A new way of shallow lake restoration- Sustainable phosphate binding by an innovative precipitation material

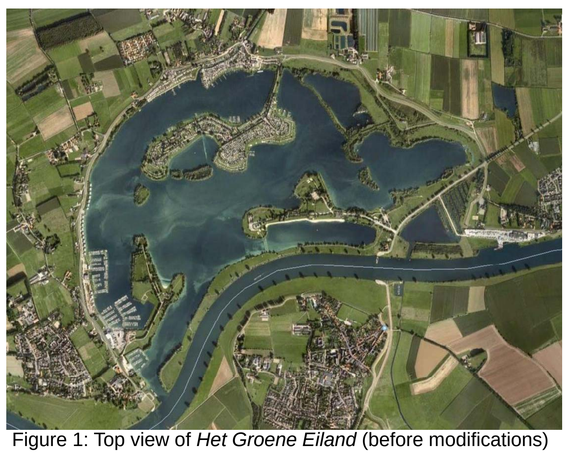

Figure 1: Top view of *Het Groene Eiland* (before modifications)

Introduction

External events usually have a higher impact on the water body of a shallow lake because of the low surface/volume ratio. High temperatures can increase the bacterial activity in the sediment. Both high temperatures and oxygen demand increase the release rate of nutrients from the sediment. This frequently induces the growth of massive algae blooms.
Two case studies indicate a positive effect on the prevention of phosphorus release from the sediment and a resulting reduction of blue-green-algae blooms after phosphate precipitation with Phoslock®.

Figure 2: The *Bärensee* and its catchment area

Case Study A: "Het Groene Eiland" is part of the larger bay "de Gouden Ham" which was formerly part of the River Maas (The Netherlands). The construction of a series of dams in February 2008 has resulted in an almost completely isolated lake within the area of "de Gouden Ham". On this enclosed water body Phoslock® was applied as a source oriented measure. The surface area of "Het Groene Eiland" is 5.3 ha, with an average depth of 2.5 m. The volume of the water body is 130 000 m^3.
Blooms dominated by blue-green algae *Microcystis* were reported in 2006 and 2007 and public swimming bans occurred several times. High iomass concentrations correlate with chlorophyll-a concentrations up to 62 µg/L.
The nutrient concentrations were monitored during the summer periods in 2006 and 2007. Phosphate concentrations in the summer of 2006 ranged between 0.04 mg/L PO_4-P and 0.10 mg/L P and 0.08 mg/L PO_4-P and 0.15 mg/L P at the end of summer. Reported phosphorus concentrations during summer 2007 were even higher, rising to 0.92 mg P/L.

Results

After the application of 11 tons of Phoslock®, phosphorus concentrations decreased significantly. Maximum chlorophyll-a concentrations during the summer period reached 22 µg/L. No swimming bans were reported in 2008.
The sediment consists mainly of sand (90%) and to a lesser extent of sludge/clay (10%). Total phosphorus concentrations in sediment are 1700 mg/kg dw. The P-fractions show an increase in the stable (permanent) P-forms. The labile (releasable) fractions decreased from 462 mg P/kg dw to 410 mg P/kg dw. (Figure 5).

Case Study B: "Bärensee" near Hanau (Germany) is an artificial lake with a surface of 6 ha and a maximum depth of 3.8 m (average depth is 2.63m) The water body has a volume of 156 000 m^3. In the last 10 years the reference status of the lake (mesotrophic) has never been achieved. According to chemical and biological parameters, the lake has to be categorized as highly eutrophic.
The lake is surrounded by the biggest camping site in the state of Hessen and is intensively used as a recreational lake.
The high nutrient load had been previously reduced by external phosphorus elimination and reed harvesting from artificial floating beds. These measures have improved the situation temporarily, but massive blue-green algae blooms have still been reported regularly (e.g. 80 µg chlorophyll-a/L in February 2007).
The sediment contains approx. 700 mg P/kg dw. 20% of this Phosphorous is considered available. The main goal of the restoration was to prevent phosphorus from being released from the highly anoxic sediment. Therefore 11.5 tons of Phoslock® were applied to the Bärensee.

Results

Total phosphorus concentrations in the water body were reduced from 84µg/L to 25µg/L. The chlorophyll-a concentrations correlated with the lower available nutrient level. No swimming bans have been reported in either 2007 and 2008. A situation of high turbidity has been induced by a storm event in August 2008. Temporarily high phosphorus concentrations were detected (refer blue circle in Figure 4), but the particle bound phosphorus was detected to be not available for phytoplankton and blue-green-algae.

