ALUM TREATMENTS TO REDUCE INTERNAL PHOSPHORUS LOADING IN LAKES

TONY GROVES | WATER RESOURCES GROUP, PROGRESSIVE AE

Internal phosphorus loading occurs when deep waters in lakes become devoid of oxygen and phosphorus that has accumulated in sediments is released to the water column. This is a common occurrence in nutrient-enriched lakes. In some lakes, the release of accumulated phosphorus can greatly impact lake water quality. Much of the phosphorus that is released from sediments is dissolved phosphorus, a form readily available to stimulate algae growth. Yet, while internal phosphorus loading can have profound water quality impacts, it is often an overlooked source of phosphorus. However, in recent years, a better understanding of the importance of internal phosphorus loading has begun to emerge. Internal phosphorus loading has become the focus of many lake management projects and considerable research is being conducted to identify the best ways to mitigate and control internal phosphorus loading. Much of this research has focused on the use of the compound aluminum sulfate, commonly called "alum."

Alum is a chemical that has been used successfully in many lakes to reduce phosphorus levels by preventing phosphorus release from lake sediments. Once applied, alum binds with phosphorus in the water column and settles to the bottom as a floc. The floc inhibits the release of phosphorus from lake sediments. Alum is commonly used to treat wastewater and drinking water and, over the last half- century, there have been hundreds of lake alum treatments.

The longevity of an alum treatment in reducing phosphorus levels is finite and dependent on several factors including alum dose, lake depth, and amount of phosphorus entering the lake from the watershed. In general, if properly dosed, the effectiveness of an alum treatment in reducing phosphorus levels is longer in deeper lakes with relatively small watersheds. In an analysis of data from 83 lakes treated with alum, Huser et al. (2015) found that alum treatments of deeper lakes were effective in reducing phosphorus for an average of 15 years. Similar results were documented on two Michigan lakes treated with alum. Byram Lake, a 133-acre lake located in Genesee County, was treated with alum in 1990. When comparing pre- and post-treatment water quality data, Byram Lake had significant reductions in phosphorus and algae growth and increased transparency 26 years after the treatment (Figure 1 and Table 1). Spring Lake, a 1,091-acre lake in Ottawa and Muskegon Counties, was treated with alum in 2005, and had similar, though less dramatic results, 15 years after treatment. Recent data for Spring Lake suggests the alum treatment in Spring Lake may be beginning to lose its effectiveness.

In addition to applying alum to prevent internal loading, known as an "inactivation treatment," alum can be used to remove phosphorus from the water column and make it temporarily unavailable for algae growth. However, unlike phosphorus inactivation treatments, the effectiveness of phosphorus removal treatments is relatively short-lived, perhaps 1 to 3 years.

