



## Biological pre-treatment for constructed wetlands and soil infiltration systems

### Biological pre-filters

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## Pre-treatment by biological filters



Practiced in Norway since 1990-95:

- First developed in Norway as a pre-filter in horizontal subsurface flow constructed wetland (HSFCW)
- To supply air during cold season
- To enhance nitrification processes improving N removal
- To pre-treat effluents from septic tanks by reduction of organic matter
- To avoid possible clogging occurring in CWs or infiltration systems
- Reduce the specific area in succeeding filters

In addition, pre-filters decrease load of these effluents into CWs and infiltration systems - stable and high effect of treatment can be achieved

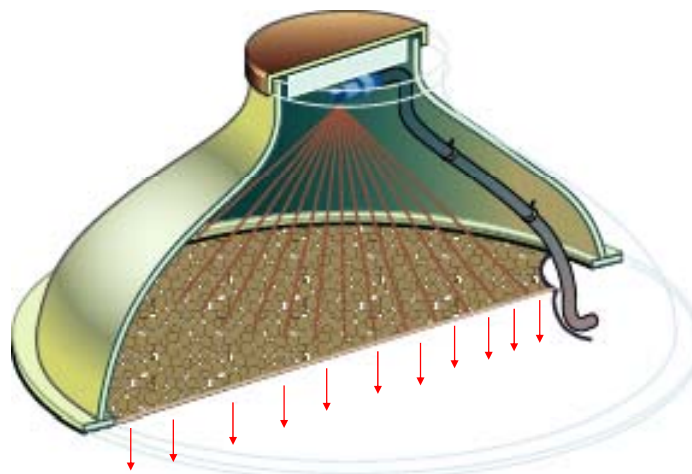
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## Pre-treatment by biological filters



- Effluent sent (via pump) from the septic tank is evenly distributed in the biofilter media
- The effluent distribution can be performed either by infiltration pipes or by spray nozzles
- Pre-filters with spray nozzles, "low-charged trickling biofilters", provide higher treatment efficiency
- Low-charged trickling biofilters became standard prefilters used in norwegian design of CWs treating domestic wastewater
- The later years low-charged trickling biofilters also more used as pre-filters before traditional infiltration systems

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Example of biological pre-filter in a dome

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## Design principles of pre-filters

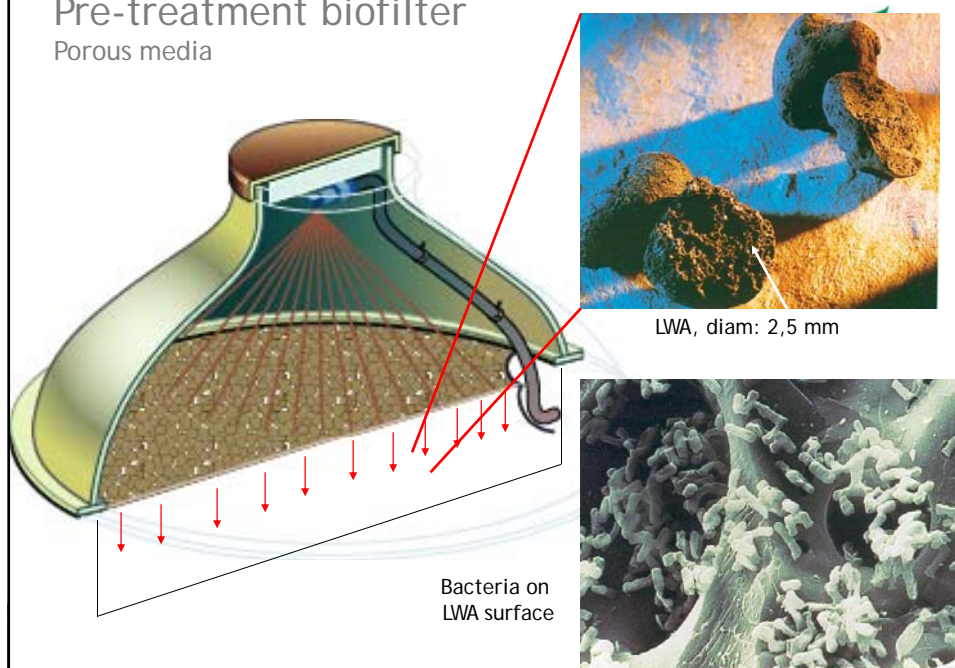


- The pre-filter constitutes a down (vertical) flow aerobic filter (biofilter) with coarse filter media, 2-10 mm
- Can be built in a dome, a tank or a bed, depending on local conditions
- The filtermedia used in most pre-filters in Norway is specially developed LWA (Light Weight Aggregate) - Filtralite® NR material (N - normal density, R - round)
- Normally used grain size of 2-4 mm or more coarse material with grain size of 4-10 mm
- Effluent from the septic tank is evenly distributed on the surface of the biofilter media by pump and nozzles
- Minimum depth of the pre-filter is 0,6 m (including a 10 cm drainage zone for effluent)
- The drainage zone usually constitutes a drainage pipe that effectively drains the biofilter media
- The drained effluent from the biofilter runs off gravitationally

