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The treatment of surface run-off waters from an equine paddock area with ferric sulphate

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Abstract

The Finnish horse industry has been growing with about 1,000 horses annually. It has been assessed that there are about 35,000 paddocks for 70,000 horses. The trampling of horses increases the risk for surface run-off from the paddocks and the faeces also make them critical source areas for phosphorus. A chemical method for treatment of run-off water from a paddock was tested in Ypäjä (SW, Finland). The surface run-off water flowed from the paddock area (5,000 m^2) where 7 young stallions were kept during winter. The horses had a run-in shelter (stable) and could freely go in and out of the stable. They were fed with hey or silage under the open sky. For dosing of the Ferix-3 granulated ferric sulphate into flowing water, a simple doser was developed. After the ferric sulphate treatment, the run-off water flowed into a sedimentation pond, and was thereafter filtered in a sand bed. During the first experimental year, 12 water samples were taken for nutrient analyses from the inflow and 14 samples from the outflow. The highest nutrient concentrations were measured during spring snow melt, the phosphorus concentrations being almost as high as in untreated urban wastewater. The reductions of dissolved phosphorus, total phosphorus and total nitrogen after the treatment were 95%, 81% and 60%, respectively.

1. Introduction

In 2005, there were about 70,000 horses in Finland. The number of horses increases by about 1,000 per year. The areas with increasing rates of horses are rural areas close to urban areas especially in the southern part of Finland. In an equine survey, it was found that horses were kept in paddocks on average for seven hours daily, and on average two horses used one paddock. The paddock areas varied considerably, but the average size was 1,100 m^2. As many as 80% of the horses were kept on pasture in summer (Pikkarainen 2005). The average age of the paddocks was 5.4 years.

A dissolved reactive phosphorus concentration as high as 17.3 mg/l was measured from a paddock puddle in our earlier studies (Jansson & Närvänen 2006, Unpublished data). This concentration was more than one hundred fold the typical phosphorus concentrations found in the run-off water from Finnish field areas. The paddock area had been in equine use for twenty years. As is typical for equine critical source areas, almost all (83%) of the total phosphorus was in dissolved reactive form.

When studying ditch sediments in various agricultural and forest areas Jansson *et al*. (2000) noticed high phosphorus concentrations in the run-off waters from horse stable areas. The high phosphorus concentrations in the run-off waters reflected high extractable contents of phosphorus in the ditch sediments.

In 2003, a project was started in order to test the chemical precipitation reduction of nutrients from paddock surface run-off waters using a sedimentation pond. The partners were Agropolis Ltd, Häme Regional Environment Centre and MTT/Equine Research, MTT/Environment Research and the Jokioinen Estates.

2. Materials and methods

In this study, a run-off treatment unit was constructed in connection with a run-in stable at Ypäjä Equine College. The building has been in run-in stable use since 1981. The number of horses kept in the stable has usually been about ten, but in different years the number has varied from 5 to 20. During the winter period 2003/2004, seven young stallions were kept in the stable. The horses could freely go in and out of the stable building. The outdoor area was 5,000 m^2 and the indoor area about 80 m^2. The horses were fed outdoors with hey or silage using a hay manger and during the last years also using a movable hay feeder wagon. For minerals and concentrated feeds, there was a through feeder with a roof. For drinking-water supply there were two insulated float controlled automatic drinkers which contained a heating element.

The area with the feeders was properly cleaned once a year. This was done in summer when the horses were not staying in the run-in stable. The droppings and the top layer were taken away and a new sand cover was spread out. The droppings were also taken away from other parts of the yard a few times a year.

The surface run-off water from this 5,000 m^2 yard was collected via an open ditch into a well. Samples of untreated water were taken from the well (see Figure 1). The water flowed from the well through a pipe to a doser of ferric sulphate.