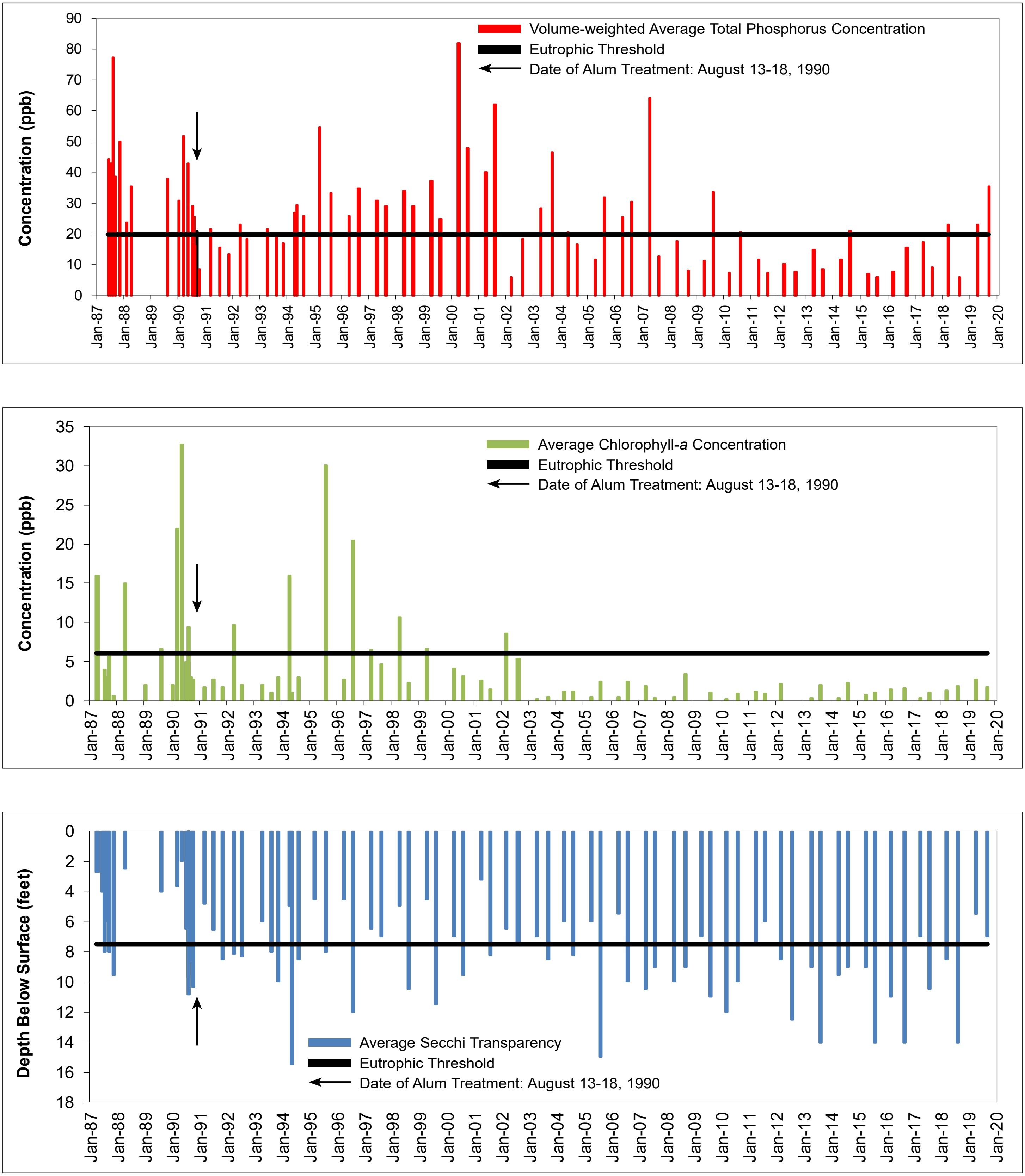

FIGURE 1. AVERAGE TOTAL PHOSPHORUS (TOP), CHLOROPHYLL-A (MIDDLE), AND SECCHI TRANSPARENCY (BOTTOM) MEASUREMENTS AT BYRAM LAKE, GENESEE COUNTY, 1987-2019 BEFORE AND AFTER AN ALUM TREATMENT.

(CONTINUED ON PAGE 26)

ALUM TREATMENTS TO REDUCE INTERNAL PHOSPHORUS LOADING IN LAKES

(CONTINUED FROM PAGE 25)

Not all lakes are good candidates for an alum treatment and alum should not be viewed as a panacea. In fact, while internal loading occurs in many lakes, it often does not rise to a level that would warrant intervention. However, in some situations, internal loading can cause persistent water quality problems such as algae blooms. In some lakes, the magnitude of internal loading is so great that watershed management alone will not improve lake conditions. In these situations, an alum treatment may be worthy of consideration.

JAMES (2016) NOTED:

Simply reducing watershed phosphorus loading to eutrophic lakes without also managing internal phosphorus loading may not be enough to reverse impaired water quality. Even though internal phosphorus loading is ultimately derived from the watershed, it can take years to decades to flush sediment phosphorus out of the system after watershed best management practice implementation, resulting in delayed recovery and continued impairment.

TABLE 1. BYRAM LAKE PRE- AND POST-ALUM TREATMENT SUMMARY STATISTICS, 1987-2019

	Total Phosphorus (µg/L)[1]		Chlorophyll-*a* (µg/L)[1]		Secchi Transparency (feet)	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Mean	100	32	9	3	5.5	8.5
Standard deviation	109	33	11	5	2.5	2.7
Median	50	22	5	2	5.0	8.5
Minimum	14	5	0	0	2.0	3.2
Maximum	466	374	37	30	10.0	15.5
Number of samples	62	366	11	67	11	71

1 µg/L = micrograms per liter = parts per billion.

