Removal of Phosphorus with Dual Porosity Filtration

Fact Sheet
DPF Plant

waterCare FILTRATION

Problem Areas

Typically lakes with clear water are only found where the concentration of phosphorus (P) in the water is low, the reason being that phosphorus will often be the nutrient salt which limits algae growth. Studies of Danish lakes have shown a clear relation between transparency depth and the level of P in the water, see figure 1. Only when the P level is below a level of 0.05 - 0.1 mg P/L, the transparency depth exceeds 1 m.

A high concentration of P may also be problematic in rivers and streams because the nutrient burden may lead to eutrophication and algae growth.

Discharge of P into fiords and coastal waters is less problematic as here nitrogen will typically be the nutrient limiting algae growth.

Removal of Phosphorus
with Dual Porosity Filtration

Phosphorus is present both as bound to particles and as dissolved in the form of inorganic phosphate which - depending on pH - will occur as either HPO_4^{2-} or $H_2PO_4^-$. In stormwater runoff from cities the P stems from dirt and dust deposited on city surfaces, from plant derbris such as dead leaves and as runoff from lawns and other surfaces covered by vegetation.

Dual porosity filtration will trap the particle-bound phosphorus by sedimentation of the particles - a process which starts in the prefilter and continues in the main filter where increasingly smaller particles will be removed. The dissolved P is removed by sorption to a mixture of limestone and other natural minerals in the main filter.

Documentation

Table 1 (page 3) shows the results of P measurements at three DPF pilot plants in Ørestad, Brønshøj and Maarslet, respectively. The P level has been measured at inlet and outlet at a number og rain events. The table shows that the inlet concentration for the 46 events in total is approx. 0.16 mg/L on average, i.e. well above the maximum 0.1 mg/L necessary to restrict the growth of algae.

In all three measurement series, the outlet concentration reaches 0.04-0.05 mg/L, i.e. considerably below 0.1 mg/L. By detailed analysis of the full data sets, it was found that the removal is distributed fairly evenly between removal of particle-bound P and dissolved P. The full data sets for Ørestad may be seen in Jensen, M.B., 2007 (Basis Report, Figure 15) and for both Brønshøj and Maarslet in Cederkvist et al., 2015 (BiV Note 7, Figure 3).

WaterCare's DPF Plant
Dual Porosity Filtration

DPF is a purification plant for treatment of surface water. Road and roof water runoff may contain polluted substances (such as heavy metals, suspended solids, pesticides and PAHs in addition to P) stemming from contact with asphalt, concrete or similar surfaces. This is problematic for the environment.

When the surface water is purified in a dual porosity filtration plant the water may be used recreationally for fountains, trenches and lakes. The water becomes so clean that it may be discharged to highly sensitive receiving water bodies.

Besides recycling the water, the process also spares the sewage system because the municipal treatment plants do not have to treat the stormwater runoff that is managed locally with DPF. This saves energy and chemicals.
As an example, in Allerød Municipality the water is carried to a new lake which will be home to large water salamanders and other species for which clean water is a necessity.

Capacity
Watercare's dual porosity filtration plants have capacities spanning from 3 L/sec and upwards, and may be combined as needed.

The Theory Behind
The theory behind the plant has been developed by Marina Bergen Jensen, Professor at the University of Copenhagen. Watercare has designed and commercialised the process and has acquired licence rights for sale and production.

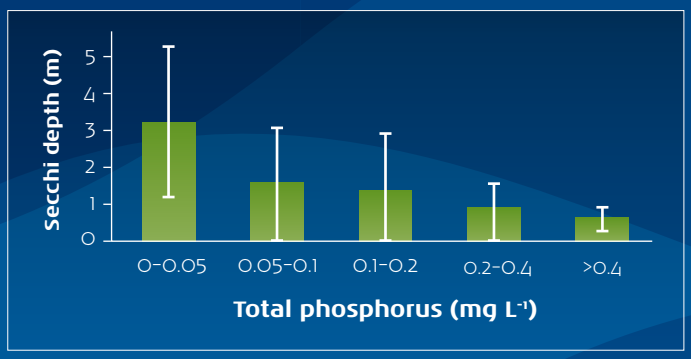

Figure 1: Relation between transparency depth (Secchi depth) and phosphorus level in lakes. Based upon measurements of 71 Danish lakes. The green columns illustrate average values while the white columns show the standard deviation of the measurements. Reference: Jeppesen et al., 2000.

