

Silbersee, Stuhr, Germany

Application dates: 14-15 November 2006

Summary

Aim: To bind phosphorus in the water column and prevent the release of sediment phosphorus.

Description: Former sand excavation pit used for recreation

Size (ha): 7
Max. depth (m): 8
Average depth (m): 5
Conductivity ($\mu\text{S}/\text{cm}$): 450

Dosage: 21.5 ton Phoslock® (14-15/11/06)

The Lake



Aerial view of Silbersee

Located near Stuhr in northern Germany, the Silbersee is a manmade recreational lake, which is popular among swimmers and fishermen. It has a surface area of approximately 7 hectares and a total water volume around 350,000 m³. It is surrounded by trees and agricultural fields with a camping site to the southwest and two sandy beaches on its northern and southern shores.

The lake has a limited catchment area, with inflow derived primarily from precipitation and groundwater.

The lake stratifies during summer.

The average pH of the water column before the treatment was 7.5, while the Total Phosphorus was 0.16 mg P/L; Water quality was regularly monitored prior to the Phoslock® application.

The largest quantity of phosphorus was present in the sediment which contained relatively high concentrations of phosphorus (400 mg available P/ kg DW according to Psenner fractionation).

In the years prior to the treatment the lake was regularly closed to swimmers due to cyanobacterial blooms.



The Treatment

During 2005, 18 kg of phosphorus were removed from the lake by hypolimnetic discharge. However this measure was insufficient to reduce the trophic status of the lake due to the high phosphorus loading in the sediment.

The lake was therefore treated with 21.5 tonnes Phoslock® on the 14th and 15th of November 2006 to bind phosphorus (as PO₄) residing in the water column and to minimize the release of sediment phosphorus. The application was performed by Bentophos GmbH, exclusive licensee in Germany. It was anticipated that this measure would prevent the intensive blooms of blue green algae that had occurred in previous years.

Prior to the application, the water was clearly stratified and anaerobic conditions were measured below 5 meters. (Figure 1).

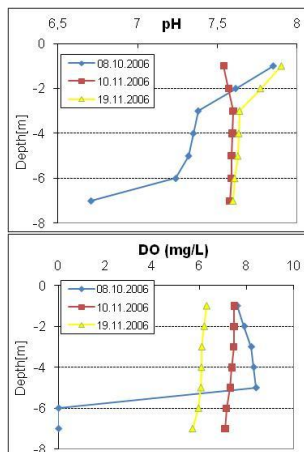


Figure 1: pH and oxygen prior to and immediately after the Phoslock® application (monitoring and analysis by IDN)



De-stratification commenced immediately prior to the application however by the time of the application the Silbersee was completely mixed. Aerobic conditions extended to the bottom of the lake and the pH had stabilised at 7.6. Most of the phosphorus in the lake was present in the form of orthophosphate, the phosphorus fraction that is immediately bound by Phoslock®. As a result, phosphorus concentrations were quickly reduced.

The application was performed by a pontoon based mixing system in which the Phoslock® granules were mixed with in situ water and then sprayed evenly over the water surface.

Restoration of Silbersee

Results

Within three weeks of the application, average ortho-phosphate ($\text{PO}_4\text{-P}$) levels dropped from 0.09 mg P/L to below the detection limit (0.01 mg P/L). Phoslock[®] only binds $\text{PO}_4\text{-P}$, but as 60% of the total phosphorus (TP) was present as $\text{PO}_4\text{-P}$ at the time of the treatment, TP levels also dropped very quickly and remained low around 0.03 mg P/L. Phosphorus levels remained around this level for two and a half years.

The application did not result in the complete eradication of blue green

algae from the lake, however numbers were substantially lower than in previous years and no swimming bans were enforced for the 2007, 2008 and 2009 season.

Anoxic conditions did develop in the hypolimnion of the lake during the summers after the treatment, however the anoxic periods were considerably shorter than before. Total lanthanum concentrations in the water column immediately after the treatment were measured to be 100 $\mu\text{g/L}$ (fig. 3).

Despite heavy wind conditions (9 Bft) after the Phoslock[®] application, no heavy resuspension of the material was detected and the levels dropped gradually to 4 $\mu\text{g La/L}$ after the settling of Phoslock[®]. No toxic effects were observed on the fauna or flora.

