Aeration Case Study: An Evaluation of Past and Present Aeration Designs for Silver Lake

Using aeration to reduce microsysitin counts/blue-green algae, and overall algal biomass in an Ohio Lake

Silver Lake, Summit County, Ohio, is a 99 acre dimictic impoundment, constructed in the mid to late 1800's. It is a groundwater-dominated seepage lake that until the early 1970's received varying amounts of wastewater. Legacy nutrients from these periods have maintained the lake as eutrophic, despite improvements in the watershed (i.e., diverted septic). The lake continually exhibits dense blue-green algal blooms, low Secchi depth (< 1 m), and summer anoxia below 4 m.

Further restoration efforts were initiated in the early 1980's to address legacy nutrients and immediately suppress eutrophication symptoms. A bottom diffused aeration system was chosen to meet these goals and was installed in 1982. The basis of the aeration design reflected research and technology of the time. Results showed improved oxygen availability in the deep area and increase in zooplankton and benthic macroinvertebrates. However, there were also increases in surface chlorophyll-a, phosphorus, and algal biomass, as well as a slight decline in transparency and the continued predominance of blue-green algae. One of the main goals for the project was reduction of blue-green algae and microcystin, which was not achieved with the 1982 aeration design.

In 2014, a redesigned aeration system was installed that reflected improved sizing of models and new aeration technology. Results for the redesigned system showed complete lake destratification, significant reductions in chlorophyll and microcystin, improved transparency, and finally a shift from blue-green algae to green algae. Overall, the redesigned aeration system has met stakeholder goals of reduced algal biomass and microcystin.

Aeration is considered an in-lake restoration tool that has been shown to effect phytoplankton growth, assemblages, and composition

Artificial Mixing

- Algal cells will be mixed to deeper, darker lake areas, decreasing the cells time in the sunlight and thereby reducing their growth rate.
- Some algae species that tend to sink quickly and need mixing currents to remain suspended (e.g., diatoms) may be favored over more buoyant species such as the more noxious blue-greens.
- Mixing of algae-eating zooplankton into deeper, darker waters reduces their chances of being eaten by sight-feeding fish; hence, if more zooplankton survive, their consumption of algae cells also may increase.

Changing Water Chemistry:

- Reduces nutrient re-cycling making for less algal growth.
- Changes in the lake's water chemistry (pH, carbon dioxide, and alkalinity) brought about by higher DO levels can lead to shifts from blue-green to less noxious green algae or diatoms.

1982 Aeration Design

- The basis of the aeration design was from Lorenzen and Fast. 1977.
- The aeration system delivered 119 cubic feet per minute (cfm) air to the deepest area of the lake (12m), through a CPVC flexible pipe with 1/16 inch holes.
- Results showed improved oxygen in the deep area an increase in zooplankton and benthic macroinvertebrates. However, there were also increases in surface chlorophyll-a, phosphorus, and algal biomass, as well as a slight decline in transparency and the continued predominance of blue-green algae.

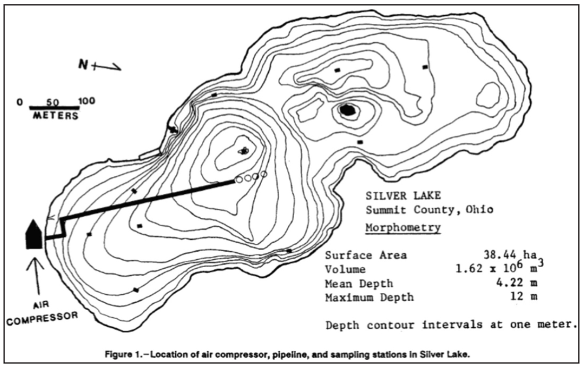
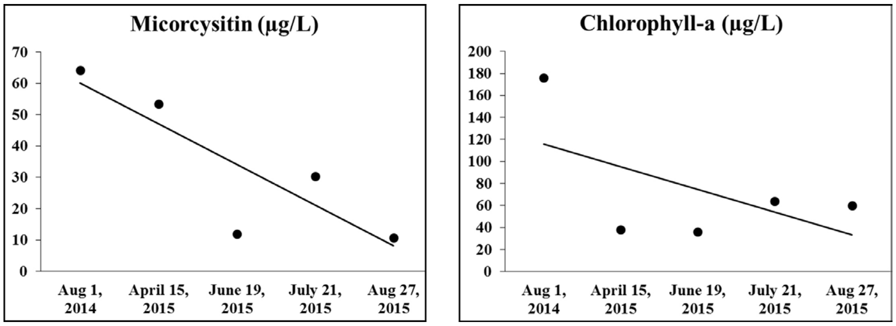


Figure 1. 1982 aeration design. Picture taken from Brosnanand Cooke, 1987

2014 Aeration Design

- The basis of the aeration design was from Pastorok, Lorenzen, and Grinn. 1982; Monzur and Takashi., 2000.
- The 2014 aeration design, delivered slightly more air (168cfm) from the 1982 design, but the air was more evenly distributed throughout the lake using fine pore EPDM membranes. A total 41 diffusers were used (Figure 2).
- Results for the redesigned system showed complete lake destratification, significant reductions in chlorophyll and microcystin counts, improved transparency, and finally a shift from blue-green algae to green algae.



