacks for mechanical sewage treatment

Filter sack

2. Rating

There are no mandatory standards which apply to the filter sack system.
Rating may be designed following:

- Ingerle, K and Stegner, U: ten filter sacks with a usable volume of 20 kg for 50 inhabitants; following the decision of the department
- of the Styrian provincial government relating to sewage disposal in rural areas: one sack per inhabitant.



Chamber with filter sacks; cross-section

3. Application

The filter sack system is an alternative to conventional mechanical multi-chamber tanks, provided that a height of approx. 1 m is available. It is suitable for use in small waste water treatment plants with serving a community of < 10 inhabitants .

The advantage of the filter sack system lies in the fact that waste water remains fresh and that only solid materials and no sludge water need be disposed of; the disadvantages include the fact that sacks have to be handled and the height loss within the facility.

4. Effectiveness, residual material

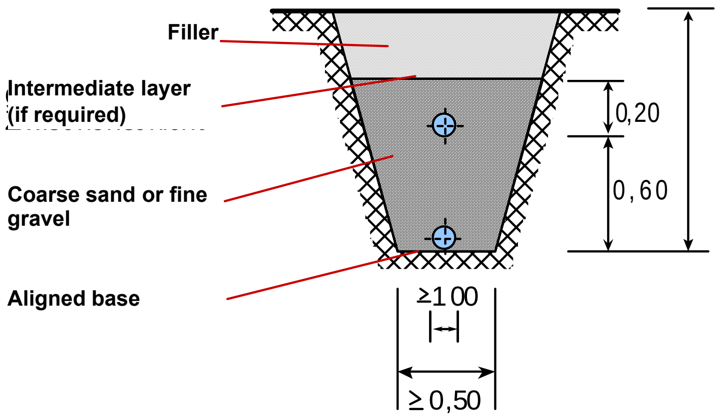
Only sporadic reports have so far been produced regarding the effectiveness of this system. The reductions in BOD and COD assays appear to be comparable to those in multi-chamber slurry pits.

Once filled, the sacks are left to drip off for several weeks and are then removed from the filter chamber, at which point new sacks are put in place.

1. Function and design

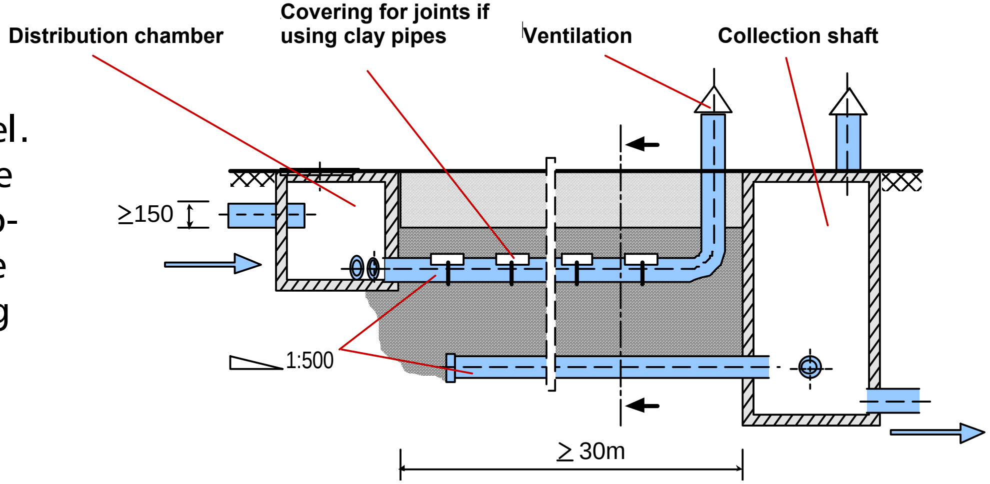
Infiltration trenches are systems for 'naturally' purifying sewage which has gone through preliminary sedimentation using aerobic biological purification. In addition, the secondary sludge produced by this process is separated from the purified waste water, stored, treated and finally 'disposed of'.

Infiltration trenches feature two drainpipes laid on top of one another, the top one for incoming waste water and the bottom one for discharged water. The space in between consists of a filter layer. The purification processes are basically identical to that of an underground trickling system with a sand/gravel base. However, the two drainpipes arranged one on top of the other provide better aeration of the filter layer.



Infiltration trench according to DIN 4261 Part 1

Biological purification is carried out by microorganisms which are present in the fine gravel. Oxygen is supplied from air which is drawn into the gravel after each feeding process through the deep-seeping waste water. A high oxygen supply volume can thus be produced through intermittent feeding of the infiltration trench.



Infiltration trench and filter bed

2. Rating

In accordance with DIN 4261, Part 1 (Small-scale purification systems; Systems without aeration of waste water; Application, rating and design):

- specific length of trench ≥6 m per inhabitant; base width ≥0.5 m; min. depth 1.25 m; length of one single line max. 30 m,
- Filter gravel 2/8 mm, min. 60 cm high; distribution and collection drainage: nominal value 100 with gradient of approx. 1:500; aeration required,
- Base layer must be slightly impermeable to water; use artificial seal if necessary.

The grain size of the filter material suggested in DIN 4261 is a compromise between the desire to achieve the most effective purification - which would require a very fine filter material - and the desire to keep the system functioning for as long as possible without blockages developing.

If space limitations mean that parallel filter trenches have to be laid out so close together that there are no earth mounds separating them, this gives rise to a infiltration bed. Infiltration trenches and filter beds are basically identical in terms of their function.

3. Application

Infiltration trenches are suitable for use in very small systems because the costs of the pipe material, replacing the soil and supplying the gravel make this an uneconomical option for larger plants in comparison with other solutions. Infiltration trenches do not require energy but do require a sufficient difference in height between the incoming water and the outflow. It is not possible to intervene in the purification process to control it.

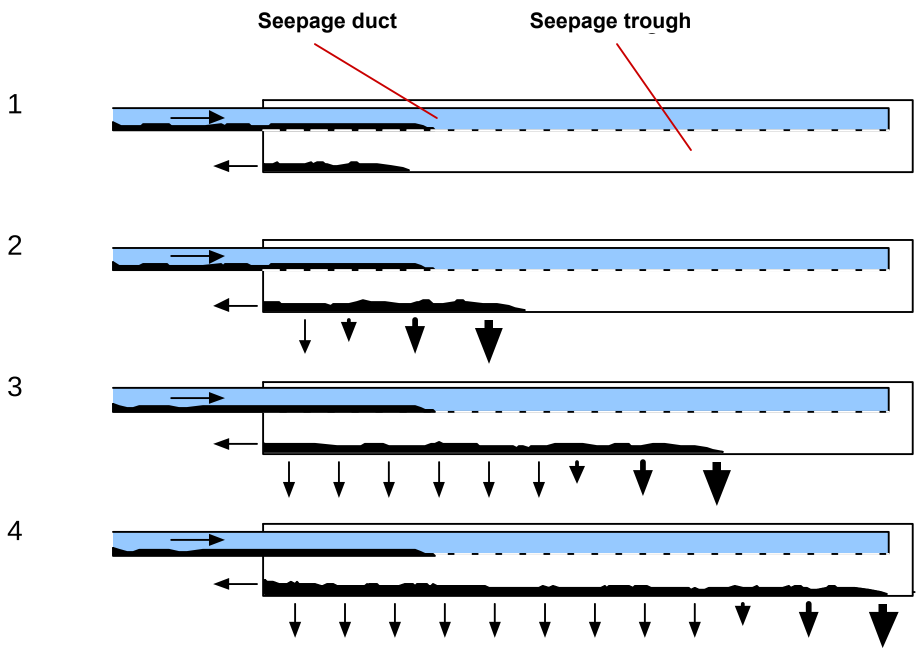
Infiltration trench and filter bed

3. Performance

Few details are available about the actual performance of infiltration trenches and beds built in Germany; most research has been performed in other countries and cannot be easily compared with the results of German filter trenches because the filter material used abroad is often sand and not the fine gravel mentioned by DIN 4261. Because of differing construction methods, impacts and concentrations of waste water in the infiltration trenches studied, the published discharge concentrations differ widely and in a 5-day BOD assay lie between > 100 mg/l and < 10 mg/l.

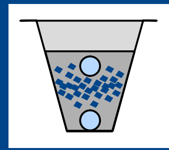
A careful evaluation of the results brings us to the conclusion that an infiltration trench designed and built in accordance with DIN 4261 can achieve a 5-day BOD of <40 mg/l and a COD of <150 mg/l . Extensive oxidation of nitrogen with a NH_4-N discharge value of <10 mg/l, as is required in Austria even for the smallest systems, is also not present.

Given the specific reactor volume of around 5 m^3 per inhabitant, more effective purification might be expected. However, bear in mind that due to the nature of the process, the waste waster only ever flows through a small proportion of the available volume and only this volume is used for purification.