A follow up treatment with 4 tonnes as phosphorus concentrations were starting to increase (results not yet included in this publication).

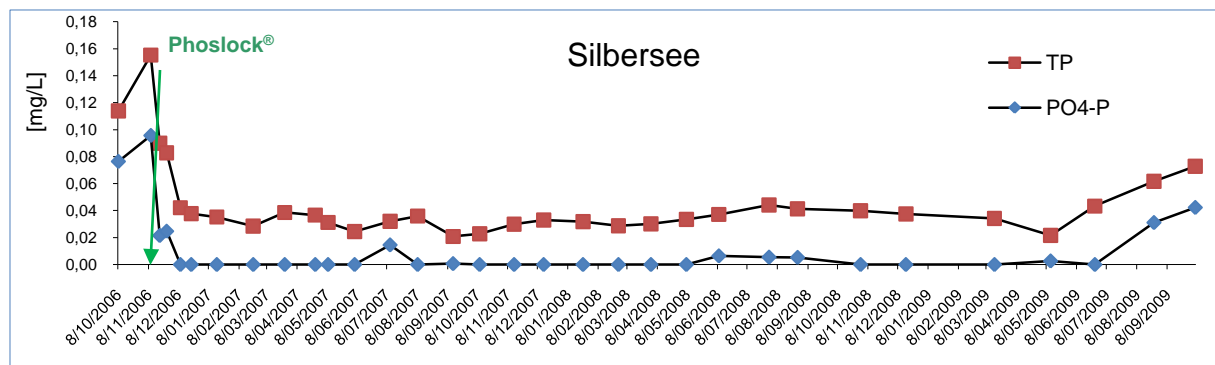


Figure 2: $\text{PO}_4\text{-P}$ and TP concentrations at Silbersee (monitoring & analysis by IDN, Insitut Dr Nowak)

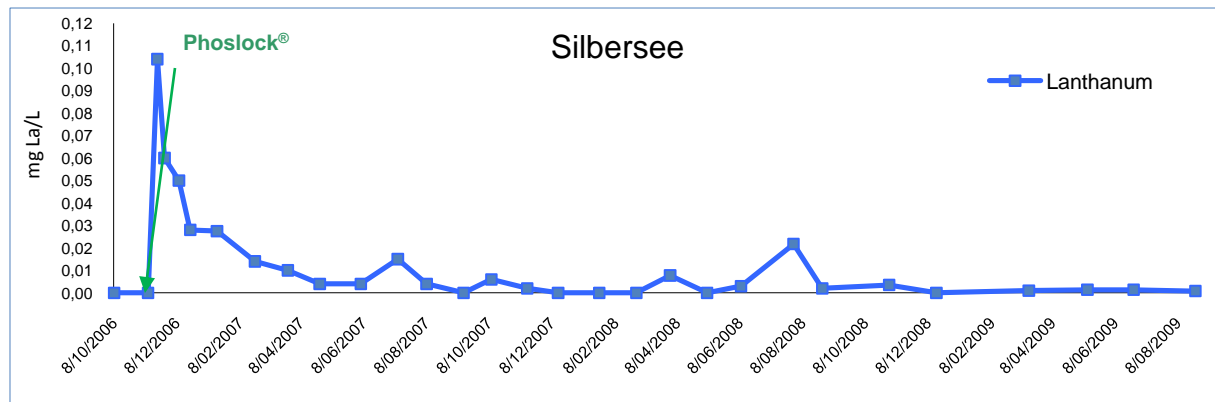


Figure 3: Lanthanum concentrations at Silbersee. (monitoring & analysis by IDN, Insitut Dr Nowak)

Conclusion

Within a month of the Phoslock[®] application 100% of ortho-phosphate and 80% of total phosphorus was removed from the water column. Since the application, ortho-phosphate concentrations have remained very low and total phosphorus concentrations have remained constant at around 30 $\mu\text{g P/L}$, for a period of nearly three years.

In relation to its phosphorous content, the trophic status of the lake changed from a strongly eutrophic to a mesotrophic condition within a period of two months. Since the application the lake has remained open for swimming for three consecutive seasons.

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Additional information can be found on our website or can be provided on request.