Photosynthetic biofilm reactor (PBR) for nutrient removal from wastewater

Allison Prill, Dr. Aravindan Rajendran, and Dr. Bo Hu

Department of Bioproducts and Biosystems Engineering

University of Minnesota
Driven to Discover℠

Introduction

Excess phosphate from first and second-point pollution sources easily enters water systems, causing serious problems like eutrophication. The consequences of excess nutrients in water systems can result in rapid decline of many native populations due to lack of oxygen and other complications[1].

An effective method of removing excess nutrients from wastewater is needed to reduce the impact of runoff and other sources of pollution. Recent research shows that several species of algae, including *Phormidium bohneri*, can be used at wastewater sites as a cost-effective means of removing excess phosphate from the wastewater in an industrial setting[2].

To test this, *P. bohneri* was cultivated in media with three different levels of initial phosphate. The phosphate levels were measured as a function of time. The results of this experiment show the *P. bohneri* has the ability to remove significant amounts of phosphate from a liquid media and bind to a mixed-media matrix successfully. These results are important in developing a system of removing excess phosphate from wastewater. Further research is necessary to understand how this species performs in a non-synthetic media.

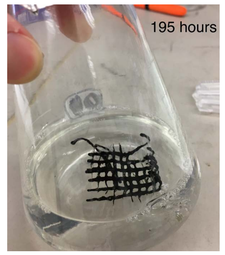

Figure 1. Trial 3B is shown after 195 hours to the right. *P. bohneri* shows nearly perfect attachment to a cotton-polyethylene matrix in a nutrient-rich media, BG-11.

Results

- The phosphate levels decreased for all trials at each of the three concentrations
- The largest percent difference in phosphate levels was a -80.52% decrease, with the average percent difference being -50.13%
- Vial 2B showed very little attachment or ability to remove phosphate, most likely due to a bacterial contaminant.

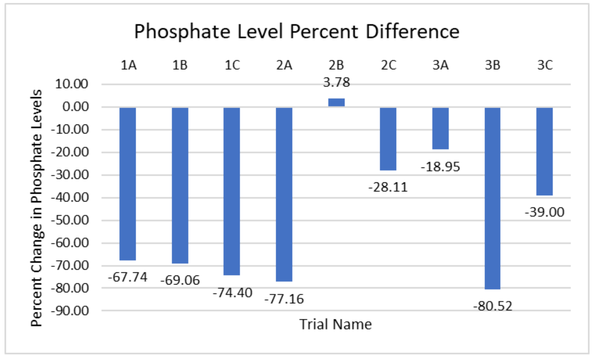

Figure 2. The percent difference between the initial and final phosphate values is shown above.

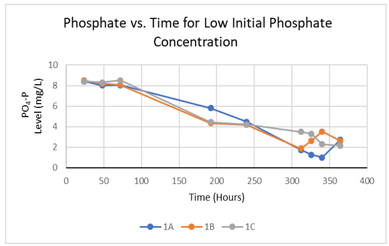

Figure 3. The phosphate level as a function of time for the lowest initial phosphate concentration is shown above.

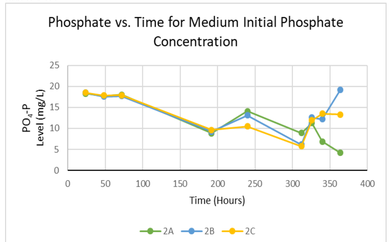

Figure 4. The phosphate level as a function of time for the medium initial phosphate concentration is shown above.

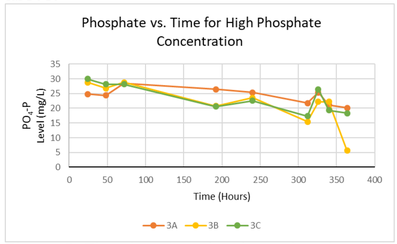

Figure 5. The phosphate level as a function of time for the highest initial phosphate concentration is shown above.