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## Pre-treatment biofilter

Porous media







## Loading rates



- The surface area is a dimensioning parameter and it mainly depends on two factors;
  1. daily water consumption (l/pe) and
  2. hydraulic load (cm/d or l/m<sup>2</sup> per day)
- Daily water consumption = 200 l/pe per day (Norwegian guidelines)
- Hydraulic load depend on spreading system (Norwegian guidelines);
  - infiltration biofilters: 10 cm/d (100 l/m<sup>2</sup> per day)
  - trickling biofilters: 20 cm/d (200 l/m<sup>2</sup> per day)
- Hydraulic loading rates depend on type of the pre-filter (infiltration or low-charged trickling biofilter) and type of treated wastewater (black- or greywater)
- By recycling the effluent, the hydraulic load can be increased



## Loading rates

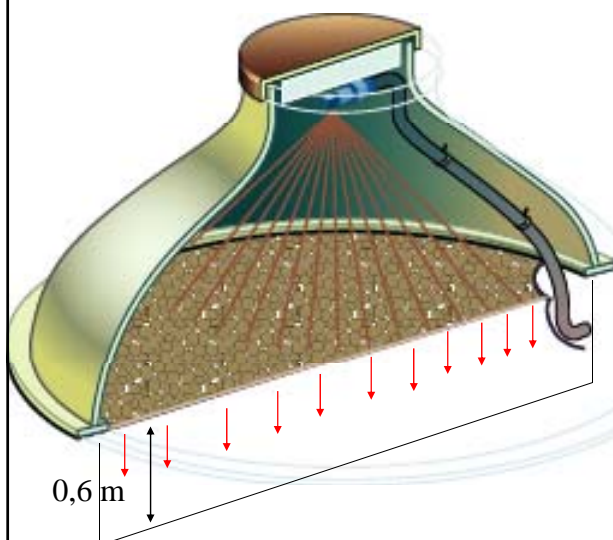


- Norwegian guidelines (VA/Miljø-Blad) suggest maximum hydraulic loading rate on 20 cm/d for the best performance of the standard pre-filters (low-charged trickling biofilters) treating domestic wastewater
- Some studies, however, revealed that high performance can also be achieved with higher loading rates up to 25-30 cm/d (250-300 l/m<sup>2</sup>) and more if the effluent is recycled
- The best treatment efficiency can be managed if the loading is dispensed with fixed small doses
- More than eight equal doses per day are recommended, but optimal number is 18 - 48 doses/d
- The doses are steered by a pump which feeds spray nozzles suspended over the filtermedia in the biofilters
- The nozzles enable to distribute the septic tank effluent over the surface of the filter media
- It is important that the effluent is sprayed evenly, in the way that the entire surface is affected

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## Pre-treatment biofilter

Loading rate - commercial systems (trickling filter)



Domestic wastewater:

- 20-30 cm/d

Greywater:

- 30 cm/d

Dosing:

- 18-48 per day
- Minimum 8 per day

Area per person:

- 0,3 - 2,0 m<sup>2</sup>

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## Treatment efficiency



- CW and infiltration systems operating under cold climate condition have showed a high and stable treatment efficiency regarding organic matter, nutrients and pathogens
- Effectively reduce organic matter (COD and BOD); major removal processes occur in the biofilters
- Depending of the loading rate, the biofilter alone can reduce BOD with over 90%
- Most of the N removal occurs in the biofilter, which efficiently nitrifies and reduces ammonia concentrations
- Total N removal up to 40 % in biofilters
- The biofilter can remove substantial concentrations of P, but becomes saturated after initial operating time
- The major removal processes of P occur in the wetland bed or infiltration filter

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## To obtain high treatment efficiency



- The biofilter has to be built with adequate surface area for receiving wastewater
- The wastewater must be dispersed evenly and the entire surface of the biofilter must be affected
- The loading is dispensed with fixed small doses
- Aerobic conditions has to be obtained in the top layer of the biofilter
- The oxygen level affects the nitrification efficiency. Thus, higher nitrification could be achieved by more effective aeration of the pre-filters
- Regularly service and maintenance is important!