The granulated ferric sulphate (Kemira 2005) was dosed in a small well where a pipe with a cone-shaped bottom was placed. In the bottom of the doser, there were holes through which the water was in contact with the chemical dissolving it. The pipe was filled with the chemical, and through the holes the chemical was dissolved well into the water. When a large flow raised the water surface in the well, more holes came to contact with the water, and thus more chemical was dissolved. It was possible to calibrate the dosing amounts by measuring the pH of the water flowing out from the outlet pipe of the doser and by adjusting the number of holes and their location on the cone. After the dosing, the water flowed into a constructed pond (100 m^2) and was filtered through a sand bed.

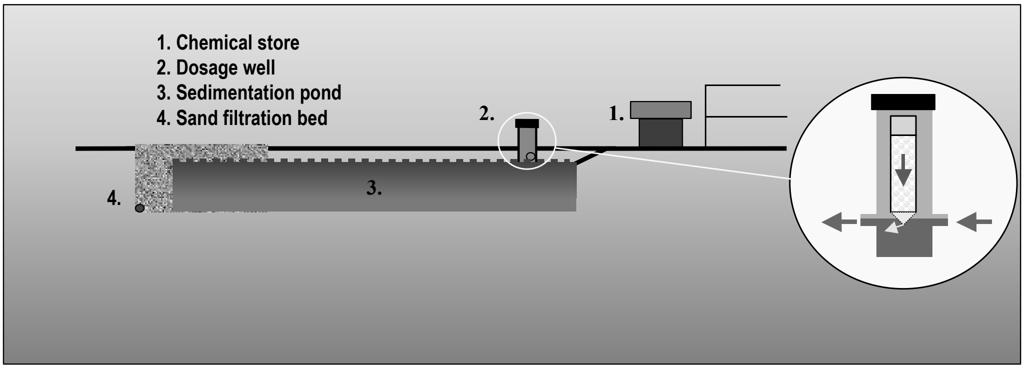

Figure1. The treatment system for run-off waters from the equine areas

The sampling of the outlet water was usually done from the filtered water, but when the water flow was higher than the filter capacity, the sampling was done from the mixture of both filtered water and the water leaving the pond as an overflow. Soil sampling from the paddock was carried out on three sites in five different layers down to one meter. In addition to that, surface soil samples (0–2 cm) representing the whole area and the feeding area were taken. Easily soluble phosphorus (P_{AAAc}) was extracted using 0.5 M NH_4-acetate–0.5 M acetic acid at pH 4.65 (Vuorinen & Mäkitie 1955), which is the method used for soil testing in Finland. The water samples were analysed for dissolved reactive and total phosphorus as described by Uusi-Kämppä and Yläranta (1996).

3. Results and Discussion

The P_{AAAc} in the upper (0–20 cm) soil layer varied from 23 to 99 mg/l soil. The surface soil samples (0–2 cm) showed somewhat higher soil phosphorus status than the upper soil layer – both in the feeding area (102 mg/l soil) and in the whole area (72 mg/l soil). These concentrations are high compared to normal concentrations in Finnish field areas. These high phosphorus concentrations were reflected as high phosphorus concentrations in the surface run-off waters from the paddock. Especially the dissolved reactive phosphorus was about 15-fold the concentration in the waters from Finnish field areas (Figures 2 and 3).

The reduction of total phosphorus concentrations in this study was generally high, although low reduction was measured twice during the spring period (Figure 2.) The reduction in dissolved reactive phosphorus was high throughout the whole test period (see Figure 3).

