Newsletter no. 6

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Introduction

The project has reached its conclusion and the final reports are delivered. Now has come the time to implement the results and the lessons learned for design of future solutions to treat stormwater runoff. The most tangible result of this project is the recreational elements created at the 3 sites, much to the delight of local residents and users of the green areas in which the facilities are located. Although the project is officially closed, it does not mean that the facilities are completely abandoned. The intention is to continue some data collection to improve the knowledge of the long term treatment performance. Furthermore are PhD students at the universities of Aarhus and Aalborg using data from facilities in their studies.

Photo's of ponds

Odense, June 30th, 2009

Århus, June 30th, 2009

Silkeborg, August 25th, 2009

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The following text is a resume of results and experiences gained during the project. A comprehensive description here off can be found at the project homepage: www.life-treasure.com.

The removal effectiveness of the wet ponds (all 3 facilities)
The pollutant removal by the ponds themselves was within the range typically reported for such facilities. However, some anomalies were seen. The pond in Odense had comparatively poor treatment efficiency towards copper and zinc. The main part of these metals is typically associated with fine stormwater particles that settle out in wet ponds. However, in this case the metals were probably illicitly discharged to the stormwater system as dissolved or colloidal bound metals in rather high concentrations, resulting in poor removal efficiency. Another anomaly was seen in the pond in Aarhus, which consistently produced high concentrations of nickel while other metals were efficiently reduced. The reason is not known, however, it seems likely that the nickel has been present in the natural soil minerals of the pond and slowly released to the bulk water. The facility in Silkeborg did also show a slight anomaly in terms of rather poor removal of zinc. The reason for this is not known but it could be the same as for nickel release at the facility in Århus.

The removal effectiveness of the sand filters (all 3 facilities)
The concentration of most of the pollutants was efficiently reduced by the sand filters. The sand filters were especially efficient for reduction of the rather high concentrations of copper, lead and zinc at the facility in Odense. However, phosphorous was not reduced by the sand filters. At the facility in Århus, the sand filters actually increased the phosphorous concentration in terms of both total phosphorous and orthophosphate. Similarly did the concentration of nickel at the facility in Silkeborg increase dramatically by passing the sand filters. At the facility in Århus and Odense, the sand filters furthermore released significant amounts of iron oxides, causing about 2 and 7 g m-3 iron in the outlet from the sand filters, respectively. At the facility in Århus the iron release from the sand filters was monitored closely and a clear decrease in iron release was observed over time. This observation indicates that the sand filters over a year or two probably will have washed clean of dissolvable compounds. The iron release was likely cause by part of the sand going anaerobic, causing iron reduction and release, which then was re-oxidized after exiting the filter. The hydraulic capacity of the sand filters was significantly lower than had been envisioned during design. When designing the filters, it was assumed that the comparatively large wet pond would cause less clogging of the filters compared to traditional infiltration basins and the filters were sized accordingly. It was furthermore assumed that the vertical filters would show little or no clogging, followed by the sloping filters and the horizontal filters clogging most. However, it turned out that all filters clogged more or less to the same extent and to a much higher degree than envisioned.

Removal of pollutants at the facility with fixed media sorption (Odense)
The fixed media sorption filters removed all measured pollutants to below the water quality criteria for fresh waters. The filters furthermore ensured that the extremely high concentrations of copper due to the illicit discharges came well below the water quality criterion for Danish fresh waters. In addition to polish the water quality of the stormwater runoff, the filters turned out to be an effective protection against pollutants which would otherwise have caused immediate toxic effects on the aquatic environment.
Sorption to fixed media of pollutants not managed by the sand filters was very efficient to further reduce pollutant concentrations. Also for those pollutants that were present in comparatively high concentrations, the sorption filters consistently ensured low outlet concentrations. The reduction of a probably illicitly discharge of copper to the facility in Odense illustrates this well. In Figure 1, the effect of the complete treatment train consisting of wet pond, sand filter and sorption filter towards

copper is presented. As is easily seen, the treatment train was an effective barrier protecting the receiving environment against the very high copper concentrations in the runoff.