Throughflow in an infiltration trench

Infiltration trench and filter bed



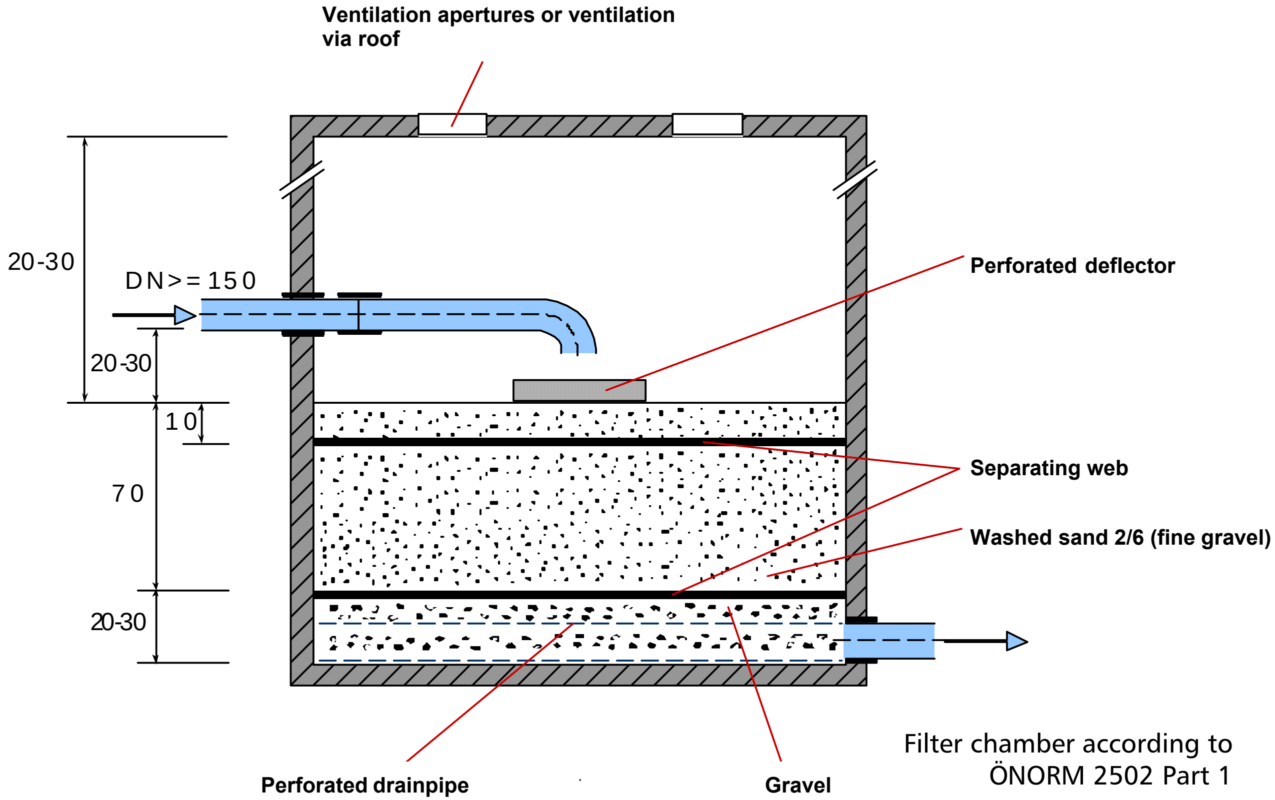
4. Residual material

The biomass produced in the filter unit (secondary sludge) is disposed of continuously as it is consumed by higher organisms and is also continually rinsed out to some degree by the relatively coarse filter material of DIN 4261 standard normally used in Germany, in a similar way to a percolating filter operating with low demand levels. An infiltration trench can therefore be expected to have a useful life of many years. If after an extended period of operation a blockage does occur, it is best to leave the filter material on the bottom and lay a new trench alongside. Residual material therefore normally accumulates only in the preliminary stage but not in the infiltration trench or filter bed itself.

1. Function and design

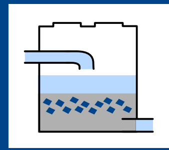
The filter chamber (not commonly used in Germany) has been introduced into the Austria's national standard ÖNORM B 2502 Part 1 (Small-scale purification systems (domestic purification systems) for systems serving up to 50 inhabitants; Application, construction and operation) as an alternative to the infiltration trench. The reason behind this was the required length of infiltration trenches in Austria of 20 m per inhabitant and the resultant high costs for these systems.

Biological purification is carried out by microorganisms which are present in the fine gravel. Oxygen is supplied from air which is drawn into the gravel after each feeding process through the deep-seeping waste water. A high oxygen supply volume can thus be produced through intermittent feeding of the infiltration trench.



Filter chamber according to ÖNORM 2502 Part 1

Filter chamber



2. Rating

DIN 4261 does not cover filter chambers but does provide for soak-aways.

In accordance with ÖNORM B 2502, Part 1 (Small-scale purification systems (domestic purification systems) for systems serving up to 50 inhabitants; Application, rating, construction and operation):

- horizontal filter surface AF ≥ 2 m² per inhabitant, min. 6 m²,
- Height of biological fine gravel layer (2/4 mm) min. 0.7 m.

3. Application

For cost reasons, filter chambers are only a viable option for very small waste water treatment plants.

4. Performance

No details are available about the performance of ÖNORM-standard filter chambers because so few of this type of system have been built as primary stages of biological purification. We can therefore only surmise that a 5-day BOD of < 40 mg/l and COD of < 150 mg/l could be achieved. Nitrification with an NH_4-N value of < 10 mg/l is not to be expected.

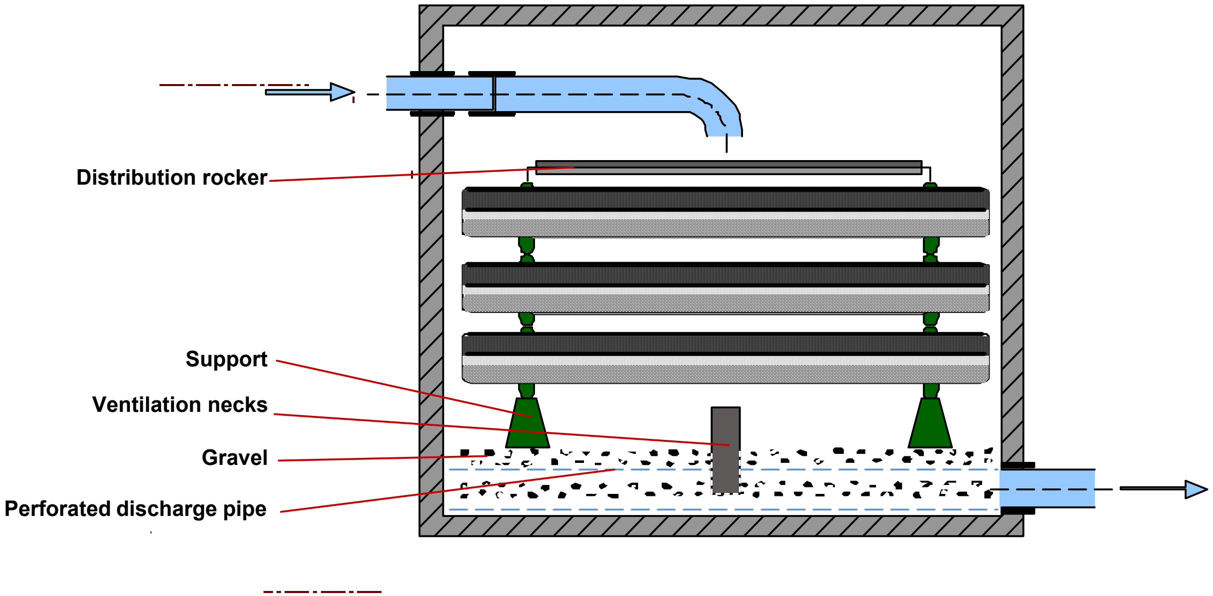
5. Residual material

Depending on the demand placed on the filter chamber, the top 10 - 15 cm of the filter sand will build up sooner or later and will need to be replaced. However, there are no field reports yet available as to when this becomes necessary. The sand which is removed is not 'sludge'; its characteristics are more like the sand collected in community purification plants.

Sediment filter

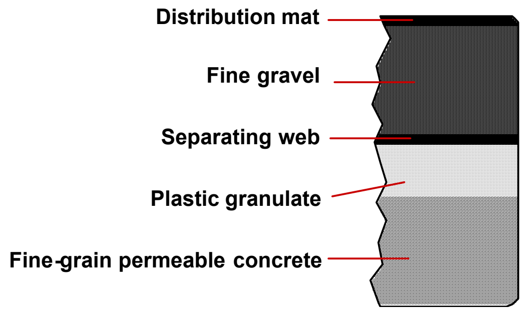
1. Function and design

Sediment filters are another further development of the filter chamber produced in Austria which have also been introduced to the German market. Sediment filters are characterised by the fact that the the total required filter surface is provided by individual 'cups' which are positioned on top of one another and through which material flows in sequence from top to bottom.



The total floor space required is therefore less than a filter chamber but with the same filtering area. The concrete cups are filled with a special filter material. The facility is usually fed intermittently with pre-treated waste water by tipping tanks.

To enhance the effectiveness of purification, sediment filter systems can be combined with a downstream recirculation shaft - discharged water being pumped back into the pre-treatment system - or an upstream percolating filter.



Sediment filter, design and cross-section

Sediment filter

2. Rating

No standards apply to the rating. With reference to the rating for filter chambers in ÖNORM B 2502, Part 1,

- a specific total filter surface of $A_F \geq 2$ m² per inhabitant is usually observed.
- If an upstream percolating filter is present, sediment filters are rated at $A_F = 0.3$ or 0.5 m² per inhabitant

.

3. Application

The preferred area of application is a community size of < 50 inhabitants, although facilities have been built which serve a community size of > 100 inhabitants.

4. Performance

In the case of simple sediment filter systems the limit value for the 5-day BOD of < 40 mg/l and that of the COD, < 150 mg/l, can be achieved but nitrification should not be expected. If nitrification is required, the sediment filter system must be combined with an upstream percolating filter.

5. Residual material

The remarks made about the filter chamber also apply to the filter material of the filter cups in a sediment filter. It is important that the filter material of the topmost cup be changed before signs of a blockage appear in the second cup. This is because it is extremely difficult to change the filter material in the second and subsequent cups.

1. Function and design

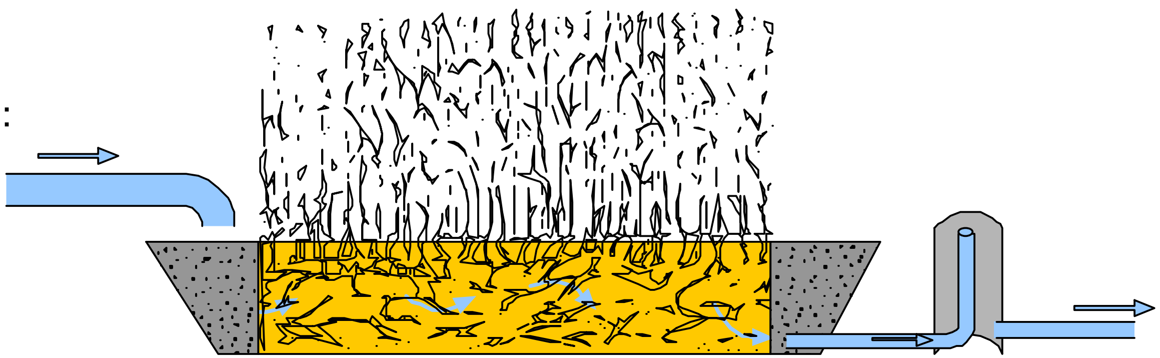
Active principle: plant beds are a component of plant purification systems. They serve to biologically purify waste water which has already gone through preliminary sedimentation. In principle, all plant beds consist of a base planted with marsh plants and covered with sand and gravel. Purification is performed mainly by the activity of microorganisms which live in this base layer, similar to the processes in an infiltration trench. The growth of the plant roots is intended to maintain the hydraulic permeability of the base layer. It is surmised that the plants may have other effects too but there are very few experimental results relating to the effect of the plants. The most important factor for the effectiveness of plant beds is a sufficient supply of oxygen for the microorganism population. The plants themselves do not however make a significant contribution to this.

Process variants: there is a wide range of possible construction and operation methods. A distinction can be made between the following main types:

- with regard to the hydraulic conditions:
  primarily horizontal and
  primarily vertical flow types and
- with regard to the water table situation:
  clogging and non-clogging

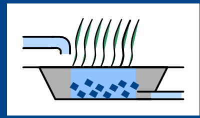
plant beds.

