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Monitoring, Operation and Maintenance of Detention Ponds for Road Runoff

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Introduction

Detention systems for storm water have been built for temporary storage to reduce, or eliminate flow peaks, during heavy storm events. In Sweden a large number of open ponds have been constructed during the last 10-15 years. These systems were also constructed to trap sediments in runoff water. The sediment accumulation processes and pollutant accumulation in sediments is essential to know, to assess the removal efficiency of the systems, and to get information about maintenance activities. The accumulated sediments may need to be removed to minimize the risk of contamination and to improve the operational efficiency of the pond. Continued accumulation of sediments in both ponds and tunnels may cause resuspension of the sediments when heavy storm events occur. The aim with this paper is to focus on the monitoring, operation and maintenance aspects such as the handling of sediments and vegetation, which depends on the quality of the sediment and on environmental regulations. The paper also discusses different ways to estimate the removal efficiency in a detention pond and the different regulations for handling of sediments.

In Sweden there are no regulations or guidelines of monitoring detention systems for stormwater treatment. Monitoring and control of the removal efficiency in a detention pond by investigating water samples from the in- and outflow to the pond is time consuming and expensive. To be able to take reliable water samples, flow-weighted samples must be taken during several successive rain-events and different seasons to get sufficient information about the stormwater quality from the specific catchment area. Another way to estimate the removal efficiency in the pond could be to investigate the accumulated sediment in the pond together with the information about the inflow of pollutants to the pond using precipitation data on the catchment area and standard concentrations of pollutants for road runoff, which have been presented by other researchers. A mass balance of pollutants flowing into the pond and the accumulated pollutants in the sediment in the pond may be calculated and results in an estimation of the removal efficiency in the pond. The advantages of investigating the sediments instead of the stormwater are the possibilities to sample the sediments throughout the year and the independence of the rain events compared to water sampling of the runoff. Sediment sampling in cold areas may also be performed during the winter period from the ice on the pond by drilling hole in the ice.

Methods

In the region of Mälardalen in Sweden 34 detention ponds for road runoff has been invented regarding aspects of maintenance and operation of the ponds. All ponds were investigated regarding the spread of vegetation in the ponds and the maintenance and operation with the aspects of the accessibility to the ponds in order to carry out the maintenance and monitoring.

Four detention ponds were investigated regarding the quality and quantity of accumulated sediment in the bottom of the ponds. Sediment samples were taken which were analysed for its content of heavy metals. The investigated ponds were constructed in 1998. One of the ponds was also investigated to estimate the potential toxicity of sediments by conducting toxicity tests with both pore water and the whole sediments.

For the investigated ponds necessary data to be able to calculate and estimate the removal efficiency in the ponds were collected. The necessary data were the connected catchment area and surface area of each pond, the accumulated precipitation since the ponds were constructed and standard concentrations of pollutants in the road runoff. To be able to calculate the amount of metals that theoretically settle in pond, the particulate bound fraction of metals in the stormwater have been assumed using reference literature together with assumptions of the fraction of the particulate bound metals that will settle in the pond.

Results and Discussion

The results from the analyses of the sediment samples from the investigated ponds are presented in Table 1. The amount of metals in the sediments has been compared with metal content in different media according to the Swedish Environmental Protection Agency in order to get an idea of the pollution level in the sediments. The sediments showed low metal concentrations when compared to Environmental Quality Criteria for Contaminated sites and for Lakes and watercourses from Swedish Environmental Protection Agency.

Table 1. Results from sediment analyses in the detention ponds and the limit values for metals in different media according to the Swedish Environmental Protection Agency (mg metal per kg dry weight of sediment).

