Nordic experiences with phosphorus removal in soil systems, filterbeds/constructed wetlands and compact filter systems

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Extended abstract. Phosphorus is regarded as the main element causing eutrophication in Norwegian freshwaters (SFT 1997). Since the 1980´s removal of phosphorus has been in focus in Norway even for smaller treatment works. The national discharge limits for smaller treatment systems is 1ppm for phosphorus and 20ppm for BOD. Based on the EU water framework, that is now being enforced in Norway, a standard of 2ppm for phosphorus is acceptable, however, Norwegian municipalities are free to set stricter standards.
The first single household size package biological/chemical treatment or mechanical/chemical systems were launched about three decades ago. These systems could remove more than 90% of the phosphorus but this required regular maintenance and refilling of chemicals. Despite development of the package treatment systems investigations show that current sytems still have difficulties in meeting the discharge limits for phosphorus especially (Johannesen et al. 2008). Therefore, there is a need for robust low maintenance onsite systems with high treatment performance. Constructed wetlands are such an alternative.

Soil infiltration of wastewater is the most common onsite system in Norway with more than 100 000 systems in operation. The majority of the systems are small single home units, but there are infiltration systems treating wastewater from up to 8000 person equivalents (Jenssen et al. 2006). In the current Norwegian guidelines it is generally accepted that small systems that are properly sited and designed remove nearly all phosphorus (> 99%) prior to any groundwater influenced by the system emerges into a surface water body (VA-miljøblad no 59, 2003). It is not always easy to measure the treatment efficiency of infiltration systems, but in the 1990´s the groundwater adjacent to 16 smaller systems were monitored (Jenssen et al. 2006), all with excellent P-removal. The larger systems in general also show excellent P-removal. In the second largest system in Norway treating wastewater from 5000 person equivalents (pe) it is estimated that the unsaturated soil zone below each of the three infiltration basins can sorb all the phosphorus discharged to the system for 14 years (Jenssen et al. 2006). The use of a P-sorbing layer under the distribution layer in large subsurface systems has also shown promising results regarding P-sorption (Robertsen 2011).

Subsurface flow constructed wetlands (CWs) with pre-treatment biofilters for Nordic climate conditions have been pioneered in Norway (Jenssen et al., 1993). These CWs show excellent performance (Jenssen et al. 2005), but occupy a relatively large area compared to the package treatment plants. Due to the size and the use of phosphorus-sorbing (P-sorbing) light-weight aggregate (LWA), Filtralite®P, the investment cost of

CWs becomes high and more compact alternatives have been developed (Heistad et al. 2006, Jenssen et al. 2010).

The first constructed wetland system with a pretreatment biofilter was built in 1991. After the turn of the millenium the number of constructed wetlands have increased and many systems are now approaching 10 years of service life or more. When using the P-sorbing media FiltraliteP (Jenssen and Krogstad 2002) a theoretical service life of regarding P-removal should be 10-15 years. However, the work of Adam et al. (2007) showed that the prediction of phosphorus sorption in treatment systems was not straight forward. It is therefore of interest to study the performance of full scale systems. In this paper data from 21 systems that have up to 10 years or more of service life is investigated. The systems range from single home units to systems for more than 50pe. Special emphasis is given to phosphorus removal.

For three of the systems running for a period of 4 to 9 years a detailed investigation of phosphorus sorption to the filter material was carried out (Skjønsberg 2010). Samples of the filter media was collected from each plant. Analysis of the content of P, Ca, Mg, Fe and Al were performed. Conducitivty, pH, Total P, Total N and TOC were measured in water samples from the inlet and the outlet. All three plants show increasing accumulation of phosphorous at increasing depths. The mean accumulation of phosphorous is largest at the inlet of all three plants showing that a phosphorus front is moving from the inlet to outlet. These results can be used to estimate the lifetime of the system combined with measurements of the outlet water P concentration.

The results of the effluent samples from all 21 systems show that in general the effluent concentrations for P increase slowly although there are individual differences between the systems. In the first years the concentrations are very low and well below the discharge limits, but 8 systems (40%) exceed the limit of 1ppm before 10 years of operation. Only 2 systems exceed the limit of 2ppm and if the average values are used all systems are below 2ppm. This is good performance, but lower than expected based on the initial tests of the FiltraliteP (Jenssen and Krogstad 2002). Some of the individual differences between the systems may be due to non-ideal hydraulic conditions in the filter media causing preferential flow pathways (Suliman et al. 2005). This may lead to suboptimal utilization of the sorption capacity of the filter media.

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