Phoslock Europe GmbH: www.phoslock.eu
Phoslock Environmental Technologies Ltd. : www.phoslock.com.au

Bärensee, Hanau, Germany

Application dates: June 2007, top up applications 2010, 2013, 2016

Summary

***Aim**: To reduce phosphorus concentrations and re-establish and preserve ecosystem function*

Description: Former sand excavation pit used for recreation

Size (ha):	6
Max. depth (m):	3.8
Average depth (m):	2.63
Volume *(10^3 m^3):*	156
Conductivity (µS/cm):	380
Dosage to date (tonnes):	21.5

The Lake

Figure 1. View of Bärensee (Google earth**)**

Lake Bärensee (Figure 1) is an artificial, shallow, polymictic lake. It is located within the largest camping area in the Federal German State of Hessen and is a popular, highly frequented lake for swimming and fishing. The lake is surrounded on 3 sides by camping grounds, has sandy beaches (Figure 2) and is bordered by a mixed forest to the east. Poorer water quality was noticed in the 1990s which transformed the lake to a hypertrophic state by 2004. Swimming bans began which severely decreased the recreational value of the lake.

The lake has a small catchment area (10 ha) and no outflow. The inflow is derived primarily from direct precipitation and groundwater. According to the German LAWA Directive, the lake is categorized as a non-stratifying gravel lake. The reference mesotrophic state has never been attained and the lake was classified as hypertrophic. Several measures, such as external phosphate elimination, food web manipulation and floating macrophyte pontoons, did help to counteract the ongoing process of nutrient pollution, however in the sediments of the lake, there was approx. 700 mg phosphorus/kg dry weight, of which nearly 20% was classed as potentially releasable (mobile P).

Figure 2. Beach of Lake Bärensee

The Treatment

Figure 3. Application of Phoslock®

In June 2007, an initial dose of 11.5 tonnes of Phoslock® (marketed as Bentophos® in Germany) was applied to reduce the phosphorus concentration in the water column and to bind a large part of the mobile P in the sediment. This initial dose corresponds to a Phoslock® load of 1,900 kg/ha. Due to external nutrient sources as well as intensive recreational use of the lake, smaller top up applications were required and performed in 2010, 2013 and 2016.

The applications were performed from a motorized pontoon. During the applications, the area of the lake within 2 m of the shore were not treated, as required by the authorities. The depth of the area being treated and the route were monitored using a depth-sounder and GPS (Figure 3).

The dosage of Phoslock® was calculated after comprehensive pre-treatment monitoring of the water and sediments. All necessary permits for the application were obtained.

Bärensee

Results: Water Chemistry Parameters

In 2007 the total phosphorus (TP) concentrations dropped from an average of 80 µg/L in the two months prior to the application (data not shown) to an average of ~65 µg/L (A – Figure 4) in the months following the application. As expected, TP concentrations dropped further during the years following the initial application (Figure 4). Small top up applications in 2010, 2013 and 2016 maintained TP concentrations within a range between 30 - 50 µg/L. The initial application reduced the phosphate (PO_4-P) concentration in the water column to levels close to the limit of detection (data not shown). These low PO_4-P concentrations have been maintained during the 10 years following the first application.

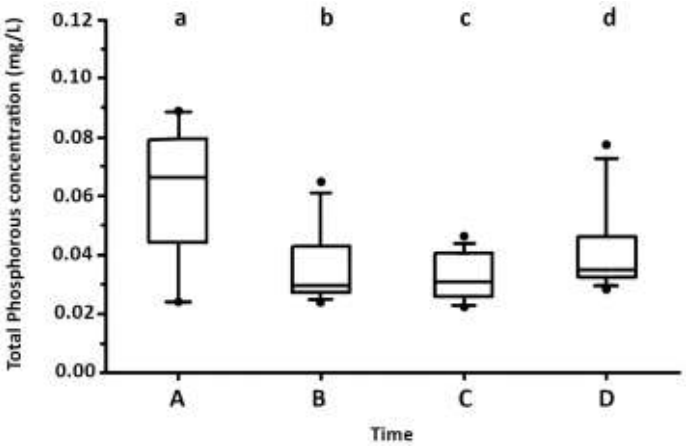

Figure 4. Range of TP among temporal subgroups (A–D). Samples in period A (n = 9) were taken in 2007. B (n = 14) comprises samples from 2008 to June 2010. C (n = 16) covers the period between the 1. and 2. reapplication of LMB in March 2013. Samples in period D (n = 14) were taken after 2. reapplication of LMB up to end of 2015. Groups that do not share the same small letter (a, b, c; above the boxes) are significantly different (Mann–Whitney U-test; $P < 0.05$) (Source = Epe et al., 2017).

Management Strategy

The potential requirement for small top-up applications was anticipated from the start of the restoration program, as intensive bathing activities were expected to be a major source for nutrient inputs. A target level for TP was defined and regular monitoring undertaken to identify increasing TP trends. This strategy enabled the subsequent target-oriented control of TP by reapplications. This management approach, adopted in cooperation with the stakeholders, maintained the improved trophic state of the lake during the 10 years following the first application.

Conclusion

Small, shallow lakes with intense recreational use are prone to nutrient pollution. The vulnerability of such lakes tends to increase due to climate change. To preserve the ecosystem service of such intensely used water bodies a reduction of the external nutrient inputs is necessary but often not sufficient on its own and additional, internal measures are required. The management strategy adopted for Lake Bärensee was agreed with the stakeholders and consisted of an initial application of Phoslock® and smaller, target-oriented top-up applications. In the 10 years since the initial application, the water quality has improved and the lake has remained open for recreational activities including swimming (Figure 5). This case study clearly demonstrates that the adopted management concept is effective to ensure good long-term water quality in an intensely used swimming lake. Results from the project are published in a peer reviewed paper (Epe et al. 2017).

Figure 5. Swimming area in Lake Bärensee

References

Epe, T., Finsterle, K., & Yasseri, S. 2017. Nine years of phosphorus management with lanthanum modified bentonite (Phoslock) in a eutrophic, shallow swimming lake in Germany. *Lake and Reservoir Management*, 33(2), 119-129.

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Publication date: February 2018
Edited publication date: April 2021