Phosphorus dynamics and retention in non-point source wetlands in southern Sweden

K. Johannesson*, K.S. Tonderski*, B. Wedding** & S.E.B. Weisner***

* IFM Biology, section Ecology, Linköping University, SE-581 83 Linköping, Sweden
(E-mail: *kajoh@ifm.liu.se; karsu@ifm.liu.se*)
** Ekologgruppen in Landskrona AB, SE- 261 32 Landskrona, Sweden
(E-mail: *bengt.wedding@ekologgruppen.com*)
*** Wetland Research Centre, Halmstad University, SE-301 18 Halmstad, Sweden
(E-mail: *Stefan.Weisner@hh.se*)

Abstract
Seven constructed wetlands receiving diffuse pollution from agricultural land in the south of Sweden were investigated with respect to water flow patterns and phosphorus (P) dynamics. P retention was positive, and correlated to P load in all wetlands. However, there was a large variation in both specific and relative retention, both between wetlands and between years. Thus, the phosphorus retention in a specific wetland is difficult to predict using simple load-retention models. The water flow was correlated to P concentrations in most wetlands; however, there were some exceptions. For instance, one wetland showed a negative relationship between water flow and P concentration during summer, which indicated that other factors than the water flow determined the dynamics of P during this season. This investigation will provide a better understanding of factors affecting phosphorus retention in constructed wetlands, with further implications for wetland research and monitoring. Furthermore, the results can assist when formulating models for phosphorus removal in wetlands receiving non-point source runoff.

Keywords
Constructed wetlands; non-point pollution; phosphorus; retention; water flow

INTRODUCTION

Data from seven constructed wetlands receiving runoff from agricultural catchments in the south of Sweden were investigated with respect to water quality in general and phosphorus dynamics in particular. The aim was to assess factors affecting the outcome of phosphorus retention models in non-point source wetlands. As a first step we have:

- measured wetland retention of phosphorus from agricultural catchments
- investigated the dynamics of inflow and outflow phosphorus concentrations, by looking at phosphate-P and particulate-P in relation to water flow and different seasons

MATERIALS AND METHODS

The seven wetlands differ in size (0.23 - 2 ha), design, land use and catchment characteristics. Wetland to catchment area varies between 0.06 and 2 %, and the soil type in the catchments range from mixed sand to heavy clay with various proportion of agricultural land use (35 – 100 %). The data series cover between 2 - 9 years in the respective wetlands with continuous flow measurements and time or flow proportional water samples for the time period covered. Additional grab samples were taken, and all water samples were analyzed for total phosphorus (TP) and phosphate.

RESULTS

The hydraulic load, as well as phosphorus load, was variable (Tab.1). There was a positive P retention in all wetlands, and the retention was correlated to the P load (R^2=0.25, p=0.004); however, in some single years a negative retention was observed for some of the wetlands.

There was a positive correlation between water flow and TP concentration in several wetlands (Tab.2). Also, the inflow TP concentration was more variable. There was a seasonal effect of in- and outflow phosphorus dynamics for one of the wetlands, where high concentrations of P occurred during low-flow periods. During summer, other factors than water flow determined in- and outflow P concentrations in this wetland.

Table 1. Hydraulic load, phosphorus load and phosphorus retention for the seven investigated wetlands.

Wetland	Hydraulic load (m yr^{-1})	P load (kg ha^{-1} yr^{-1})	P retention (kg ha^{-1} yr^{-1})
Stene	7	16	3
Lilla Böslid	437	676	56
Bölarp	265	118	2.5
Edenberga	54	30	12
Slogstorp	684	455	33
Råbytorp	148	175	17
Genarp	85	92	28

Table 2. R^2 values of linear regression analyses between P concentrations and water flow in periods with grab sampling at inlet and outlet, respectively, of the seven wetlands (n.s. = not significant; n.d. = no data, i.e. no grab sampling).

Wetland	In (R^2)	Out (R^2)
Stene	0.64	0.82
Lilla Böslid	0.04	0.14
Bölarp	0.52	0.52
Edenberga	0.41	0.38
Slogstorp	n.s.	n.s.
Råbytorp	n.d.	n.d.
Genarp	n.s.	0.35

CONCLUSIONS

Phosphorus retention was positive, and correlated to the phosphorus load for all wetlands. However, there was a large variation, both between wetlands and between years. Thus, the phosphorus retention in a specific wetland was difficult to predict using simple load-retention models.

The strength of the concentration-flow relationship in the inflow varied considerably between wetlands. Outflow P concentrations were, however, less variable than inflow P, which showed some form of stabilizing effect of the wetlands.

In some wetlands, high P concentrations were observed also during low-flow periods in summer, suggesting that other factors than water flow influenced the phosphorus concentration dynamics, e.g. rural wastewater or anoxic water upstream.