Algae Harvesting Boat to End Harmful Blooms on Utah Lake and Beyond

Dr. Kevin Shurtleff
Utah Valley University, Chemistry Department
kshurtleff@uvu.edu, 801-360-9799

Introduction

Harmful algae blooms (HABs) are a serious environmental issue worldwide. Locally, Utah Lake experiences large algae blooms every summer, preventing use of some parts of the lake. HABs also occur on many other lakes in Utah, including East Canyon Reservoir, Forsyth Reservoir, Holmes Creek Reservoir, Jordanelle Reservoir, Pineview Reservoir, Millrace Pond: Jordan River and Canals, etc.

HABs occur when water conditions (warm temperature, sunshine, and abundant nutrients) foster rapid growth of the algae (cyanobacteria). Algae blooms become harmful, because some types of cyanobacteria produce neurotoxins. High concentrations of cyanobacteria in the water not only make it unappealing, but block the sunlight, preventing photosynthesis, killing the cyanobacteria. Upon death, the cyanobacteria, release high concentrations of toxins into the water, making the water harmful to people and animals. It is important to note that killing the algae (cyanobacteria) may make the water look cleaner, but it actually makes the water more harmful.

Algae blooms do not occur across the entire lake. They are concentrated in the same areas each year. It is important that the algae removal technology be mobile, so it can target problem areas with the highest algae concentrations. In addition, algae require sunlight, which means they float on the water. This means it is not necessary to process entire water column from the surface to the bottom. The most efficient algae mitigation technology only needs to skim the floating algae off of the surface.

These criteria have led Utah Valley University to develop an algae harvesting technology that can be deployed on a boat to target areas with the highest algae concentrations. We have designed, built, and tested an effective, environmentally-benign algae harvesting technology. It uses recycled cellulose (wood) fibers added to an algae contaminated water stream. The cellulose and algae are filtered from the water using a a plate and frame filter press. The cleaned water is discharged. The algae and cellulose form a high-solids filter cake, which can be used to sequester carbon dioxide or it can be used as a carbon-neutral biofuel, natural fertilizer, or to produce other products (e.g. bioplastic shoes).

Algae Harvesting Technology

Exhibit 1 shows a small-scale demonstration of our algae harvesting technology on Utah Lake. As shown in the graph, after one-pass through our filtration system, the opacity of the water improves significantly. An advantage of our filtration technology is that it captures all-types of very small particles. So, it not only captures the very small algae

cells, it also removes microplastic particles, dirt particles, etc. from the water. This results in safer and cleaner.

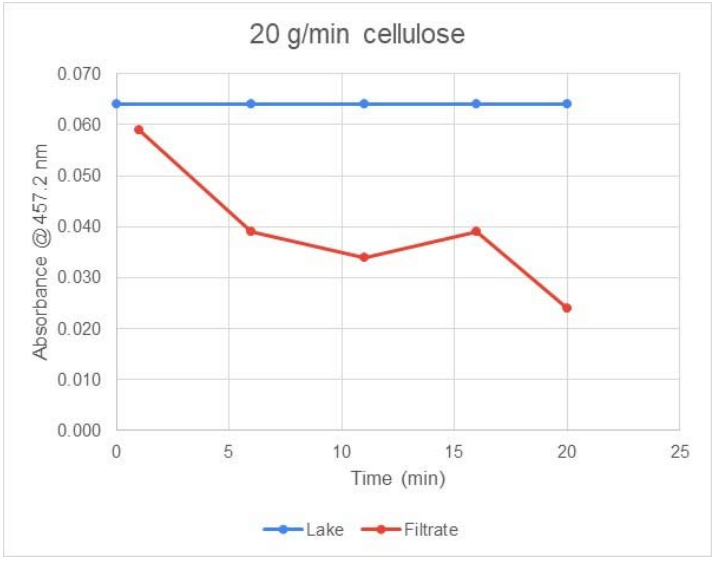

Exhibit 1. Small-scale demonstration of filtration technology on Utah Lake.

