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Laguna Niguel Lake, California, USA

Application dates: 29th April – 2nd May 2013

Summary

***Aim**: Reduction of the phosphorus loading within the lake causing cyanobacteria outbreaks*

***Description**: Manmade lake built during the construction of Sulfur Creek Dam*

***Size** (ha):*	*12.4*
***Max. depth** (m):*	*9.5*
***Average depth** (m):*	*3.7*
***Dosage (tonnes)**:*	*51*

The Lake

Figure 1: Aerial view of Laguna Niguel Lake (2009)

Laguna Niguel Lake (Sulfur Creek Reservoir) was built in 1966. The lake is primarily used for scenic recreation and local fishing, however it also is an important sanctuary for waterfowl. Recent issues with surface cyanobacteria scum's, foul odours, declining fishery and outbreaks of avian botulism prompted the need for water quality management. Although the nutrient inputs from the inlet creek and surface runoff contribute to the annual load of phosphorus into the lake, monitoring of the water quality and lake sediments in recent years suggested internal phosphorus loading as a significant contributor to the water quality issues.

Treatment

The Phoslock application was carried out over a period of 4 days. Phoslock was mixed with lake water in a custom mixing chamber and injected to the lake surface. Global Positioning System (GPS) technology was used on the boat to assure uniform application in the 4 treatment zones of the lake (Figures 2 & 3). Phoslock dosing in each zone was based on surface area, water depth, sediment characteristics and phosphorus concentrations.

Figures 2 & 3: Phoslock application to 4 established zones of Laguna Niguel Lake.

Monitoring

Water quality analyses were conducted from lake samples (3 fixed locations in the lake) in 2012 and 2013. Post-treatment water sample collection and analysis continued through September 2013.

Benthic macroinvertebrate sampling and assessment were conducted both upstream and downstream of the lake immediately before treatment (4/29/13) and four days after Phoslock application completion(5/6/13) .

Sediment samples were collected from 3 sites in the lake using a threaded stainless steel coring apparatus. Sediment samples were taken prior to the Phoslock application (4/29/2013); and 3 and 6 months post treatment (8/7/2013; 12/4/2013) (Figure 4). The top 5cm layer of sediments(2 samples homogenized composite) from each sample location where sent to the lab for analysis. Sequential extraction was used to determine relevant phosphorus fractions and compare concentrations of available and stable phosphorus forms prior to and following the treatment.

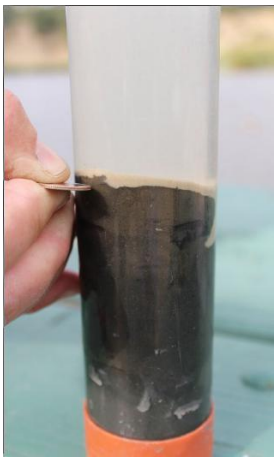

Figure 4: Sediment cored sample collected after Phoslock application to Laguna Niguel Lake

Laguna Niguel Lake

Results

No significant changes were measured in pH, turbidity, conductivity and alkalinity throughout the study. However, Phosphorus rapidly (< 2 weeks) and significantly ($p < 0.0005$) decreased the total (> 80%) and free reactive phosphorus (> 95%) in the water column (Figure 5). It was also documented to bind the potentially releasable sediment phosphorus fractions to form stable fractions post-treatment.

Secchi depth greatly increased post Phoslock application with an average of 122.6 cm from April – September, 2013 where the corresponding timeframes measured 61.6 and 100.5 cm in 2011 and 2012, respectively.

Prior to the Phoslock application, the lakes algal community was dominated by cyanobacteria (primarily *Aphanizomenonflos-aquae*) with an average density of 33,300 cells/mL. However after the application and subsequent inactivation of phosphorus, the main species of algae shifted to green algae and diatoms (average 6,000 cells/mL; Figure 6). Cyanobactraia concentrations fell significantly to an average of 1,200 cells/mL. Cyanobacteria levels remained below or near detection limits, despite documented cyanobacteria blooms and high pretreatment cell densities.

In previous years, 10-12 reactive algaecide applications were required on an annual basis to maintain the desired aesthetic quality of the lake. Increased aesthetic quality and no noticeable cyanobacteria scum formations were observed post Phoslock treatment and no reactive algaecide applications were required for cyanobacteria in 2013.

The monitoring also document no significant composition or diversity alteration to the benthic macroinvertebrate community after the Phoslock application.

Phoslock provided the water resource managers of Laguna Niguel lake an ecologically sound *in situ* solution to specifically address phosphorus pollution and restore water quality.

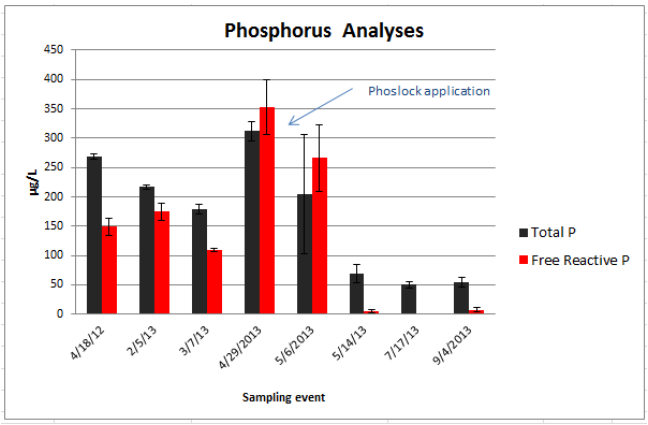

Figure 5: The Total and free reactive phosphorus concentrations. Values are averages from three sampling locations. Error bars represent one standard deviation. Underlined event represents sampling during the Phoslock application period (Figure taken from unpublished paper by Bishop et al at westb@sepro.com).

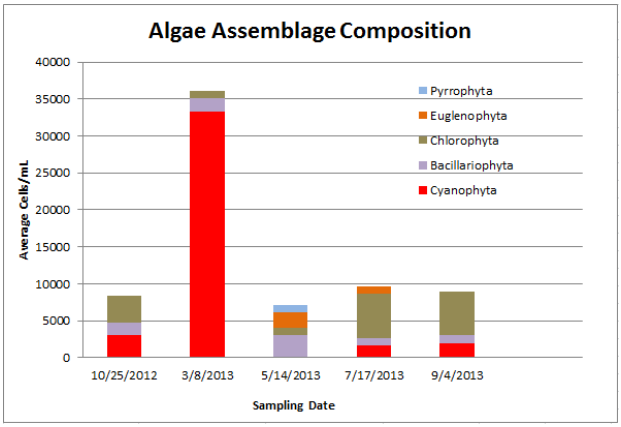

Figure 6: Algae assemblage composition at different sampling events in Laguna Niguel Lake. Values are averages from three sampling locations. Arrow represent Phoslock application (Figure taken from unpublished paper by Bishop et al at westb@sepro.com).

Conclusion

Phoslock significantly decreased and sustained lower concentrations of phosphorus in the water column. The application also shifted sediment phosphorus fractions to highly stable forms compared to pre-treatment concentrations. Consequently the algal assemblage shifted from historic cyanobacteria dominated blooms at nuisance densities, to green algae/ diatoms dominant with decreased cyanobacteria presence.

Phoslock provided the water resource managers of Laguna Niguel Lake an ecologically sound *in situ* solution to address phosphorus pollution and restore water quality.

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