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Suspended solids and nutrient retention in rural constructed wetlands in cold climate

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Three constructed wetlands (CWs), two located in southern and one in central Finland, were monitored during 2013–2015. The southern CWs Hovi (0.6 ha wet area) and Rantamo-Seitteli (24 ha wet area) were monitored continuously by s::can nitro::lyser (www.s-can.at) sensors. On average 10 pairs (inflow and outflow) of water samples were annually taken in the two southern CWs and 20 pairs in the northernmost Tarvaala CW (wet area 1.4 ha). In Tarvaala, a portable, continuously measuring Micromac 1000 -phosphate analyzer (www.systea.it) was also tested at the CW outlet in 2015. The CWs differed in their size, dimensioning (CW-to-catchment area ratio) and in the characteristics of their upstream catchments. The Hovi CW has 5.0% CW-to-catchment area ratio and 100% agricultural land use in its clayey catchment. The corresponding percentages were for the Rantamo-Seitteli CW (clayey catchment) 1.3% and 42%, and for the Tarvaala CW (coarse soil type in the catchment) 1.0% and 16%.

The average annual total suspended solids (TSS) retentions in Hovi, Rantamo-Seitteli and Tarvaala CWs were 79%, 6% and 50%, respectively. The average annual total phosphorus (TP) retentions were 61% at Hovi, 22% at Rantamo-Seitteli and 23% at Tarvaala. The unexpectedly high TSS and TP retentions at Tarvaala were probably due to the coarse soil type with more readily settling particles than in two other CWs. In Hovi and Rantamo-Seitteli CWs also dissolved reactive phosphorus (DRP) was measured. The DRP retentions (83% at Hovi and 27% at Rantamo-Seitteli) were higher than those of TP, which was probably due to the high contents of P-binding Al- and Fe-oxides in the soil of these two CWs. In the Hovi CW, vivid biological activity (abundant vegetation, algae and microbes) might also have played a role. The average annual total nitrogen (TN) retentions in Hovi and Rantamo-Seitteli CWs were 66% and 14%, respectively. At Tarvaala, TN retention varied annually so that no net retention over the whole period occurred. The most probable reason behind the occasional negative nitrogen retention was the ditching and earthworks made at the Tarvaala CW. These actions have obviously mobilized nitrogen and increased its concentrations. Micromac 1000 -phosphate analyzer proved to produce reliable (uncertainty <15%) results when PO4-P concentration was >30 μg/l.

According to the results of this study, the major factor behind the differences in the retention performance of the CWs was dimensioning. Indeed, the average annual nutrient retentions measured here are close to those predicted by the model equations presented in Finnish CW planning and dimensioning guidelines (Puustinen et al. 2007): TP retention for Hovi 58%, for Rantamo-Seitteli 27% and for Tarvaala 23%. Another factor affecting the CW retention performance was the land-use of the upstream catchment; the more agricultural land there was, the higher were the inflow concentrations, and the higher were also the retentions. On the base of our results, CWs can be recommended as water protection measures in Finnish rural areas. However, generous dimensioning, like in Hovi, often reduces their cost-effectiveness and the willingness of the landowners to build them.