The Vermont Legislative Research Service

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The two nutrients of concern are nitrogen and phosphorus. The announcement states that these nutrients come from a variety of sources, "including legacy contributions from years past."

[1] This means that these nutrients are not only currently entering waterways in but also that contributions from years past are producing the high levels seen today.

Lake Champlain has high concentrations of phosphorus. These high concentrations are negatively affecting the lake by damaging ecosystems and causing algae blooms. In recent years, Vermont has been actively trying to reduce phosphorus concentrations in the lake. This has historically been expensive and difficult to do, which is why there is currently an investigation into whether there is potential to commercialize these nutrients for profit. Phosphorus is a finite material and the easily accessible phosphorus reserves are being depleted. As the easily accessible supply of phosphorus in the world decreases, the price of phosphorus will likely increase in the market, making these commercialization techniques more profitable.[2]

Phosphorus has the greatest potential for commercialization due to various uses and high concentrations in Lake Champlain. Through a commercialized phosphorus removal process, it may be possible to profit from the reduction of phosphorus concentrations of both water in the lake and water flowing into the lake. New technologies are being developed that have the potential to achieve this goal. Some of these technologies are: hydroponic farming, organic systems (biochar and algae filtration systems), nano-technology, and improved wastewater treatment facilities.

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[1] Tamara Dickinson, "Innovating to Protect our Waterways," White House Office of Science and Technology Policy, December 17, 2014, accessed April 3, 2015, https://www.whitehouse.gov/blog/2014/12/17/innovating-protect-our-waterways.

[2] Michigan State University, "New method to remove phosphorus from wastewater," ScienceDaily, August 15, 2012, accessed April, 10, 2015 http://www.sciencedaily.com/releases/2012/08/120815112243.htm.

Phosphorus enters Lake Champlain largely through “nonpoint sources,” which are generated by runoff and erosion across the landscape, as opposed to “point sources” which can be wastewater treatment facilities and storm water discharges that are conveyed by a pipe.[3] Relative to nonpoint sources, point sources are easy to regulate, because the water is being stored or transferred within a constructed system.

Since 2007 phosphorus levels have been stable or slightly increasing, with nine of the thirteen segments of the lake (Figure 1) exceeding established targets for phosphorus concentration levels in 2010. Flooding in 2011 caused a large spike in phosphorus concentration levels--the largest spike since 1990 in certain parts of the lake. The greatest increases in phosphorus levels in the last five years were in the Main Lake, Burlington Bay, and Missisquoi Bay. Many other areas of the lake were also affected and exceeded their annual targets.

Current Actions by Vermont

Vermont issued its first TMDL (Total Maximal Daily Load) for phosphorus in Lake Champlain to the EPA in 2002. A TMDL is a measurement of how much of a certain nutrient can flow into a body of water each day, while maintaining water quality standards for that body of water. A TMDL provides the state with a measurable goal of phosphorus loading, aro 02 Tw [(o)3(f th)9(e l)3(ak)1(e ()]TJ -26.87 -1 0 Td

Figure 1: Phosphorus Target Levels and Actual Levels for the

New Hampshire Experiment

In the 1980s, the EPA deemed Kezar Lake in New Hampshire “the highest priority for restoration” in the state. The treatment decided upon by the EPA was a combination of wetlands management and aluminum salt injections on the lake bottom. The aluminum salt (a 2:1 ratio of Al_2SO_4 : $NaAlO_2$) was shown to be effective at deactivating phosphorus in a test plot of the lake. This result led to a larger portion of the lake receiving treatment. The lake was then monitored for 4 years. After 4 years, the lake had returned to phosphorus levels close to those pre-treatment. The levels at the conclusion of that 4-year watch period, however, were more stable and safe for recreation. The other aspect of this project was “wetlands manipulation.” This part of the project involved raising the water levels in Chadwick Meadows, an area around Lion Brook, a tributary to Kezar Lake. The central idea behind this wetland manipulation was that “macrophytic nutrient uptake and sedimentation of suspended particulates” would be encouraged by the plant life. This piece of the overall project did not greatly affect the phosphorus load in the lake. Nevertheless, it was fairly inexpensive, and helped to create wetland habitat and promote some sedimentation.

Figure 2: *Clear as Water* publication displaying input-output of their process

precipitate struvite, magnesium ammonium phosphate.[16] The process is conducted in wastewater treatment plants (point sources), where water molecules are split with and separated from phosphorous molecule. This process uses no chemicals and researchers say that it does not use much energy. The end result of the process is phosphorous crystals that can be used as fertilizers.[17] There is a stigma associated with using sludge, which is human waste.

Conclusion

There are a number of ways that phosphorus levels in Lake Champlain are already being reduced. The research shows that there is potential for commercialization, but the technology needs further development. The majority of the research pertains to decreasing levels of phosphorus entering the lakes via point sources. Discovering more cost effective methods of removing phosphorus from wastewater facilities could increase profit margins for firms and also mitigate costs through sale of byproducts. Hydroponic farming has potential, however, its scalability remains in question. Algae filtration systems are another method of phosphorus extraction and markets for byproducts appear to be profitable. Research is still necessary to determine more effective methods of phosphorus removal. As a result, there are remaining questions of the cost of extraction, creation of end products and profitability of these products in the marketplace. As global phosphorus reserves continue to be depleted and more phosphorus enters Lake Champlain, there could be increased incentives in the near future for the commercialization of legacy nutrients in Lake Champlain. A final question research has not yet touched on is the total net effect on the environment and how EPA regulation will influence the implementation of these technologies.

This report was completed on May 10, 2015 by Becka Brolinson, Matthew Donovan and Jonathan Gonin under the supervision of Professors Jack Gierzynski, Robert Bartlett and Eileen Burgin in response to a request from Representative Sheldon.

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