The diagram shows an example of the structure of a non-clogging plant bed.



Non-clogging plant bed

Plant beds



2. Rating

According to Process Sheet A 262 (Draft) (Principles of rating, construction and operation of plant beds for district waste water for community sizes of up to 1000 inhabitants) published by the German Association for Waste Water Treatment (ATV):

- Surface required for horizontal flow
  $A_{PKA} \geq 5\ m^2$ per inhabitant, min. 20 m^2, sediment filter layer thickness 0.6 m, freeboard 0.3 m,
- Surface required for vertical flow
  $A_{PKA} \geq 2.5\ m^2$ per inhabitant, min. 15 m^2, sediment filter layer thickness 0.8 m, freeboard 0.3 m,
- permeability of sediment filter
  $k_f \geq 10^{-4}$ to 10^{-3} m/s,
- Base layer must be sealed ($k_f \geq 10^{-8}$ m/s); if necessary, use artificial seal,
- Plant with reeds, cattails, irises.

3. Area of application

Plant beds exist in all sizes up to around 1000 inhabitants (population equivalent). They are particularly well suited to small communities (individual structures); when considering larger plant purification systems, the issue of cost-effectiveness should be investigated in comparison with 'mechanical' systems.

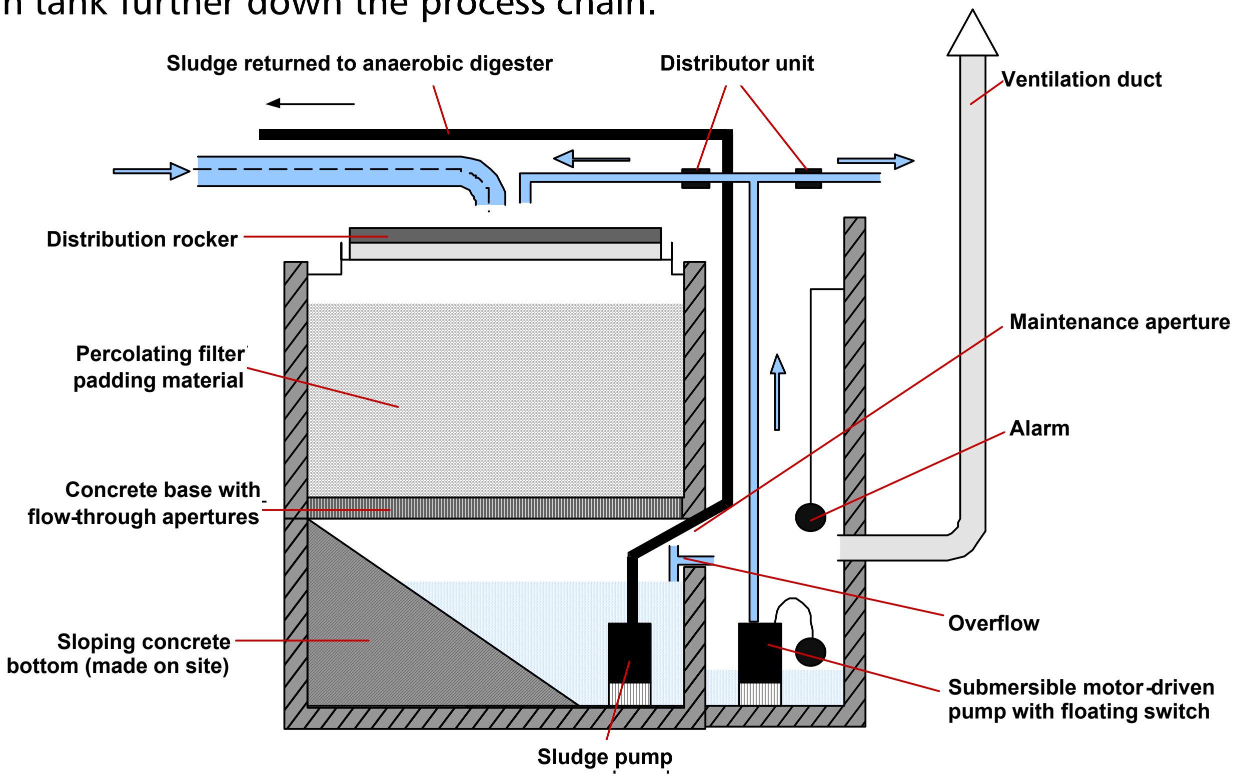
4. Performance, residual material

For the system to be effective, a sufficient supply of oxygen for the microorganism population is essential. Vertical-flow, non-clogging and intermittent-feed plant beds all feature favourable conditions for the supply of oxygen, such that a 5-day BODof <20 mg/l, a COD of <100 mg/l and extensive oxidation of nitrogen with NH_4-N <10 mg/l can be achieved. Horizontal-flow plant beds are less effective because with this system, clogging beds do not provide sufficient oxygen and non-clogging beds only allow material to flow through a part of the sediment filter. With these systems nitrification cannot be guaranteed, but a 5-day BOD of < 40 mg/l and COD of < 150 mg/l can be achieved. As long as the vegetation is not cut or mowed, no residual material should accumulate in the plant bed itself.

1. Function and design

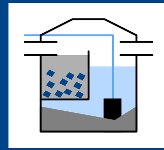
Percolating filters are 'mechanical' components used in the biological treatment of pre-treated waste water. Waste water which has had the sludge removed is spread over a porous padding material with a large surface upon which microorganisms settle. Stone chippings or plastic chips are used as padding material. These microorganisms remove the utilisable, dissolved or finely dispersed matter from the waste water as it trickles over the padding and convert it into biomass which is continuously rinsed out of the percolating filter and separated out in a sedimentation tank further down the process chain.

Small percolating tanks are normally operated using 'return pumps', for example such that the sludge/water mixture pumped from the sedimentation tank to the preliminary treatment stage is a multiple of the of the inflow volume and the sewage is routed via the percolating filter several times.



Small percolating filter with sedimentation pump, sludge pump and circulation pump

Percolating filter



... Function and design

In exposed locations, percolating filters may need to be covered during the winter months to ensure that they do not malfunction. Nowadays, small percolating filters are no longer planned as 'one-offs' because a large number of suppliers in partnership with concrete works now offer complete kits which simply need to be correctly put together on site.

2. Rating

Up to 50 inhabitants: in accordance with DIN 4261 Part 2 (Small-scale purification systems; Systems with aeration of waste water; Application, rating, design and inspection:

- permissible volume load $B_V \leq 0.15$ kg/m^3.d; for waste water which has gone through preliminary sedimentation, required percolating filter volume $V_{PF} \geq 0.27$ m^3 per inhabitant,
- Height of percolating filter $h_{PF} \geq 1.5$ m; return ratio RR = 3,
- when H_{PF} =2.5m, RR = 1.

3. Area of application

There are no upper or lower limits on the areas of use for percolating filters. It should be noted, however, that the applicable standard for the rating of larger percolating filters (>50 inhabitants) is not DIN 4261 but the ATV Process Sheet A 122 (Principles for rating, construction and operation of small purification systems with aerobic biological purification processes for community sizes of between 50 and 500 inhabitants). Percolating filters require less energy than the activation process but the associated construction costs are much higher.

4. Effectiveness, residual material

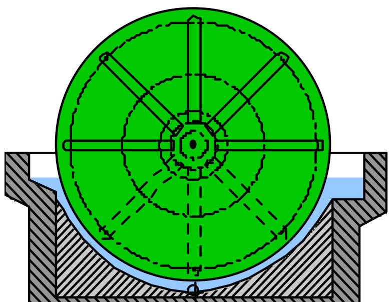
Provided that the rating and design recommendations of DIN 4261 Part 2 are observed, a 5-day BOD of <40 mg/l and COD of <150 mg/l (discharge values) and partial oxidation of nitrogen can be expected. The continuously rinsed secondary sludge and that separated from the waste water in the sedimentation tank accumulates in the percolating filter. It is normally transported to the component where pre-treatment is taking place and disposed of together with the primary sludge.

Rotating biological contactor

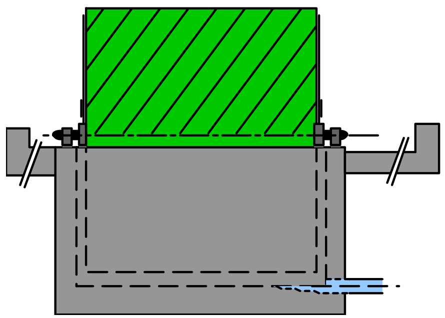
1. Function and design

Rotating biological contactors are used to purify district waste water which has gone through preliminary sedimentation using a process of aerobic biological purification. Rotating biological contactors consist of roller-shaped growth-encouraging units for microorganisms which pivot around a horizontal axis. Various different versions exist. The rollers are immersed about halfway in vats of pre-treated waste water and are set to slowly rotate so that the microorganisms alternately come into contact with waste water and air. There is therefore a periodic alternation between the absorption of food and the absorption of oxygen. Both the microorganisms which are present on the special units and those which move freely about in the vats are involved in the process of biological purification. Nowadays, small rotating biological contactors are prefabricated in the factory and then simply erected or put together on site.

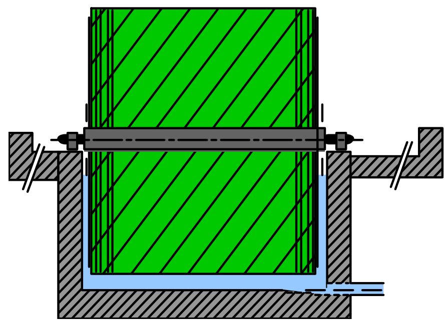
Rotating biological contactor



Cross-section of vertical axis of rotation

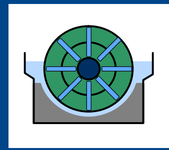


View



Cross-section of axis of rotation

Rotating biological contactor



2. Rating

Up to 50 inhabitants: in accordance with DIN 4261 Part 2 (Small-scale purification systems; Systems with aeration of waste water; Application, rating, design and inspection):

- permissible surface load of $B_A \geq 0.004$ kg/(m² · d)
- for waste water which has gone through preliminary sedimentation, required growth surface area $A_{RBC} \geq 10$ m² per inhabitant
- Min. surface area 45 m².

3. Area of application

There are no upper or lower limits on the areas of use for rotating biological contactors. It should however be noted that, like the percolating filter, the applicable standard for the rating of larger units (> 50 inhabitants) is the ATV Process Sheet A 122. RBCs are also lower energy consumers than the activation process but the associated construction costs are usually higher, assuming that the same purification output is required.

