Prospects of Simulating Agricultural Management Practices in a Rural Catchment in South-Western Finland with SWAT

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INTRODUCTION

Tools are needed to assess loading from agricultural sources to water bodies as well as the effect of alternative management options in varying environmental conditions. For this, mathematical models like SWAT offer an attractive option. In addition, SWAT offers a possibility to include various agricultural management practices, including constructed wetlands (CWs) in the modelling set-up. Here, prospects of such simulations in an agricultural catchment in southwestern Finland are contemplated and the first results are presented.

METHODS

The experimental catchment

The Yläneenjoki catchment (233 km^2) is located in south-western Finland south of the Lake Pyhäjärvi (Fig. 1). The soils in the river valley are mainly clay and silt, whereas moraines and organic soils dominate elsewhere in the catchment. Agriculture comprises a third of the land-use in the catchment, which is responsible for over 60% of the external nutrient loading into the Lake Pyhäjärvi. Therefore, various management actions aiming at reduction in the loading have been taken in the Yläneenjoki area during the last 10 years.

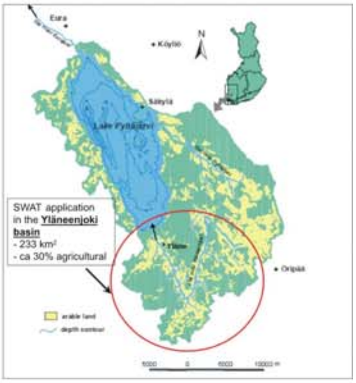

Figure 1. The catchment of the Lake Pyhäjärvi with the measurement point Vanhakartano at the river Yläneenjoki.

SWAT model and simulation of agricultural management practices

SWAT is a process-based model that functions under ArcView-environment. It simulates water and nutrient cycles at catchment scale on a daily time step. SWAT is a process-based model, including also empirical relationships. As background information, SWAT needs (i) land elevation data, (ii) land use data, (iii) soil data and (iv) weather data. SWAT incorporates a huge set of user-defined parameters which regulate numerous water and soil processes occurring, as well as management actions done, in the catchment. Here, up to 3 scenarios were, independently from each other, set up for simulations of 4 management practices (Table 1).

	Management action			
	Constructed wetlands (CWs)	Buffer zones (BZs)	Autumn tillage	Fertilization
0-scenario	No CWs	No BZs	Plowing in early autumn	Mean amounts used in the region
Scenario 1	10 CWs (total area 2.6 ha)	21 meter wide BZs along the cultivated fields beside the main channel	Plowing postponed till December 10th	Max. amounts used in the region
Scenario 2	29 CWs (total area 7.5 ha)	As in scenario 1 but additionally 15 meter wide BZs in agricultural subbasins	Harrowing in early autumn	Layer fresh manure in grass areas
Scenario 3	10 CWs with areas of 5% of catchment (total area 350 ha)			Swine fresh manure in grass areas

Table 1. Agricultural management scenarios used in the SWAT set-up.

RESULTS AND DISCUSSION

Nutrient loading was not much reduced by CWs in scenarios 1 and 2, while scenario 3 yielded ca. 18% reductions for both N and P. This suggests that CWs have to be well-dimensioned if substantial reductions are desired. Moreover, This is in line with Finnish experiences, which also suggest that it is most efficient to place CWs in locations where input loading is high and the above catchment is not very large (Koskiaho 2006).

Currently, the buffer zone area in the Yläneenjoki area is ca 70 ha. In scenario 1 the present situation was simulated with 21 meter width BZs along the main channel (Fig. 2) while in scenario 2 buffer zones were also placed along the tributaries. According to Bärlund et al. (2007), SWAT has a tendency to overestimate the BZ efficiency and therefore the width of BZs was decreased to get a better fit of the efficiency based on earlier field experiments (e.g. Uusi-Kämppä, 2005). Scenario 1 decreased total nitrogen load by 9 % and total phosphorus load by 19 % at the river outlet. For scenario 2 the corresponding decreases were 17 % for nitrogen and 36 % for phosphorus.

In terms of autumn tillage, scenario 1 reduced P loading by 8%, while scenario 2 led to 22% reduction. Both scenarios 1 and 2 for autumn tillage had minor effect in N loading (2% and 4% reductions, respectively) . Maximum fertilization rate (scenario 1) increased N and P loading 12% and 17%, respectively. Manure application increased particularly P loading (25% in scenario 2 and 27% in scenario 3) while the increase in N loading was only 5% for both.

The results suggest that substantial reductions in nutrient (particularly P) loading can be achieved by large scale establishment of BZs, and by reducing fertilization and tillage intensity. In addition to these actions, wisely sited and well-dimensioned CWs can make a good supplement.

Figure 2. Buffer zones in the mid-reaches of the Yläneenjoki main channel.

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