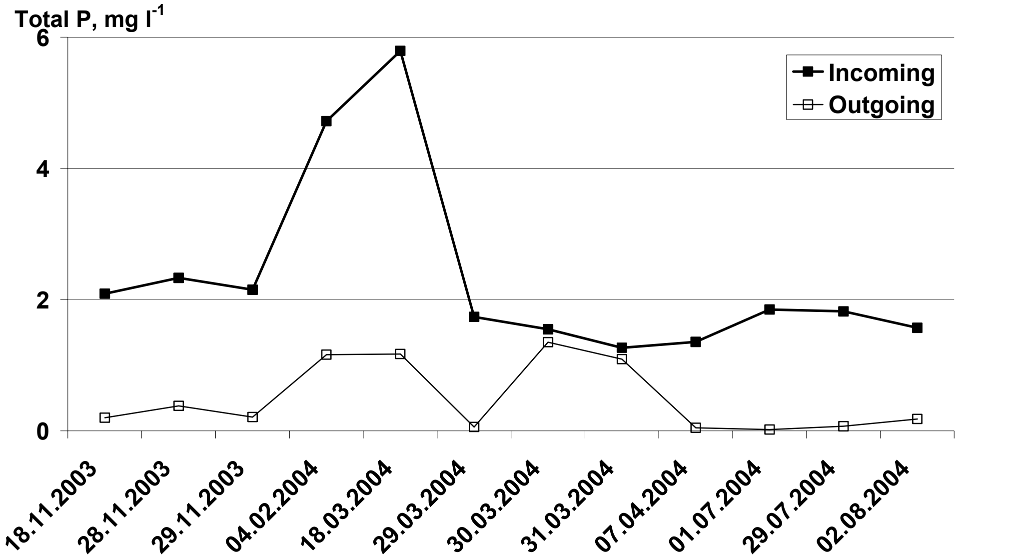

Figure 2 The concentrations of total phosphorus in the incoming and outgoing (treated) equine area water at the Ypäjä treatment site.

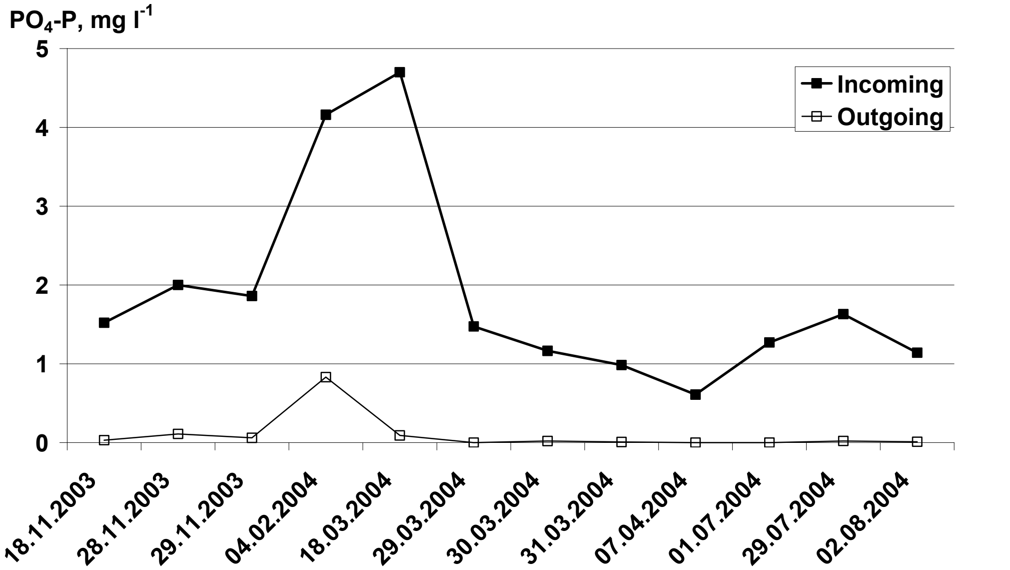

Figure 3. The concentrations of dissolved reactive phosphorus (PO_4-P) in the incoming and outgoing (treated) equine area water at the Ypäjä treatment site.

4. Conclusions

A further reduction of phosphorus load from agriculture should be carried out in Finland. It has been estimated that in Finland there are about 2,500 lakes suffering from algae blooms, and in these lakes phosphorus is the nutrient limiting the algae growth. The Agri-Environmental Programme has not been successful in reducing the total phosphorus status in agriculturally loaded lakes (Ekholm *et al.* 2004). In this study, it was shown that waters from equine areas can be treated chemically to reduce the phosphorus concentrations. A chemical treatment of the phosphorus-rich waters from horse paddocks would be a good start in reducing the phosphorus load from agriculture. To make this possible for stable owners, it is recommended that the Finnish horse industry should be granted financial support through the Agri-Environmental Programme, to reduce the high phosphorus load from equine critical source areas.

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