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## Technical design and building/operating experience

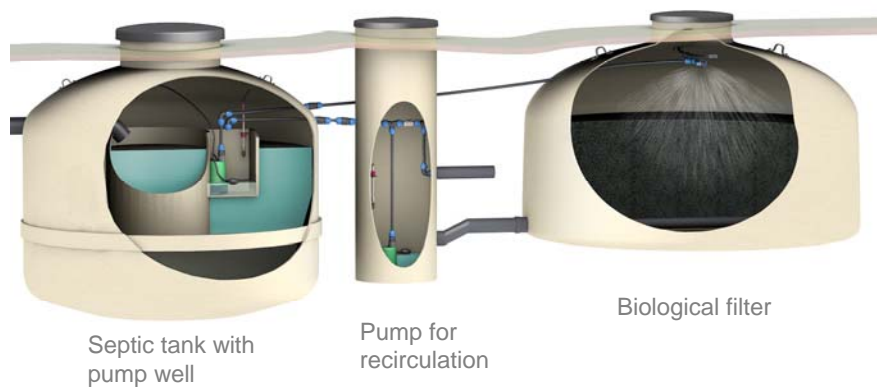
Examples;

- Plant for one household
- Plant for tourist business and cottages
- Larger systems



## Small treatment package plant

HACO plant for one household





## Rehabilitation – Tourist business and cottages

- Existing soil infiltration
- Need for additional capacity
- No traditional expandability

### Solution

#### Biological pretreatment

- Pump station
- 6 bio-filter
- Recirculation
- PLC

#### Gain achieved

- 3 times increase in capacity



Q=13 m<sup>3</sup>/d



## Larger systems

Nortura Chicken hatchery treatment plant

Biological pretreatment for soil infiltration systems

**Nortura Chicken hatchery treatment plant** **HACO FB-PLS**

Q<sub>dim</sub> = 60  
m<sup>3</sup>/dogn

Established 2008

	Inlet	After pretreatment	Treatment efficiency - Pretreatment
BOF5 mg/l	292	13	99,96 %
KOF mg/l	698	85	99,88 %
SS mg/l	147	17	99,88 %
TKB qty/100 ml	3 200 000	8 000	99,99 %

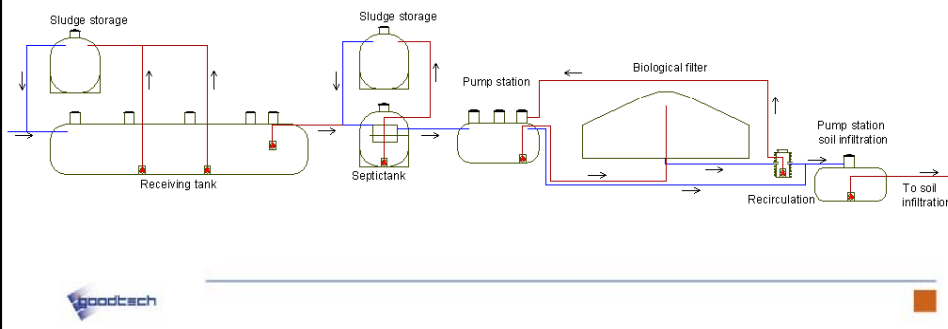


## Larger systems

Aadalen treatment plant

Biological pre treatment for soil infiltration

- Several building steps
- Now 300 cottages –  $Q=200 \text{ m}^3/\text{d}$  – prepared for 500
- Now  $1875 \text{ m}^2$  soil infiltration – prepared for  $3750 \text{ m}^2$



## Larger systems

Aadalen treatment plant



Receiving tank



Biological filter

## Larger systems

Aadalen treatment plant



Preparation for soil infiltration



## Recommendations



- The dosing pump needs a technical control regularly
- The spray nozzles, suspended over the surface of biofilter media, can be clogged by grease and small particles from the septic tank effluent or due to hard water
- The nozzles need to be cleaned and flushed
- Biofilm that appears on the surface of the biofilter, can get into a quite thick layer and thus clogging of filter media may happen
- To avoid stagnant water on the surface, coarse filter media (4-10 mm) can be used on the top of the biofilter
- The surface needs to be raked regularly - this is important to provide sufficient air access down to the biofilter
- Minimum surface area of the biofilter has to be kept. If the minimum area still has to be scaled down, recirculation of the effluent is required
- Adequate insulation is necessary to let the system function effectively during cold season of the year

## Biological pre-treatment in pre-filters



### Advantages:

- Effectively reduce organic matter - avoid possible clogging occurring in CWs or infiltration systems
- Enhance nitrification processes and improve N removal
- Reduce the specific area in succeeding filters (infiltration systems 3-5 times)
- Possible to build infiltration systems in more marginal types of soil
- Enables direct emissions to less vulnerable recipients
- Less area needed for infiltration systems, gives lower costs and less land use conflicts

### Disadvantages:

- More technical system
- Needs more maintenance and operation from professionals
- Increase cost in investment and maintenance