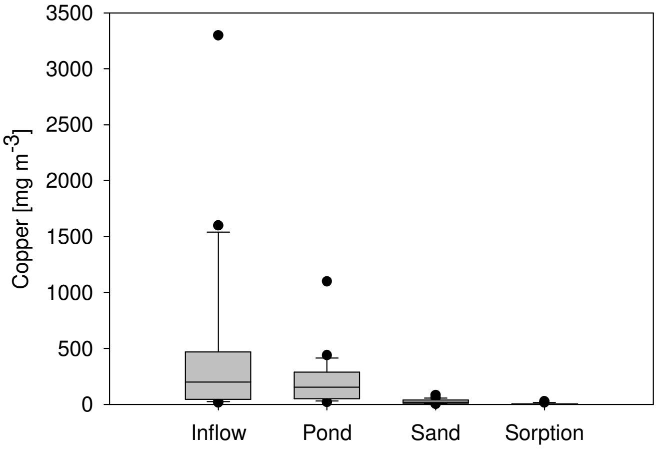

Figure 1. Removal of copper at the facility in Odense. The box shows the 25%, 50% and 75% percentiles, the error bars show the 10% and 90% percentiles and the full circles show outliers.

Removal of pollutants at the facility with iron enrichment of bottom sediments (Århus)

The iron enrichment of the bottom sediments did not cause any measurable reduction in chemical water quality parameters. Actually, for a number of heavy metals the pond water concentrations increased compared to the time before the addition and the treatment efficiency of the pond itself deteriorated correspondingly. The product used for iron enrichment of the bottom sediments could, however, not have been the direct cause of the reduced treatment efficiency, as the product contained much less of the problematic metals than could be accounted for by the increased concentrations in the pond water. After the iron addition, nickel concentration in the pond doubled to approximately 8 times the inlet concentration. Other metals stayed consistently below the inlet concentrations.

The treated water exiting the sand filters had similar heavy metals concentrations before and after the addition of iron to the pond. I.e. the sand filter reduced the increased concentrations of the pond water to the same and constant level, indicating that the additional heavy metals present after the addition of iron to the pond were associated with suspended particles.

Even though the iron enrichment of the bottom sediments did not result in decreased concentrations of pollutants, it did counteract growth of algae in the pond (Figure 2). Compared to the pond in Odense, the spring algae bloom was delayed and very much shortened and the chlorophyll content was low the rest of the summer. Drawbacks of this technology are its labour-intensity, a temporary colouring of the pond water and a short drop to rather low pH values during the addition.

Removal of pollutants at the facility with flow proportional addition of aluminium to the stormwater (Silkeborg)

The addition of aluminium to the stormwater runoff entering the facility in Silkeborg was much less labour intensive than the iron enrichment of the bottom sediments of the facility in Århus. The work was restricted to calibrating the dosing to the desired dosage level. As is seen from Figure 2, the dosing of aluminium was very effective to hinder algae blooms in the pond – more so than the iron enrichment of bottom sediments in Århus. However, when it came to chemical water quality

parameters, no reduction could be seen. Actually, there was a slight increase in most heavy metal concentrations in the pond compared to before the addition. The difference in heavy metal concentrations from before the addition to during the addition was, however, not statistically significant. After passing the sand filters the water concentrations were similar to those before the aluminium addition.
Comparing the algae growth in the 3 ponds, especially the aluminium addition was effective in reducing the algae growth. Most of the time the algae concentration, measured as chlorophyll concentration, was a few percent of what was found in the Odense pond. This was the case even though no difference in the total phosphor and orthophosphate concentrations were observed. The reason here for is believed to be that the measurements after aluminium addition only covered a growth season and not a winter season. During the growth season, the algae will take up most bio-available phosphorous. However, when adding aluminium, the bio-available phosphorous fraction becomes severely limited, inhibiting the algae growth.