4. Effectiveness, residual material

Provided that the rating and design recommendations of DIN 4261 Part 2 are observed, a 5-day BODof <40 mg/l and a COD of <150 mg/l plus partial oxidation of nitrogen can be expected.

The continuously rinsed-out secondary sludge and that which is separated out further down the process (in a sedimentation tank / lamella separator) accumulates in the rotating biological contactor. It is normally transported to the component where pre-treatment is taking place (multi-chamber settlement tank or slurry pit) and disposed of along with the primary sludge.

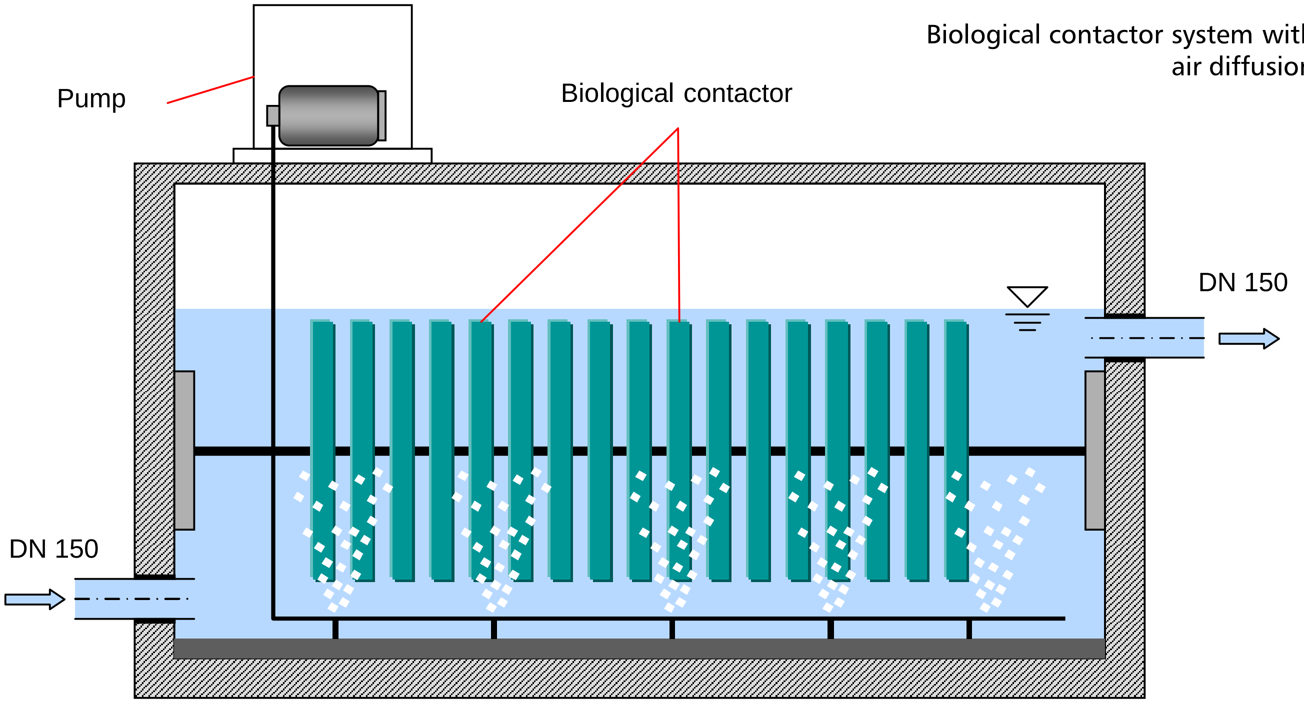
Biological contactor system

Activation process using growth-encouraging units

1. Function and design

Biological contactors, which are still not very frequently used in Germany in small purification plants, are used to purify district waste water which has gone through preliminary sedimentation using a process of aerobic biological purification. Biological contractors are 'packed-bed reactors' where fixed, permanently immersed plastic elements serve as growth-encouraging surfaces for microorganisms. Free-moving suspended microorganisms are also found in the water. Oxygen is supplied from below by diffused air.

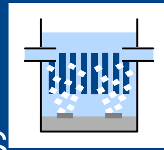
The required reaction volume should be divided between several cascades through which material flows one after the other. The packed bed can be subsequently integrated into existing tanks, e.g. into the third chamber of a multi-chamber slurry pit, and this then converted into an aerobic biological purification system.



Biological contactor system with air diffusion

Biological contactor system

Activation process using growth-encouraging units



2. Rating

No standards yet apply to the rating; for the time being, it would seem reasonable to observe the recommendations given for the rating of RBCs in DIN 4261 Part 2 (Small-scale purification systems; Systems with aeration of waste water; Application, rating, design and inspection):

- permissible surface load of $B_A \leq 0.004$ kg/(m² · d)
- for waste water which has gone through preliminary sedimentation, required growth surface area $A_{BC} \geq 10$ m² per inhabitant
- Min. surface area 45 m².

3. Area of application

From a technical point of view there are no upper or lower limits on the areas of use for biological contactors. It is not yet possible, however, to say definitely whether biological contactors are a viable solution in small-scale purification plants for up to 50 inhabitants in comparison with other options.

4. Effectiveness

Only isolated reports have been produced so far regarding the effectiveness of small biological contactors. According to these, a 5-day BODof < 40 mg/l , a COD of < 150 mg/l (in discharge) and extensive oxidation of nitrogen can be expected.

5. Residual material

The secondary sludge which is continuously discharged with the waste water and separated from the waste water in subsequent separation stages (sedimentation tank / lamella separator) accumulates in the biological contactor. It is normally transported to the component where pre-treatment is taking place (multi-chamber settlement tank / slurry pit) and disposed of together with the primary sludge.

Activation tank

continuously-fed

1. Function and design

Process: continuously-fed activation tanks combined with a pre-treatment stage and downstream sedimentation tank are the most frequently-used 'mechanical' components in both large and small sewage treatment plants for traditional aerobic biological purification. In the traditional, generally familiar version, the waste water which has been through preliminary sedimentation is artificially aerated and powerfully circulated in the activation tank. Free-moving, suspended microorganisms remove the biologically utilisable matter from the water and convert it into biomass. This is separated from the treated waste water in a sedimentation tank further down the process chain. Most of the biomass is returned to the activation tank either continuously or discontinuously (return sludge). Only the continuously forming growth of microorganisms (excess sludge) is removed from circulation and transported to the upstream multi-chamber pit.

For systems serving up to 50 inhabitants, the activation tank is usually aerated by the diffusion of air. Numerous manufacturers offer type-specific and (for smaller systems) pre-fabricated activation systems. These are activation tanks handling low demand levels 'with simultaneous aerobic sludge stabilisation'.

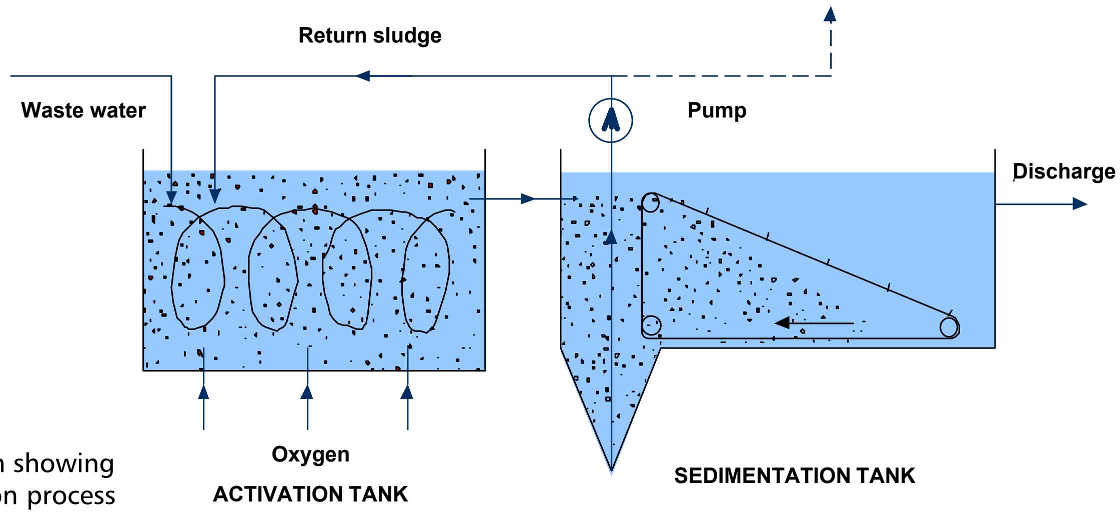
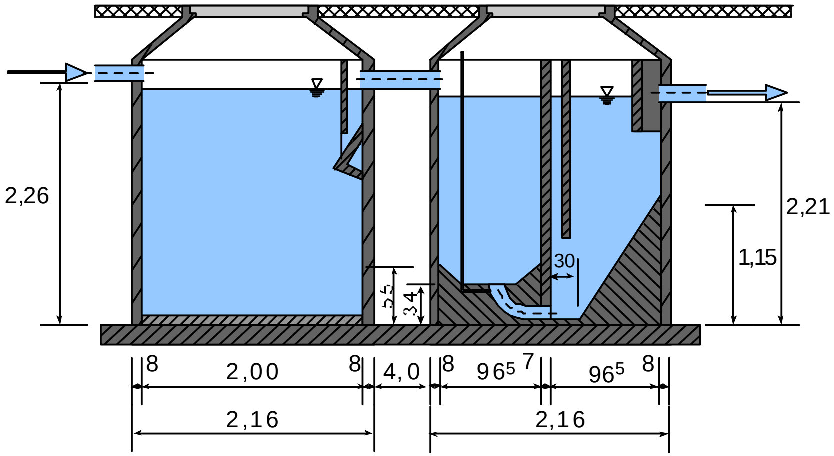


Diagram showing traditional activation process

2. Operation with preliminary sedimentation

In most of these systems a multi-chamber settlement tank is fitted upstream of the activation tank to pre-treat the waste water. This is advantageous, particularly in terms of separating out problematic coarse materials, but it also has disadvantages:

- The inevitable sewage decomposition in the settlement tank can be undesirable for the activation tank (activated sludge, lack of growth particles for the nitrifiers).
- The accumulating sludge is not stabilised and requires separate treatment.
- Preliminary sedimentation involves costswhich are in no way commensurate with the actual contribution to the purification process.



Small activation system with preliminary sedimentation

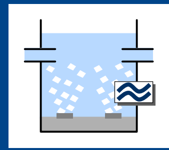
It can therefore be beneficial to dispense with preliminary sedimentation and only to separate out coarse materials contained in the untreated waste water in the interests of operational reliability. The following may be considered:

- Screen baskets or sieve baskets which are suspended in the inflow zone of the activation tank,
- Suspended scum baffles as described by Renner, H. to separate out floating coarse materials.