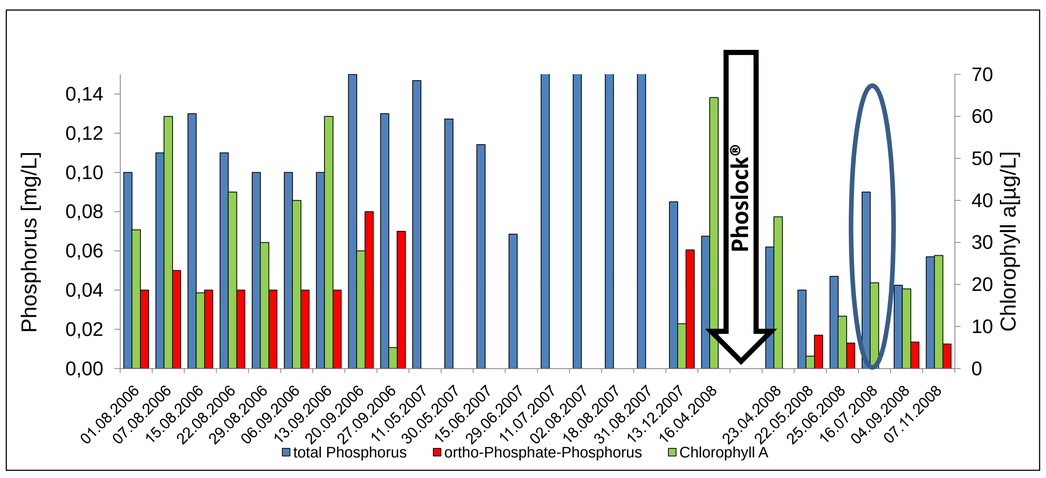

Figure 3: Phosphorus and chlorophyll-a concentrations at the Gouden Ham (Remarks: results of 2006 are from Zwemwaterprofiel by Grontmij & DHV, results of summer 2007 are from Drema, phosphate and chlorophyll concentrations were not reported; results after autumn 2007: Institut Dr Nowak). Higher P-concentrations (blue circle) in July 2008 are wind induced, the phosphorus was not available for biological processes.

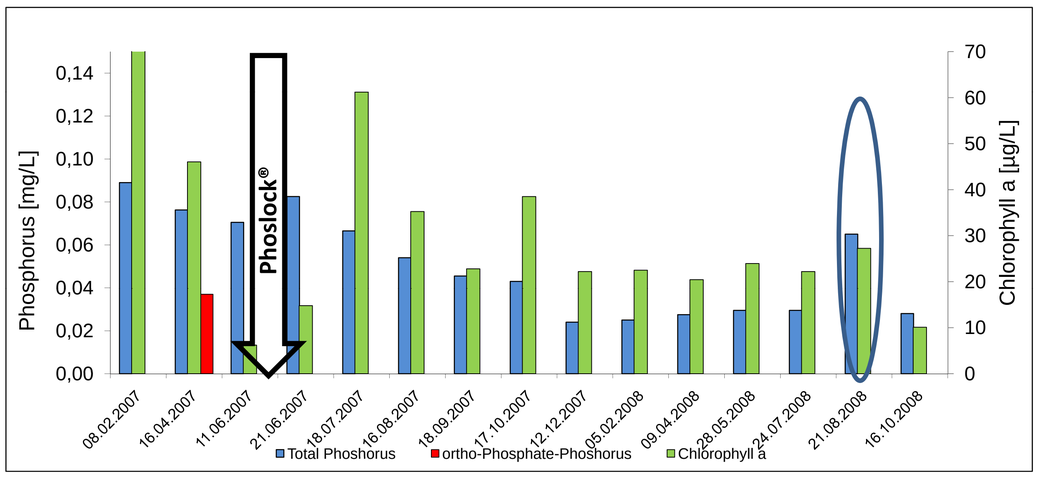

Figure 4: Phosphorus concentrations at the Bärensee. (Institut Dr Nowak, limit of detection was 0.01 mg P/L). Higher phosphorus concentration was induced by a higher wind-forced turbidity. Sediment-particles carried phosphorous which was bound on Phoslock®. This phosphorus is not available for biological processes. The recent data shows a steady decrease of the phosphorus level (25 µg/L).

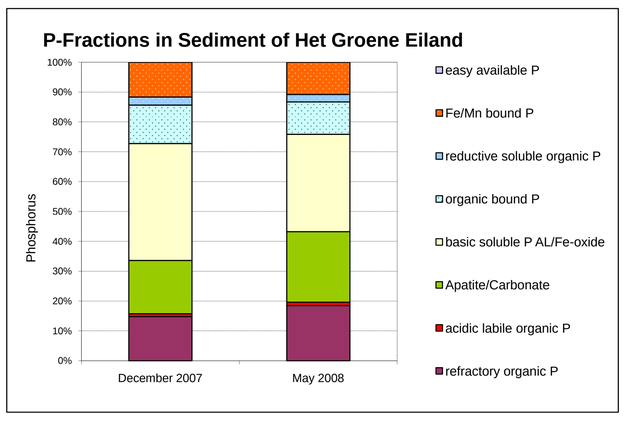

Figure 5: P-Fractions (Psenner-method, modified by Hupfer) in sediment of the "het Groene Eiland". A decrease of labile P-forms (dotted area) has been determined after application. An increase in stable phosphorus fractions has been achieved through the application of Phoslock®.

Figure 6: Massive blue-green algae bloom in the „Gouden Ham" in September 2008 (right). The treated area of the „Het Groene Eiland" (left) has experienced a reduced biomass-production.

Conclusion

Phosphorus as the key nutrient in water bodies plays a significant role in biomass production.
The water quality increased in both lakes after the phosphorous precipitation with Phoslock®. No swimming bans have been reported in either lake. The measures taken prevented both treated water bodies from being covered by hazardous blue-green algae blooms.
Despite the total water body circulation induced by strong wind events and temperature effects which enforce the release of nutrients from the sediment, both case studies presented above and our experiences in long term development of treated water bodies indicate a new sustainable method of shallow lake restoration.
Furthermore Phoslock® is planned to be used in the restoration of ecologically sensitive shallow lakes:
In autumn 2009 a 22 ha shallow lake (avg. depth 1,60 m) in northern Germany will be treated with Phoslock®. The aim of this measure is to reset the trophic status of the lake to mesotrophic. The regular appearance of massive blue-green-algae blooms shall be prevented and the dominance of macrophytes achieved.

Institut Dr. Nowak
Analytik · Beratung · Gutachten

Dr. Said Yasseri
Mayenbrook 1
28870 Ottersberg / Germany
Tel +49 4205 3175-28
Fax +49 4205 3175-819
Mob +49 151 14568812
Email sy@limnowak.com