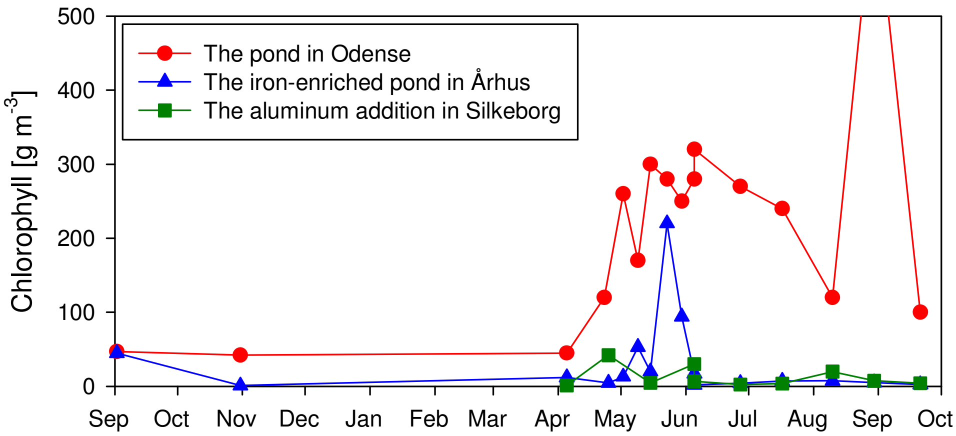

Figure 2. Algae concentrations in the 3 ponds (measured as chlorophyll)

Even though this technology did not meet the expectations with respect to pollutant removal in general, it was very effective in creating a clear water phase and hereby managing phosphorus. Had the pollutant loads on the facilities been as high as in Odense, it is likely that the aluminium addition would have had some effect on such elevated concentrations.

The role of the macrophytes (all 3 facilities)
The nutrient and heavy metal concentrations in the plant tissues sampled in the three systems are dependent on the physiological requirements of the plants (concerning macro and micronutrients) and the external concentrations that the plants are exposed too. In general, the element concentrations found in the *Phragmites* stems and leaves from the three systems are comparable to concentrations in plants growing in natural unaffected areas. Heavy metals are taken by the roots of the plants, and particularly Cu and Zn were accumulated in the roots of the plants in the Odense systems. However, the heavy metals were barely translocated from the roots, and the concentrations in the stems and leaves were much less elevated. This is of importance when considering the risk of spreading and potential biomagnifications of heavy metals in the food chain. The plant tissues that are eaten by birds and insects (leaves, stems) generally contain much lower concentrations of the hazardous heavy metals compared to the roots. Hence, the risk of spreading and biomagnifications

of heavy metals from the ponds through plant uptake and subsequent grazing is very limited. The hazardous heavy metals taken up by the plants remain in the roots, and upon dead and decomposition of the roots, they will be bound in the sediment. The concentrations of heavy metals are consistently higher in plants sampled from the system in Odense than Århus and Silkeborg, as a consequence of the high concentrations in the water and the sediment. Concentrations of some heavy metals in roots are a factor 100 times higher than in roots of plants growing in natural unaffected vegetations. Although the concentrations of heavy metal in plants in the Odense system are significantly elevated in roots, the concentrations in the aerial tissues from the same plants are low and do not generate threats for the fauna or visitors to the site.
Besides the contributing to the detainment of heavy metals and other pollutants, the planted macrophytes were found to be an important asset in terms of integrating the facility into the urban environment and enhancing the recreational value of the facilities.

Continued operation and monitoring of the established facilities
During the Treasure-project, the demonstration facilities have been intensively monitored and detailed knowledge has been gained on the design and operation. Due to the time-scale of the project, information has been gained on the first 1 to 2 years of the life of the established stormwater treatment facilities. However, the systems are designed with a much longer life expectancy, and the partners of the project therefore have a significant interest in continuing the monitoring of the performance of the facilities. During the next couple of years, the facilities will be technically modified in accordance with the experiences gained during the LIFE TREASURE project period. The so modified facilities will be monitored for a large number of years by means of focused monitoring campaigns to gain knowledge on the long-term operation of the demonstration facilities.

Both involved universities are planning to use the sites for various research projects on the MSc and PhD level within the respective curriculums taught.

In addition hereto there are ongoing negotiations with representatives from the Danish National monitoring program NOVANA to monitor pollutant loadings and pollutant discharges from 2 of the 3 facilities. NOVANA will focus on various organic micro-pollutants, and especially such which have not been studied during the Treasure-project.

This is the last newsletter.

Project web site (www.life-treasure.dk (Danish) and www.life-treasure.com (English)) will as a minimum be open to the end of year 2014.
The main reports and documents drawn up during the project are available for download on the web-site (home-page).