When comparing costs, bear in mind that if there is no preliminary sedimentation then a separate sludge storage tank will need to be built.

Activation tank

continuously-fed



3. Rating

Up to 50 inhabitants: in accordance with DIN 4261 Part 2 (Small-scale purification systems; Systems with aeration of waste water; Application, rating, design and inspection):

- permissible volume load $L_V \leq 0.2$ kg/m³ · d; for waste water which has gone through preliminary sedimentation,
- required activation tank volume $V_{AT} \geq 0.2$ m³ per inhabitant; min. volume 1 m³,
- aeration unit should ensure O_2 content of ≥ 2 mg/l,
- freeboard (distance between maximum water level and upper edge of tank) ≥ 0.3 m.

Activation tanks without preliminary sedimentation are not covered by DIN 4261; for such systems, ÖNORMen B 2502 Parts 1 and 2 prescribe a minimum volume of 0.3 m³ per inhabitant.

4. Area of application

There are no upper or lower limits on the areas of use for the activation process. The activation process can produce particularly good purifying effects, but the energy required is generally greater than that for percolating filters and RBCs.

5. Performance, residual material

Using the specific tank volume stated above, a 5-day BODof <40 mg/l, COD of < 150 mg/l and NH_4-N of <10 mg/l (discharge) can be expected.

In an activation tank with preliminary sedimentation, the excess sludge (secondary sludge) produced by microbial activity and separated out in the sedimentation tank accumulates and is usually transported to the component where pre-treatment is taking place. In the case of activation tanks without preliminary sedimentation, the excess sludge which accumulates in the activation tank is an aerobically stabilised mixture of primary and secondary sludge. The sludge requires no further treatment; it is stored in a separate tank until it can be disposed of.

Activation tank

Sequencing batch method

Function and design

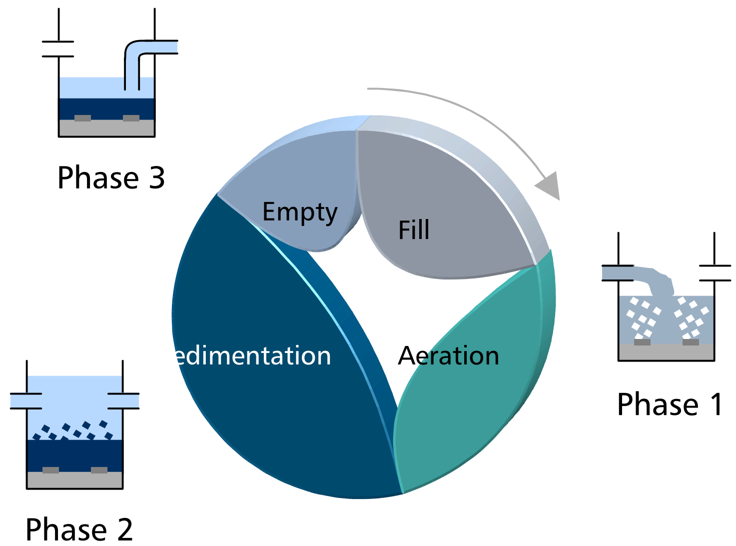
An activation tank using the sequencing batch method is a remake of an old idea. With this method, the phases

- aeration phase (aeration switched on, interrupted by pauses if necessary; no outflow; water table rises according to inflow to the system),
- settlement phase (aeration switched off; no outflow; water table continues to rise; activated sludge sediments) and
- removal phase (aeration switched off; clarified water is discharged or pumped off)

alternate periodically once or several times a day. The timing of the three phases can be controlled in terms of volume or time or a combination of the two.

The advantage of the sequencing batch method is that there is no need for a sedimentation tank. On the other hand, the release of treated water can be intermittent in sensitive discharge systems. It would not be correct to describe any and every kind of sequencing batch process as a 'single-tank system' because although this process dispenses with the sedimentation tank, a sludge storage tank must still be present.

DIN 4261, Part 2 does not cover the activation process using the sequencing batch method. In principle, the remarks made about continuously-fed activation tanks apply with regard to rating, area of application and residual materials.

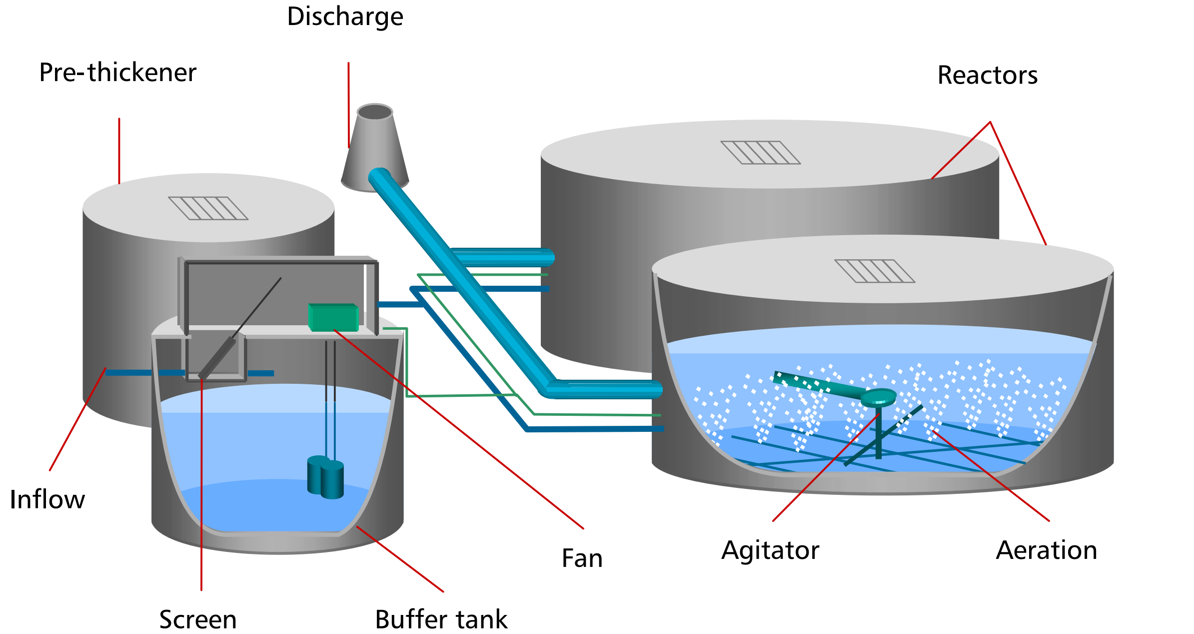


1. Function and design

Sequencing batch reactors (SBRs) are purification systems which use the activated sludge process which operates using batches. Here, processes which in the biological stage of a conventional community plant would take place in separate locations all function in the same tank in sequential steps. In certain size ranges the price of a container does not increase in a direct relation to the tank volume, and it is often cheaper to set up two identical components than to build an activation tank and sedimentation tank. SBRs are therefore particularly suitable for smaller community sizes as of about 8 inhabitants because in these scenarios they can be built more cheaply than continuous systems. However, a control system is always required.

The advantages compared with conventional small activation plants include:

- can be controlled regardless of load
- functions with more energy savings
- usually produce better discharge values.



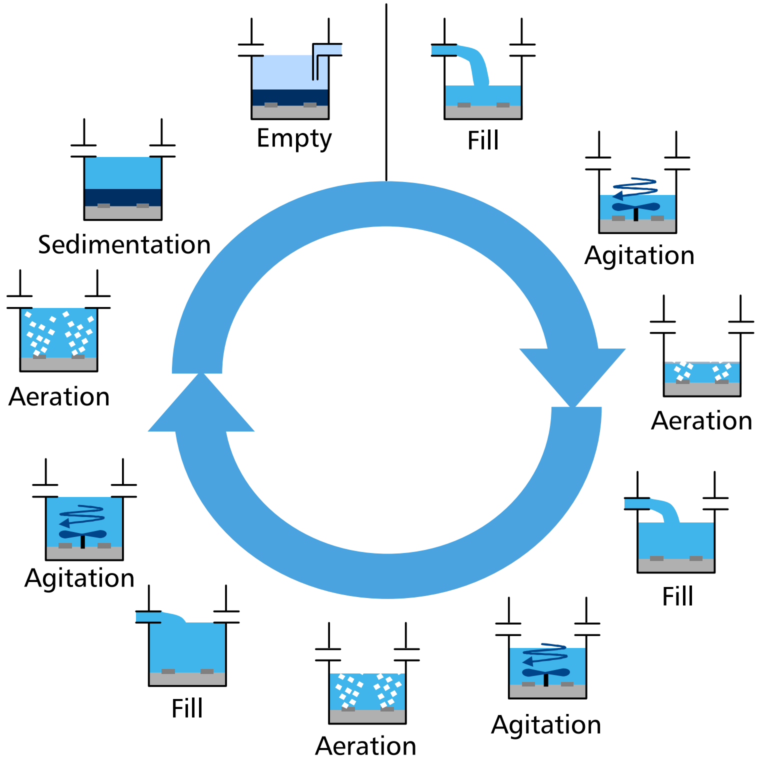
SBR system with two reactors by MALLBETON

... Function and design

A small SBR system generally consists of a two-chamber intake tank. This is where mechanical pre-treatment take place, i.e. the settling of large, heavy solids, and where the volume and concentration of waste water is buffered. From here, the waste water passes into the actual reactor tank at predefined control intervals.

2. Treatment phases

There are various control processes, which may take the following form: During filling and for a defined period thereafter, the sludge is artificially aerated. After aeration the sludge settles to the bottom of the reactor tank. From here, part of the activated sludge (excess sludge) is pumped into the sludge tank before the clarified water flows off. The reactor, which will still be around 30 - 70% full, is then aerated at defined intervals until fresh waste water is again pumped in under aeration. If there is no aeration, an agitator is activated. By selecting the appropriate agitation interval, denitrification can be performed in systems with nitrification. To do this, agitation should be performed during and after the filling process so that the nitrate formed during the previous cycle can be processed.