Figures 3 & 4. Preliminary results for microsysitin and chlorophyll-a before and after the 2014 aeration

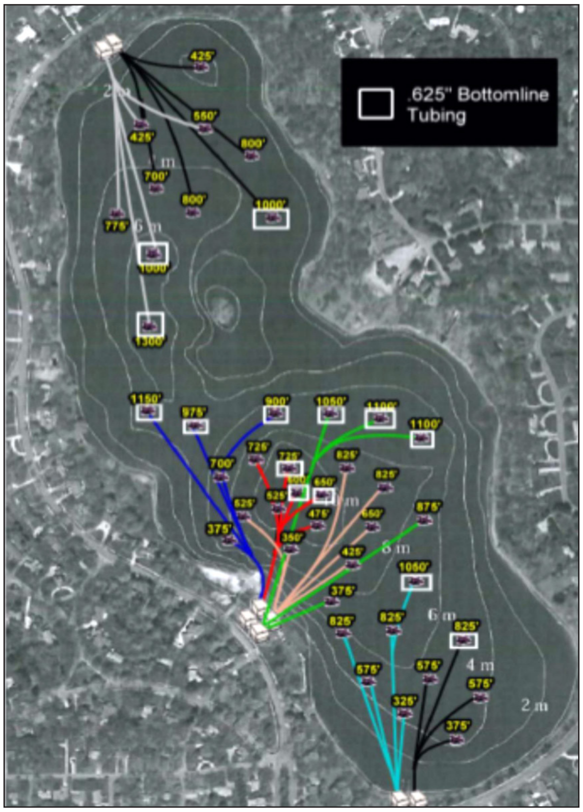
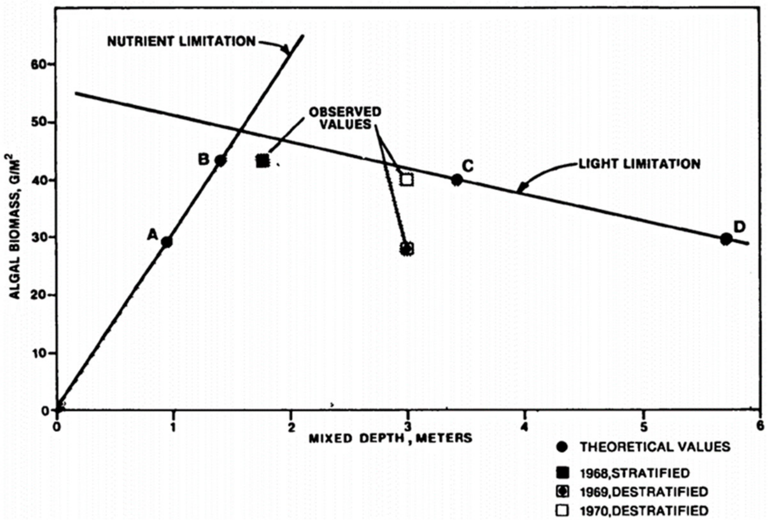


Figure 2. 2014 aeration design done by Vertex Water Features.

	8/1/2014		4/15/2015		6/19/2015		7/21/2015		8/27/2015	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Total-Phosphorus (mg/L)	0.246	0.325	0.147	0.173	0.202	0.21	0.205	0.236	0.252	0.35
Total Nitrogen (mg/L)	2.95	3.69	1.37	1.69	1.54	1.73	1.411	1.509	1.537	1.952
TSS (mg/L)	32	25	10	10	5.5	4.9	12.4	15.6	1.4	N/A
Ammonia (mg/L)	1.75	1.52	0.362	0.466	0.68	0.737	0.035	0.015	<0.002	<0.002
Dissolve O2 (mg/L)	12.71	0.06	11.59	9.67	7.99	5.97	6.8	3.02	7.69	3.17
Temperature (Deg C)	22.2	25.1	11.1	9.1	25	24.5	26.01	25.19	24.04	23.96

Lorenzen and Fast (1977) Model



Monzur and Takashi (2000) Model

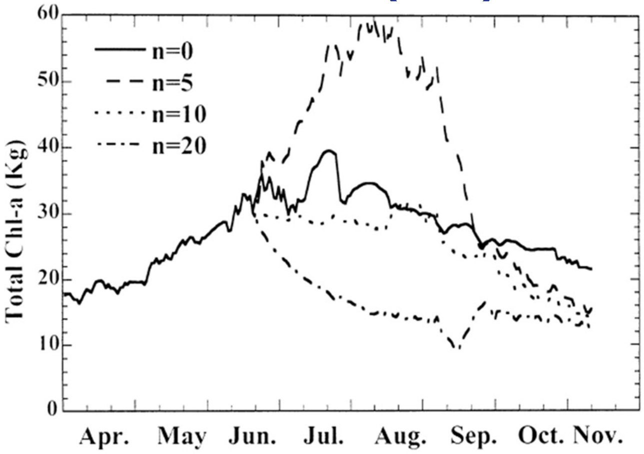


Fig. 3. Effect of number of ports on total Chl-a.

Much of the results can be explained from the different sizing models used. The 1982 design used Lorenzen and Fast (1977) model, which did not account for air distribution only mixing depth, maximum chlorophyll-a, and light limitation.

- No reduction in phosphorus was observed suggesting the sediments were already saturated for iron binding sites.
- Changes in nitrogen, pH, along with artificial mixing were the main mechanisms for the reduction in microsysitin and Chl-a.

References

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- Lorenzen, M. W., and A. W. Fast. 1977. A guide to aeration/circulation techniques for lake management, Environmental Protection Agency, Office of Research and Development, Corvallis Environmental Research Laboratory.
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- Pastorok, R. A., M. W. Lorenzen, and T. C. Ginn. 1982. Environmental Aspects of Artificial Aeration and Oxygenation of Reservoirs: A Review of Theory, Techniques, and Experiences. DTIC Document.

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