	Ørestad (25 Events)	Brønshøj (10 Events)	Maarslet (11 Events)
Inlet	0.18	0.13	0.16
Outlet	0.05	0.04	0.04

Table 1: Overview of inlet and outlet average concentrations for total P in mg/L from three pilot plants

Establishment of DPF plant in Allerød Municipality (Lynge Nord)

The Watercare DPF box has been designed in cooperation with the University of Copenhagen

Plant Design

The principle behind dual porosity filtration (DPF) has drawn inspiration from nature, where stormwater that is seeping down from the surface to the ground water is purified by limestone in the soil. Only, when using DPF you do not have to wait the 20-30 years which nature spends on the process! In the Watercare DPF system the purification takes place in a horizontal flow. Thanks to a minor difference (10 o/oo) in water level in inlet and outlet gravity will force the water to flow.

Prior to the purification itself the water flows into a detention basin which also functions as a sand trap. From here the water is led into a series of Watercare DPF-boxes which contain limestone and other natural substances.

From the last DPF box the purified water flows into an outlet gully, and it is now ready to be carried to a receiving water body, infiltrated or be used for recreational purposes. No chemicals are used in the plant, and usually there is no need for pumps.

Maintenance

The maintenance consists of two annual flushes and cleaning of the prefilter boxes through flush pipes. This is done from the ground with a normal vacuum tanker. Replacement of the natural minerals which act as sorbent takes place every 15-20 years and may be handled without any need for digging around the boxes.

The flow of water through the DPF plant

The water is led to a detention basin which also functions as a sand trap

The water is led to a DPF-prefilter where particles sediment/are removed

The water is led to the main DPF-filter boxes which contain limestone and other natural substances

In the main filter, dissolved solids such as phosphorus, heavy metals etc. are adsorbed

From the last box the purified water flows into an outlet gully

From the outlet gully, the water is led to the receiving water body, infiltration or other applications

Recommendation

Dual porosity filtration is recommended for purification of stormwater runoff prior to discharge into lakes and streams, or infiltration to recharge groundwater. Dual porosity filtration can also be used for purification of lakes which are already negatively impacted by phosphorus. This implies that the lake water will be recirculated via a DPF plant.

Where stormwater runoff is to be discharged into a lake which is already impacted by phosphorus, the DPF plant may be constructed for purification of stormwater and – in dry weather conditions – to reduce the phosphorus concentration in the lake as much as possible by recirculation over the filter.

References

Jeppesen, E., J.P. Jensen, M. Søndergaard, T. Lauridsen, and F. Landkildehus. 2000. Trophic structure, species richness and biodiversity in Danish lakes: changes along a phosphorus gradient. Freshwater Biology, 45: 201– 218.

Jensen, M.B., 2008. Basisrapport. Dobbeltporøs Filtrering. Pilotafprøvning – Rensning af vejvand i Ørestad. Hændelse 1-25, januar – juli 2007.

Cederkvist, K., M.B. Jensen, P. Bjerager and P.E. Holm. 2015. BiV-notat 7. Rensning af regnafstrømning med dobbeltporøs filtrering.

Watercare

Watercare is a solid Danish production company, specialising in products which improve the environment in Danish fiords, streams and other recipient water bodies.

Watercare has many years of experience within handling and purification of waste water, and the company annually delivers more than 5,000 tanks and gullies.

The company uses rotational moulding machines for production of tanks, pump wells etc. at own production facilities in Assens. Skilled and experienced employees guarantee that the quality is top notch. All tanks are quality assured prior to shipment to ensure that they fully meet the company's strict demands for consistently high quality.

At Watercare we take pride in our products, and the path from moulding to sale is short.

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