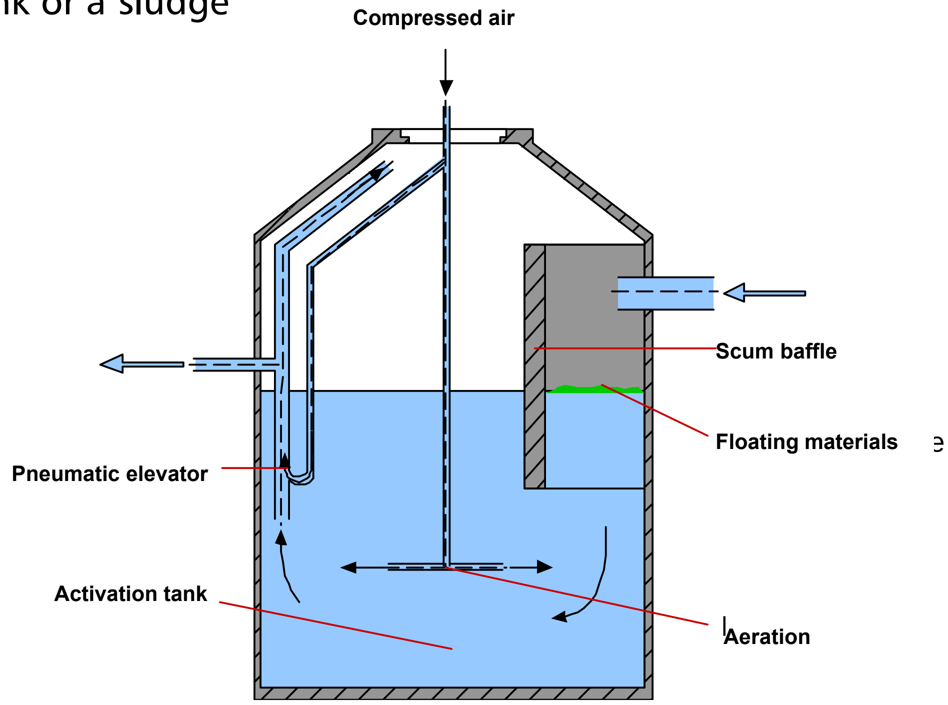
Phases of a cycle in sequential biological purification

Enlarged activation tank

1. Function and design

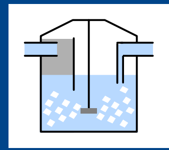
One special form of the sequencing batch process is the 'authentic' single-tank small activation system, first built in the Austrian province of Styria, which does in fact consist of only one tank (the activation tank) and does not feature preliminary sedimentation, a sedimentation tank or a sludge storage tank. One special form of the sequencing batch process is the 'authentic' single-tank small activation system, first built in the Austrian province of Styria, which does in fact consist of only one tank (the activation tank) and does not feature preliminary sedimentation, a sedimentation tank or a sludge storage tank.

This is made possible by incorporating an enlarged activation tank with a specific volume of 1.5 - 2 m 3 per inhabitant. With a container of this size, the amount of sludge in the activation tank increases so gradually that it is only necessary to remove excess sludge every one to one and a half years, such that the activation tank also takes over the function of the sludge storage tank. In this system, treated water is pumped off once a day, overnight, by an air-lift pump (Renner, H.). This method makes the facility completely insensitive to fits and starts in the inflow; however, the disadvantage is the intermittent discharge of the treated waste water.



Single-tank small activation system

Enlarged activation tank



2. Rating

No standards apply to the rating. The specific volume of 1.5 - 2 m^3 per inhabitant stems from an assumed volume of accumulated sludge of 35 g/(inhabitant · d) and the requirement that the sludge accumulated in one year can be stored in the activation tank between two removals of excess sludge.

3. Area of application

For small communities these systems are straightforward and cheap to build, but become more expensive for larger community sizes of > 20 inhabitants.

4. Effectiveness

Nitrification possible: in the discharge, values below a 5-day BODof <10 mg/l, COD of <70 mg/l and NH_4 -N of <5 mg/l can be achieved on a regular basis. Fears that an activation tank with a specific volume of 1.5 - 2 m^3 per inhabitant would be constantly underloaded and therefore provide poor treatment quality have, in practice, been proved unfounded; in fact, the opposite seems to be the case.

When required (when the system is working at full capacity, once a year) the tank is completely emptied so that only a small amount of seeding sludge is left. The sludge is aerobically stabilised but may contain non-decayed, visible coarse material from hygiene products if the residents who depend on the facility do not exercise sufficient discipline.

Sedimentation tank

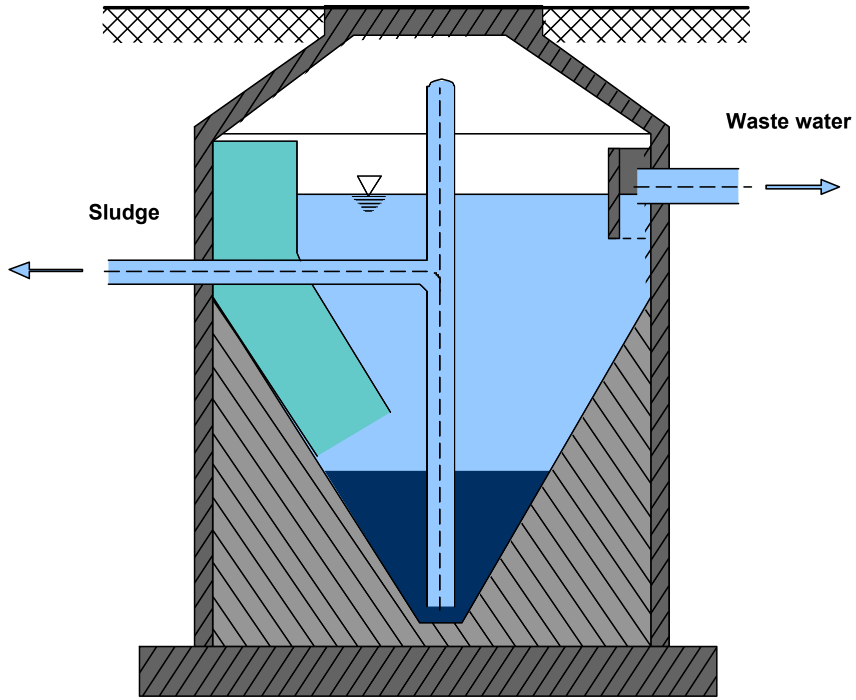
1. Function and design

The sedimentation tank is the component most frequently used for separating out biomass from treated waste water. In small-scale purification plants, it normally takes the form of a hopper tank. In these systems, the sedimentation tank is frequently combined with the biological reactor to form one single structure. It is unnecessary to go into detail about function and design principles.

2. Rating

Up to 50 inhabitants: in accordance with DIN 4261 Part 2 (Small-scale purification systems; Systems with aeration of waste water; Application, rating, design and inspection:

- Throughflow time $t_{ST} \geq 3.5$ h,
- Surface area $A_{ST} \geq 0.7$ m²,
- Water depth $h_{ST} \geq 1$ m,
- permissible surface loading depends on the type of upstream biological reactor,
- for activation tanks, $q_A \leq 0.3$ m/h; for packed-bed reactors (percolating filters, RBCs, biological contactors) $q_A \leq 0.4$ m/h.



Sedimentation tank (hopper tank of a small-scale purification plant)

Sedimentation tank

3. Area of application

There are no upper or lower limits on the areas of use for sedimentation tanks.

4. Effectiveness

The Institut für Bautechnik (Institute for Construction Technology) in Berlin demands a limit value of 0.3 ml/l of solid materials in the discharge from the sedimentation tank before a quality mark can be awarded. This figure must be met in qualified random sampling and according to the '4 out of 5' rule. An indirect regulation also applies to the performance (separating effect of the biomass) of the sedimentation tank, because a 5-day BODof <40 mg/l and a COD of <150 mg/l may not be exceeded in the discharge. The limit values given here can be met under normal operating conditions; major hydraulic overload may however cause these values to be exceeded as a result of the discharge of sludge.

5. Residual material

In the sedimentation tank itself no residual material is produced; only the biomass from the upstream biological process is separated from the purified water. If an upstream packed-bed reactor is present, the deposited biomass is usually transported as a whole to the component providing preliminary treatment. If an activation tank is being used, most of the sludge is routed back to the activation tank (return sludge) and only the continuous build-up of sludge (excess sludge) is removed from circulation using various different methods and then transported to the preliminary treatment component or a sludge storage tank as the case may be.

Lamella separator

1. Function, design and application

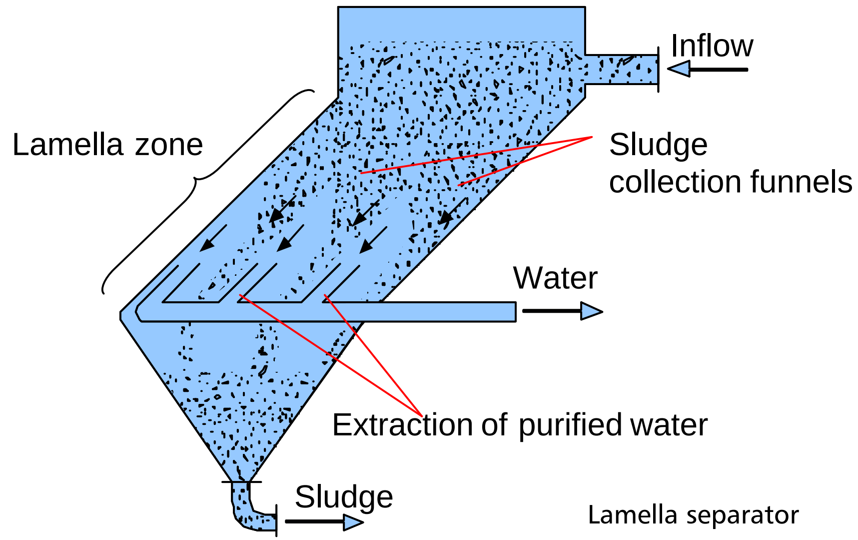
Like the sedimentation tank, the lamella separator (see Fig. 6.14) serves to separate out the biomass from treated waste water. It consists of a bundle of plates or pipes with a parallel incline through which the sludge-containing waste water flows either upwards (counterflow) or downwards (co-current flow). Solid particles sediment and slide downwards to the plates or the bottom of the pipes. Thus, a lamella separator can be likened to several very flat settlement tanks arranged on top of one another with inclined bases. The advantage of the lamella separator is that, compared with conventional settlement tanks, it takes up less room.

Lamella separators are normally used with systems serving > 50 inhabitants, particularly when it is important that the facility take up as little space as possible (compact and container treatment plants). In terms of effectiveness and accumulation of residual material, please refer to the remarks given for the sedimentation tank.

2. Rating

No standards apply to systems serving up to 50 inhabitants; indicators can be found in Process Sheet A 122 (Principles for rating, construction and operation of small purification systems with aerobic biological purification processes for community sizes of between 50 and 500 inhabitants) from the Association for Waste Water Treatment (ATV):

- permissible surface load $q_A \leq 0.4 - 0.6$ m/h
- The surface is considered to be the total of the horizontally projecting lamella surfaces.



