VERTICAL FLOW WETLANDS

AUTHOR

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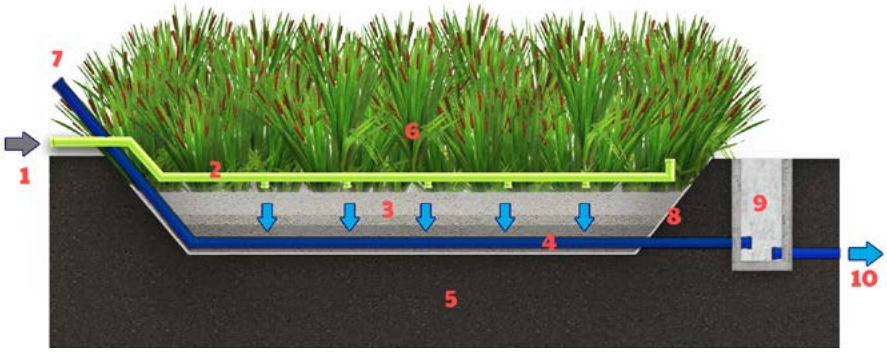

1 - Inlet
2 - Feeding system
3 - Layers of different porous media size
4 - Drainage system
5 - Original soil
6 - Plants
7 - Aeration chimney
8 - Waterproof liner
9 - Regulation manhole
10 - Outlet

Description

In vertical flow (VF) wetlands, primary treated wastewater is intermittently loaded on the surface of the filter and percolates vertically through it. During two loadings, air re-enters the pores and aerates the filter so that aerobic degradation processes mainly occur. Effective primary treatment is required to remove particulate matter to prevent clogging of the filter. A loading tank is required to collect the primary treated wastewater between two consecutive loadings. Emergent wetland vegetation is used.

VF wetlands are used when aerobic treatment of the wastewater is required (e.g. nitrification). The treatment efficiency and acceptable organic loading rate depend heavily on the granularity of the filter media used.

Advantages

- Lower land requirement than many other NBS
- Lower risks of clogging compared with HF
- Low energy usage possible (feeding by gravity)
- No specific hazard with mosquito breeding
- Robust against load fluctuations
- Operation in separate and combined sewer systems possible
- Reuse potential at building scale (toilet flushing, irrigation)

Disadvantages

- Feeding system needs either mechanical (siphons) or electromechanical (pumps) component

Co-benefits

High	Water reuse			
Medium	Biodiversity (fauna)	Biomass production		
Low	Biodiversity (flora)	Carbon sequestration	Aesthetic value	Recreation

Compatibilities with Other NBSs

VF wetlands can be combined with other main treatment wetland types, e.g. horizontal flow (HF) and free water surface (FWS) wetlands, depending on treatment goal.

Case Studies

In publication

- Treatment wetlands for WWTP effluent polish treatment and water pollution control in Pingshan River watershed, Shenzhen, China
- Two-stage vertical flow wetland at the Bärenkogelhaus, Austria
- Vertical flow wetland for Matany Hospital, Uganda

Operation and Maintenance

Regular

- Nitrification can be checked by measuring effluent ammonia nitrogen using a test kit on a monthly basis, minimum
- Measurements should be recorded in a 'maintenance book' together with all maintenance work done and operational problems that occur

Annual tasks

- Sludge removal from primary treatment to prevent sludge drift to the VF beds. The emptying interval depends on the volume of the tank, but sludge must be removed at least once a year
- The intermittent loading can be checked by measuring the height difference in the loading tank before and after a loading event
- To prevent freezing of wastewater in the distribution pipes, it is essential that after a loading no water stays in the pipes. This needs to be checked once a year
- Wetland plants should be cut every 2–3 years. If cut before the cold season, the plant material should be left on the filter surface to provide an insulation layer

Extraordinary

- During the first year, weeds should be removed until a mature cover of wetland vegetation is established

Troubleshooting

- After a few years, the rubber part of some siphons can get porous, which allows wastewater to seep continuously and thus only one part of the VF filter is loaded

NBS Technical Details

Note: technical details are given for VF wetlands with intermittent loading that use sand (0.06–4 mm) as the main layer.

Type of influent

- Primary treated wastewater
- Greywater

Treatment efficiency

• COD	70–90%
• BOD_5	~83%
• TN	20–40%
• NH_4-N	80–90%
• TP	10–35%
• TSS	80–90%
• Indicator bacteria	Fecal coliforms ≤2–4 $\log_{10}$

Requirements

- Net area requirement: 4 m^2 per capita
- Electricity needs: can be operated by gravity flow, otherwise energy for pumps is required
- Other:
  - Primary treatment is essential
  - Granularity of filter medium determines treatment efficiency and applicable organic load

Design criteria

- HLR: up to 0.1 $m^3/m^2/day$
- OLR: 20 g COD/m^2 /day
- Main layer: 50 cm washed sand (0–4 mm)
- Intermediate layer: 10 cm gravel (4–8 mm)
- Drainage layer: 15 cm gravel (16–32 mm)

Further information is presented for a main layer of washed sand (0.06–4 mm). The effect of different filter media on the treatment efficiency is described, for example, in Pucher and Langergraber (2019).

Literature

Dotro, G., Langergraber, G., Molle, P., Nivala, J., Puigagut, J., Stein, O. R., von Sperling, M. (2017). Treatment wetlands. Biological Wastewater Treatment Series, Volume 7, IWA Publishing, London, UK, 172 pp.

Pucher, B., Langergraber, G. (2019). Influence of design parameters on the treatment performance of VF wetlands – a simulation study. Water Science & Technology, 80(2), 265-273.

Stefanakis, A. I., Akratos, C. S., Tsihrintzis, V. A. (2014). Vertical Flow Constructed Wetlands: Eco-engineering Systems for Wastewater and Sludge Treatment. Elsevier Publishing, Amsterdam.

NBS Technical Details

Commonly implemented configurations

- Vertical down flow with intermittent loading
- Recirculation of 50–100% outflow volume to loading tanks can be applied to enable denitrification
- Single stage VF wetlands are usually implemented for treating the wastewater from single households, small settlements, and municipalities up to 1,000 capita

Climatic conditions

- VF wetlands have been implemented in all climatic condition