The optimum alum dose for a particular lake can be determined by collecting sediment cores, measuring the amount of available phosphorus in the upper sediment layer, and calculating the dose rate accordingly. Alum is typically applied at a certain dose over the deeper portions of the lake with a specialized application barge (Figure 2). If applied properly, alum should not adversely impact aquatic life.

In Michigan, the application of alum to surface waters requires a Rule 97 Certification of Approval from the Michigan Department of Environment, Great Lakes, and Energy. State approval would likely require monitoring of lake conditions before, during, and after the alum treatment.

To find out more about internal loading, visit www.michiganlakeinfo.com

FIGURE 2. ALUM APPLICATION BARGE .

Some practical considerations in evaluating an alum treatment include:

- Ample pre-treatment water quality data must be collected to document that internal loading is a problem and the extent to which an alum treatment may control internal loading and improve lake conditions.
- While alum is effective in controlling algae growth, rooted plants generally are not impacted since they are able to draw phosphorus from the lake bottom sediments.
- The potential benefits of an alum treatment (e.g., reduced phosphorus levels, less algae growth, improved transparency) must be compared to the financial costs and anticipated years of effectiveness.

Again, it is important to emphasize that alum should not be viewed as a cure-all. It is but one tool that can be used to restore water quality; alum should not be applied to the exclusion of other management alternatives such as the preservation and restoration of natural shoreline areas. As with any lake improvement technique, sufficient information must be gathered to evaluate effectiveness, technical feasibility, environmental impacts, regulatory requirements, and costs.

BIBLIOGRAPHY

Cooke, G.D., E.B. Welch, S.A. Peterson, and S.A. Nichols. 2005. Restoration and Management of Lakes and Reservoirs, 3rd Edition. New York: CRC Press. 612 pp.

Huser, B.J., Egemose, S., Harper, H., Hupfer, M., Jensen, H., Pilgrim, K.M., Reitzel, K., Rydin, E., and F. Futter. 2015. Longevity and effectiveness of aluminum addition to reduce sediment phosphorus release and restore lake water quality, Water Research (2015), http://dx.doi.org/10.1016/j.watres.2015.06.051

James W. F. 2016. Internal P Loading: A Persistent Management Problem in Lake Recovery. LakeLine. 36: 6-9.

Jensen, H.S., and K. Reitzel. 2015. Evaluation of alum treatment efficiency on water quality and internal phosphorus cycling in six Danish lakes. Hydrobiologia. DOI 10.1007/s10750-015-2186-4.

Kuster A.C., A.T. Kuster, and B.J. Huser. 2020. A comparison of aluminum dosing methods for reducing sediment phosphorus release in lakes. Journal of Environmental Management, 261 (2020) 110195 .

Nürnberg, G.K. 2009. Assessing internal phosphorus load – Problems to be solved. Lake and Reservoir Management. 25(4): 419-432. DOI: 10.1080/00357520903458848

Osgood, R.A. 2017. Inadequacy of best management practices for restoring eutrophic lakes in the United States: guidance for policy andpractice. Inland Waters, DOI: 10.1080/20442041.2017.1368881

Progressive AE 2018. Byram Lake 2018 Water Quality Monitoring

Report. Byram Lake Association.

Progressive AE 2019. Spring Lake 2019 Water Quality Monitoring Report. Spring Lake – Lake Board.

Steinman A. and M. Hassett. 2017. Internal Phosphorus Loading in Spring Lake 11 Years Following Alum Treatment. Annis Water Resource Institute, Grand Valley State University.

Steinman A.D., and B.M. Spears. 2020. Internal Phosphorus Loading in Lakes: Causes, Case Studies and Management. Plantation, FL: J. Ross Publishing. 466 pp.

Wagner K.J. 2017. Preface: Advances in phosphorus inactivation. Lake and Reservoir Management. 33:103–107.

Wetzel, R.G. 2001. Limnology: Lake and River Ecosystems, third edition. Academic Press. San Diego, CA.1006 pp.