Lamella separator

Sludge storage tank

1. Function and design

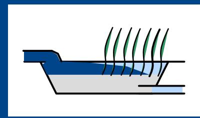
Since organisation of the removal of sludge cannot always be guaranteed at short notice at any time of the year, small-scale purification plants need a sludge storage capacity of several months. If a multi-chamber slurry pit is being used for preliminary treatment, there should be sufficient storage space; if using a multi-chamber settlement tank, extra volume will need to be provided. Activation systems without preliminary purification require their own sludge storage tank, normally a simple tank with a base which inclines towards a sunken point.

2. Rating

In accordance with DIN 4261, Part 1 (Small-scale purification systems; Systems without aeration of waste water; Application, rating and design):

- If a plant has a multi-chamber slurry pit for preliminary purification, this can be used to perform the function of the sludge storage tank; no additional storage space will be required.
- If a plant is using a multi-chamber settlement tank for preliminary purification, this can also be used to store the sludge if its capacity is enlarged to 0.05 m^3 per inhabitant for packed-bed reactors (percolating filters, RBCs, biological contactors) or by 0.125 m^3 per inhabitant for activation systems (sludge storage supplement).
- Activation systems without preliminary treatment require a separate sludge storage tank. The volume should amount to 0.25 m^3 per inhabitant. The issues of application, effectiveness and residual material do not apply to the sludge storage tank.

Effluent sludge composting bed



1. Function and design

Conventional sludge drying beds in their traditional form, with a concrete surround and base drainage, have become less important in small-scale treatment plants since the introduction of vacuum liquid manure tanks and gully emptiers for removing and disposing of liquid sludge.

A more recent development is the effluent sludge composing bed, which dehydrate and 'refine' anaerobically or aerobically stabilised sludge (Reinhofer, M). These are simple basins of soil which can be sealed with a film whose base is laid with a gravel drainage layer covered with humus. Similar to plant beds, reeds and other aquatic plants are planted in the humus and the basin is then fed continuously with liquid sludge. Water flowing off through the drainage system is routed into the inflow to the purification plant.

The plants help the sludge water to evaporate and contribute to converting the sludge, over the course of a few years, into an earthlike product comparable to compost with a water content of approximately 60%. The original volume of sludge is considerably reduced.

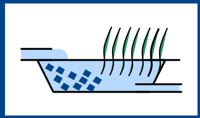
2. Rating and application

Rating: no standards apply to the rating of composting beds. A surface area of $A_{KVB} \geq 0.25 – 0.5$ m³ per inhabitant is recommended.

Composting beds have already been built for communities of several hundred inhabitants.

The remaining material, a volume of around 15 - 20 l/(inhabitant · a) is similar to humus.

Polishing pond



1. Function and design

Polishing ponds provide advanced purification of biologically treated sewage before it is allowed to flow into sensitive discharge systems. They constitute a simple process for enhancing output water in terms of suspended solids, organic load (5-day BOD, COD), nitrogen, phosphorus and bacteria. The growth of algae during warm months can however result in the water discharged from the polishing pond demonstrating poorer results in the 5-day BOD and COD than when it flowed in.

2. Rating

No standards apply to systems serving up to 50 inhabitants; indicators can be found in Process Sheet A 201 (Principles for rating, construction and operation of waste water ponds etc.) from the Association for Waste Water Treatment (ATV):

- Throughflow time 1 - 5 days; water depth 1 - 2 m,
- Impact surface in inflow area, deflective surfaces if necessary; the sludge removal method to be used must be considered at the early planning stage.

3. Application

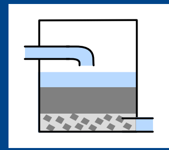
As far as small-scale treatment systems are concerned, polishing ponds have frequently been built for individual houses downstream of small plant purification systems. The main focus is often the pond's function as a storage pond to allow purified waste water to be used for watering the garden.

4. Performance, residual material

It is not possible to make any general statements because the effectiveness of a polishing pond depends on the properties of the inflow, the throughflow time and the season. However, so long as there is no secondary contamination caused by algae and assuming that all significant parameters are present, a significant fall to less than half of the original concentration can normally be expected.

The level of accumulation of sludge is minimal; the height of sludge deposits grows by only a few centimetres a year. The sludge which needs to be cleared out at intervals of several years is well-stabilised.

Sand filter for post-treatment



1. Function, design and application

Sand filters as a post-treatment stage after 'mechanical' small-scale purification systems are a very effective way of enhancing output water before it flows into sensitive discharge systems. Their effect is to hold back all suspended solids, to reduce the 5-day BOD, COD and ammonium-nitrogen levels and, if a ferrous base material is used, to eliminate phosphorus to a certain degree. They also serve to moderate the outflow, which is particularly desirable in sequencing batch activation systems, and provide assurance that brief malfunctions in the technical facilities will not have an immediate impact on the receiving water. Process: post-treatment sand filters are similar in structure to filter chambers and plant beds and, provided they are built with an open design, are usually planted with reeds etc. They may also create themselves a natural cover over time as seeds of various types are spread.

2. Rating

Rating: no standards apply to downstream sand filters. Data Sheet No. 3 (Waste water disposal in external applications (small-scale purification systems)) of the North Rhine-Westphalia environmental agency recommends

- a surface area $A_{SF} \geq 0.2$ m² per inhabitant
- to ensure a long service life, it is better to opt for a surface area $A_{SF} \geq 0.5$ m² per inhabitant
- or, for domestic purification systems, even up to 1 m² per inhabitant

.

3. Application, performance

Various sized post-treatment sand filters have already been built for communities of several hundred inhabitants.

With the exception of phosphorus, the discharge values of a sand filter are close to those of natural discharge systems.

With a normally functioning biological primary stage, no residual material requiring disposal accumulates in a large-sized post-treatment stage.

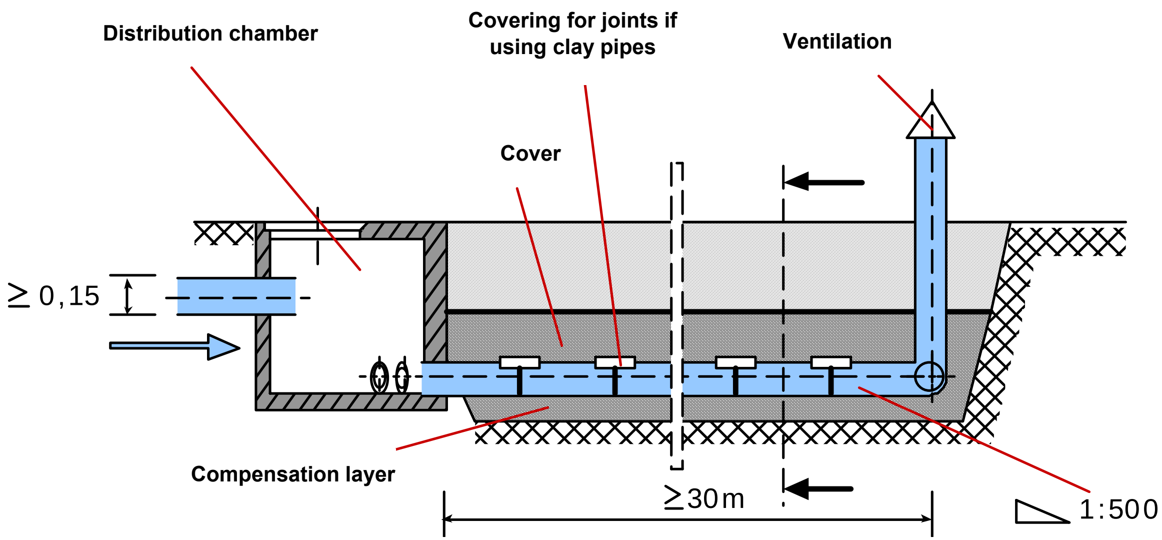
1. Function and design

The underground trickle system is not a component of the sewage treatment plant in itself; rather, it serves to route pre-treated waste water into the subsoil following a line or plane. Microorganisms in the natural base do however cause biological purification to take place beneath the trickling system. A permeable base is required for application of the system.

2. Rating

In accordance with DIN 4261, Part 1 (Small-scale purification systems; Systems without aeration of waste water; Application, rating and design):

- Length of trench l, depending on base layer: if gravel and sand, ≥10 m per inhabitant, if loamy sand, ≥15 m per inhabitant, if sandy loam, ≥20 m per inhabitant,
- Distribution drainage pipes NW 100, gradient 1:500; aeration required
- Minimum distance from ground water 0.6 m.



Underground trickle system
in accordance with DIN 4261 Part 1

3. Application

Underground trickle systems are preferred for small plants. In terms of observation, one disadvantage is that the processes of decomposition and purification taking place underground cannot be monitored.

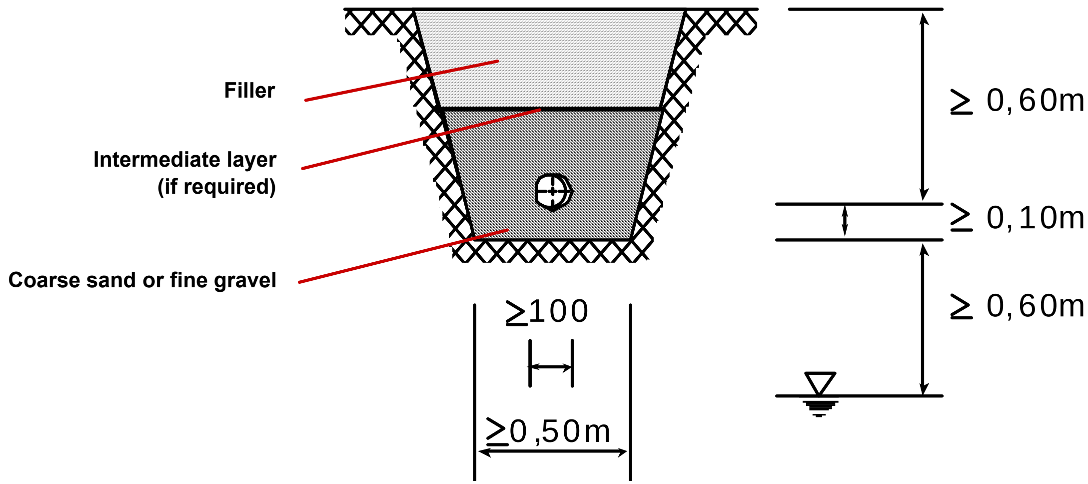
4. Performance

The trickle system itself does not make a significant contribution to the purification of waste water. No general statements can be made as to the performance of the base layer because the degree of decomposition of the water contents depends on the soil characteristics and the vertical distance underground through which the water can seep.

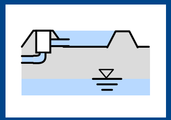
3. Application

No residual material accumulates in an underground trickle system. In a natural base layer, if the system has been designed properly a balance will emerge in the long term between the creation of biomass and the simultaneous consumption of biomass by higher organisms.