Conclusions

From the data given, it is reasonable to conclude that *Phormidium bohneri*, when cultivated in the nutrient-rich BG-11 media with proper lighting and agitation, has the ability to drastically reduce the phosphate levels in a synthetic media. This result is important because it identifies *P. bohneri* as a candidate species for phosphate removal from water systems. While most of the flasks displayed a drastic reduction in phosphate levels, there were a few flasks that did not follow this trend to the same extent. The reason for this has yet to be determined, but an ion chromatography analysis of the samples in the future could reveal some answers. Most likely, this is due to bacterial contamination. Regardless, the conclusion that phosphate levels are reduced by *P. bohneri* holds true, although the level of reduction varies.

Further Studies

- The experiments should be repeated in a nonsynthetic media, ideally from a nearby body of water known to have undesirably high levels of phosphates that leads to lower water quality.
- Ion chromatography analysis should be performed on all samples to determine any key differences between the high-performing flasks and the outlying low-performing flasks.
- The same biofilm mats should be cultivated in new media to determine their ability to continually remove phosphate from a non-depleting source.

Materials and Methods

Phormidium bohneri was inoculated with the liquid BG-11 media in a different concentration for each trial. Three flasks were prepared in each trial.

- The low concentration had 8.5 mg/L of K_2HPO_4
- as the initial source of phosphate.
- The medium concentration had 18.5 mg/L of K_2HPO_4 for the initial phosphate source.
- The high concentration had 30 mg/L of K_2HPO_4 as the initial source of phosphate.

The flasks were cultivated under fluorescent lighting and were constantly agitated by a shaker. Periodically, Hach Reactive Phosphorus tests were used to monitor the phosphate levels in each flask.

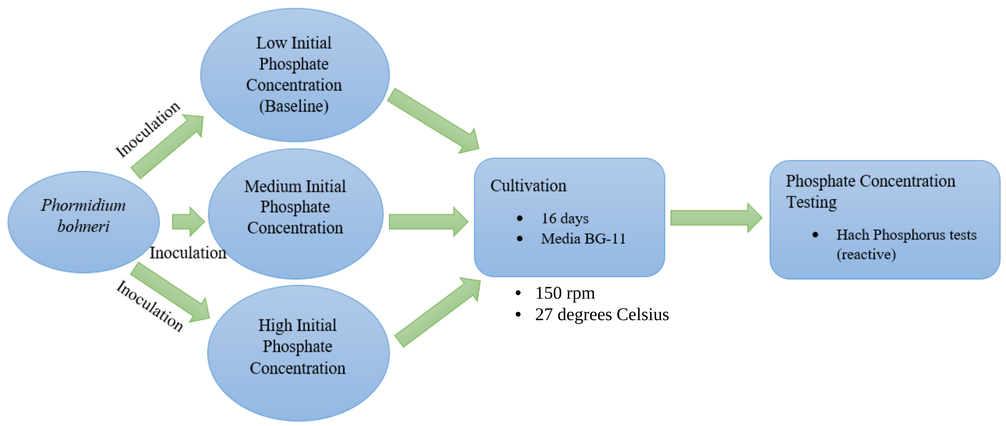

Figure 6. The experimental procedure for the reactive phosphate level experiment is shown above.

Bibliography

1. Talbot, P., & Noue, J.D. (1993). Tertiary treatment of wastewater with Phormidium bohneri (Schmidle) under various light and temperature conditions. *Water research, 27*(1), 153-159. doi:10.1016/0043-1354(93)90206-w

2. Blier, R., Laliberte, G., & Noue, J.D. (1995). Tertiary treatment of cheese factory anaerobic effluent with Phormidium bohneri and Micractinum pusillum. *Bioresource Technology*, 52(20, 151-155. doi:10.1016/0960-8524(95)00014-6

This project was supported by the University of Minnesota's Undergraduate Research Opportunities Program.

UROP University of Minnesota