	Cd (µg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
F1, in	130	18	15	7	40	61
F1, out	220	53	39	25	47	162
U5, in	246	37	34	15	29	544
U5, out	200	32	27	16	30	909
Vallby, in	210	49	44	23	59	192
Vallby, out	180	58	48	25	51	236
Gälleråsen, in	30	22	25	25	18	72
Gälleråsen, out	40	18	23	22	21	37
Polluted soil[1]	400	120	100	35	80	350
Lake sediment[2]	32000	160	140	80	6400	2400
Sewage sludge on fields[3]	200	100	600	50	100	800

Classification	
	Class 1
	Class 2
	Class 3
	Class 4

[1] Swedish guideline values for metal levels in polluted soil (SEPA, 1996)
[2] Swedish guideline values for metal levels in polluted sediment in lakes in Southern Sweden (SEPA, 1999a)
[3] Limit values for metals in sewage sludge on fields (SEPA, 1998)
[4] Classification according to SEPA, which signify deviation from background levels in sediment in lakes and water courses (SEPA, 1999b)

Regarding the toxicity tests on the sediment, the pore water of the collected sediment was not toxic but the whole sediment tested by the Microtox® Solid-phase test showed toxicity.

The calculated removal efficiencies of particles in the ponds were 26 % for F1, 58 % for U5 and 43 % for Vallby. These results were obtained by using information to calculate the suspended solids flowing into the pond and the measured amount of accumulated sediment in the pond. To be able to verify these results, information about the water quality flowing in and out from the ponds should have been available. However, this method gives a rough estimation of the function of the ponds and the removal efficiency of suspended solids in the ponds. Using removal efficiencies as a parameter to evaluate the function of ponds may be used when comparing ponds, which take care of the same type of runoff, and when you want to compare parameters such as pond design and specific pond area in order to improve the design on new ponds. This method may be an important tool in monitoring programs of these treatment systems, which can be made without time consuming and expensive sampling programs of the runoff.

The results from the calculations of the accumulated amount of metals in the ponds in proportion to the metals in the incoming road runoff showed a very large spread, from 2 to 84 % depending on metal and pond. The calculations were difficult to make depending on the assumptions regarding the percentage of particulate bound metals in the runoff and the assumption of the share of particles that settle in the pond. To be able to use this type calculations, further knowledge is needed concerning how metals are bound and transported in the road runoff, if the metals are bound to particles that will settle in the ponds or if they are dissolved or bound to colloidal particles.

The inventory of the 34 detention ponds showed that the accessibility to the ponds were sometimes very poor or prevented by game fences surrounding the pond, which of course render the maintenance more difficult. It is important for the maintenance and operation of the treatment plants to have accessible roads to the ponds and not too steep slopes down to the ponds in able to get close with the necessary equipment. Removal of sediment in the ponds is difficult to accomplish caused by above-mentioned aspects. A program for control and supervision of the detention ponds needs to be set-up, which covers not only vegetation and sediment removal but also checks of gratings at the inlet and outlet. For 18 of the 34 invented ponds, vegetation covered 50 % or more of the surface area.

Conclusions

When evaluating the results from the ponds the metal content in the sediment is not so polluted compared to values from SEPA for polluted soil or lake sediment, on the other hand the Microtox® Solid-phase test showed toxicity. The differences in the interpretation of the results compared to the guidelines from the authorities make it difficult to develop a program for operation and maintenance regarding the sediments in the detention systems. Since there are no guidelines how to assess and handle sediments from stormwater treatment systems, there is a need of regulations and directives concerning criteria for risk assessment of the environmental impact from these sediments.

The method of evaluating the function of the ponds by using information about the accumulated sediment and the use of calculations of the pollution load to the pond is useful regarding the estimation of the removal of suspended solids from the runoff. For calculations of metals the results showed large variations because of the uncertainty of the amount of

metals that are particulate bound together with the assumption of these metals that will settle in the ponds.

Sediment sampling is often difficult and could be improved by planning and designing some type of access to the pond, for example a footbridge. The difficulties in sampling the sediment are an important issue for the designers of these systems if we want to be able to follow-up the ponds regarding their removal efficiency and to get information about the maintenance activities. The inventory also showed that the maintenance and monitoring is difficult because of inadequate access to the ponds.

References

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