Underground trickle system
in accordance with DIN 4261 Part 1



Seepage basin



1. Function and design

A seepage basin is used to convey treated waste water into the subsoil over a large surface area above ground. It is a flat soil basin with a permeable base, planted with vegetation, which is fed intermittently with treated waste water.

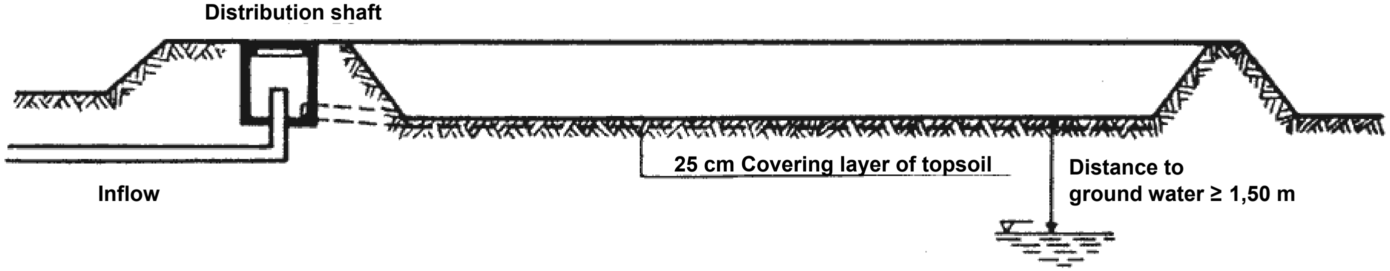
2. Rating

No standards apply to seepage basins. Data Sheet No. 3 (Waste water disposal in external applications (small-scale purification systems)) of the North Rhine-Westphalia environmental agency recommends a surface area A_{SB} = 5 -10 m² per inhabitant depending on the permeability of the base layer.

4. Performance, residual material

It helps to purify the water by holding back all suspended solids, reducing the 5-day BOD, COD and ammonium-nitrogen levels and, if a ferrous base material is used, to eliminate some phosphorus. However, these effects cannot usually be demonstrated since it is impossible to take representative water samples from the subsoil.

If designed properly no residual material requiring disposal should accumulate, in the natural base layer a balance will emerge between the existing/filtered biomass and the simultaneous consumption of biomass by higher organisms.



Cross-section of seepage basin

1. Function and design

If purified waste water cannot be conveyed into a discharge system or underground using laminar trickling / seepage or a system located near the surface, a soak-away can be an essential part of a sewage treatment system. It is used to route treated waste water underground and not to purify it.

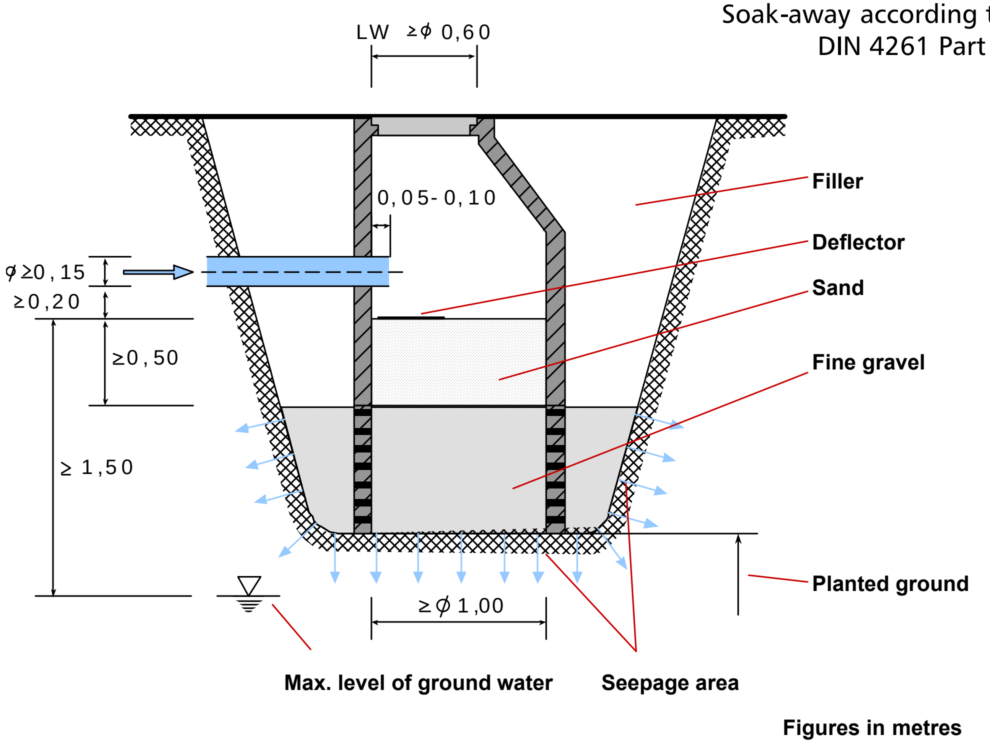
The sand layer underneath the deflector should not therefore be considered as a biological reactor but simply as a mechanism to prevent the ingress of suspended solids into the base layer and to ensure a long service life for the soak-away.

2. Rating

In accordance with DIN 4261, Part 1 (Small-scale purification systems; Systems without aeration of waste water; Application, rating and design):

- The required usable seepage surface area depends on the absorption capacity of the ground and the height of the water column in the soak-away; guide value $A_{SA} \geq 1\ m^2$ per inhabitant.
- Diameter of shaft ≥1 m; minimum distance from ground water 1.5m.

Soak-away according to DIN 4261 Part 1



Selecting a small-scale purification plant

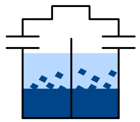
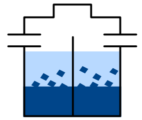
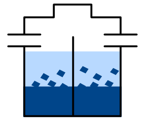
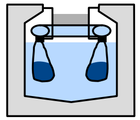
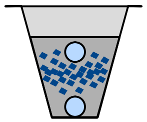
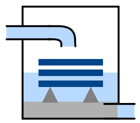
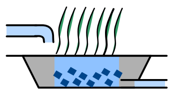
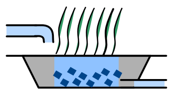
1. Possible combinations

As mentioned previously, one single component does not represent a water purification system in itself; it only becomes one when combined with other appropriate components. The combination possibilities are manifold, as is the number of possible types of sewage treatment systems.

In the following summary of the different types, purification processes are divided simply into the two largest groups, 'semi-natural' and 'artificial' processes. This summary does not cover all the conceivable combinations, only those which have already been used on many occasions.

All system types can be equipped with extra components such as sludge composting beds, polishing ponds or post-treatment sand filters. Underground trickle systems, seepage basins or soak-aways can be necessary when there is no receiving water (discharge system) available to receive the purified water.

Semi-natural processes

Type A	Type B	Type B	Type D
 Multi-chamber settlement tank	 Multi-chamber settlement tank	 Multi-chamber settlement tank	 Filter sack
 Infiltration trench	 Sediment filter	 Plant bed	 Plant bed

Selecting a small-scale purification plant

... Possible combinations

Mechanical processes

Type E	Type F	Type G	Type H	Type I	Type J	Type K
Multi-chamber settlement tank	Multi-chamber settlement tank	Multi-chamber settlement tank	Multi-chamber settlement tank	Activation tank	Activation tank, sequencing batch method	Enlarged activation tank, sequencing batch method
Percolating filter	Rotating biological contactor	Sludge storage tank	Sludge storage tank	Sedimentation tank	Sludge storage tank	Sludge storage tank
Sedimentation tank	Sedimentation tank	Rotating biological contactor	Activation tank	Sludge storage tank		
		Lamella separator	Sedimentation tank			

Selection criteria

1. Size

In principle, all the waste water treatment plant types listed here can be used for all community sizes of up to 50 inhabitants. Types A, D and K are particularly suitable for domestic systems serving up to around 10 residents.

2. Period of usage

For obvious reasons, if a small purification plant is only to be used temporarily the 'lost' investment costs should be kept as low as possible The ideal solution for short-term usage is transportable units in containers. This kind of solution is obviously only available for 'mechanical' purification methods. The available range of transportable treatment systems for communities of up to 50 residents is however somewhat meagre. For small domestic purification systems, the costs of constructing a multi-chamber slurry pit + plant bed combination (Type C) are relatively low. If these components are also used as rainwater storage tanks / wetland areas etc. after being connected to the sewage system, there will logically be no 'lost' investment costs.

3. Construction and operating costs

The local situation regarding building costs and the treatment method to be used will influence the costs of investment. The trend is that 'semi-natural' processes are more cost-effective for small community sizes (domestic systems), while 'mechanical' solutions are a better cost option for larger community sizes. However, the main reason for the difference in costs is the scope of services and quality of construction. The services supplied range from 'ex-works concrete parts' to turnkey facilities including planning, approval, connection to the national grid etc. When designing a system, the possible options range from quality concrete and stainless steel to coated iron and recycled plastic. This is not to say that only an expensive sewage treatment system will work; the point is simply that differing prices can represent very different services.

Selection criteria

... Construction and operating costs

The details given about operating costs are not based on uniform principles. It has been shown that

- cost comparisons for operating costs sometimes only take electricity costs into account,
- and companies' documentation often gives no information about the time required to manage a system correctly
- sewage treatment operators' hourly rates for ongoing system management vary enormously and
- the costs of regular maintenance by the manufacturing company and the officially required discharge inspections vary greatly.

For the reasons listed, it is impossible to make any reasonable absolute statements about the costs of constructing and operating small-scale water purification systems. We can say with certainty, however, that the smaller the system, the higher the specific construction and operating costs.

4. Requirements

The minimum requirements which apply in Germany can be observed when using all of the system types listed above. For purification effectiveness requirements which exceed these, large-sized activation systems are recommended, supplemented by downstream sand filters. If managed properly, this system combination achieves a level of purification which is is no way inferior to a large-scale sewage treatment plant.

Selection criteria

5. Space requirements

'Semi-natural' purification methods, particularly the open beds of plant purification systems, require a lot of space which is not always available. Not everyone is happy to have a wetland area filled with waste water next to their house if it is not totally odour-free. No such problems are associated with an underground 'mechanical' system.

6. Disposal of effluent sludge

Regardless of the type of treatment system used, sludge will accumulate which has to be disposed of. If it is possible to dispose of effluent sludge for agricultural purposes in the vicinity of the plant, it is best to choose combined processes which yield stabilised sludge, e.g. a combination of a multi-chamber slurry pit and a 'natural' biological purification process or an activation tank without preliminary treatment.

Decentralised Waste Water Treatment (End)

Tasks, function and selection of small-scale purification plants

Contents

End Continue

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