Proposed Algae Harvesting Boat

With funding, we propose to build and operate a full-scale algae harvesting boat on Utah Lake during the Spring and Summer of 2020. Our proven algae harvesting technology using cellulose addition with industrial plate and frame filter presses will be scaled-up and made mobile by mounting it on a self-propelled, flat deck, work boat. Exhibit 2 shows a schematic diagram of the proposed algae harvesting boat. The algae harvesting boat will be 30 feet long x10 feet wide. Four – 600 gallon per minute, electric pumps will suction-up 2400 gallons per minute of algae contaminated surface water through a floating boom (skimmer) at the front of the boat. Cellulose powder will be added to the input water stream from a hopper. Two – 630 mm x 630 mm plate and frame filter presses with a total filtration capacity of 16 cubic feet will filter the water stream removing the cellulose, algae, and other small particles. Clean water is discharged from the filter presses back into the lake. When triggered, the semi-automatic filter presses will cycle, partially drying the filter cakes with compressed air and discharging them into bins below the presses. The bins will hold all of the filter cake produced during each day. The boat will operate during two – 8 hour shifts each day, 6 days per week, for 4 months (May – August 2020). During each 16 hour day, the harvesting boat will filter approximately 2.3 million gallons of water. At an algae concentration of 2 million cells per milliliter of water and 50% removal efficiency in a single-pass through the filter, the boat will harvest approximately 872 kilograms of algae using 1,744 kilograms of cellulose for a total of 2.6 metric tons of biomass collected each day. The boat can clean a 12 foot wide by 29 mile strip of water each day at 1.8 miles per hour. Under these operating conditions, the boat can clean 42 acres of water in one day. It will take the boat 15 days to clean one square mile of water. The boat will be

moved around Utah Lake to target the areas with the highest concentrations of algae, for example Provo Bay, Lincoln Beach, Utah Lake State Park marina, etc. We envision a fleet of boats and ships operating across Utah and the world to prevent and/or mitigate algae blooms.

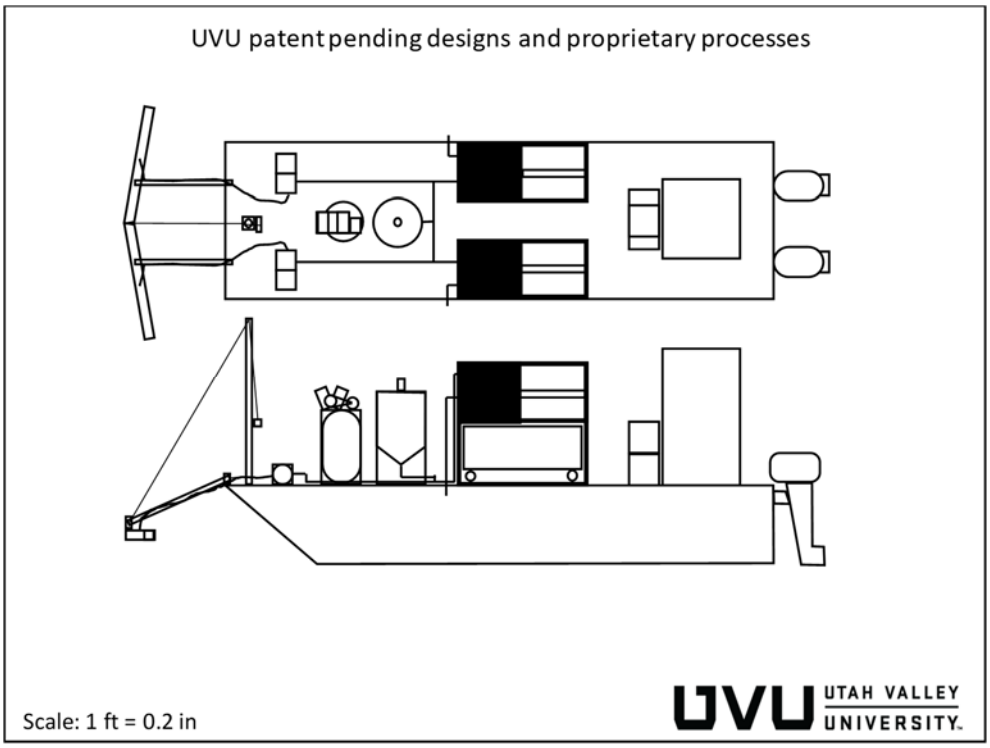

Exhibit 2: Scale drawing of medium-sized, algae harvesting boat.

Conclusion

Funding the UVU algae harvesting boat will be huge step forward in preventing and/or mitigating HABs on Utah Lake. First, it removes algae and other particles from the water, preventing the release of toxins, reducing the nutrient load on the lake, and making the water cleaner, clearer, and safer. Second, it does this without any chemicals being added to the water, which makes it safe for the lake's ecosystem and for people and animals using the lake. Third, it is mobile so it can target areas with the highest algae concentrations making it very efficient at removing algae from the water. Fourth, it supports UVU's mission of engaged learning. Fifth, it will help make Utah lake even more useful to the local community and preserves this important, valuable resource.

Budget

Boat Size	Medium
Project length (months)	4
Capital Costs per Boat	$171,000
work boat cost	$75,000
filter press cost	$56,000

generator	$10,000
air compressor	$2,000
pumps	$8,000
intake skimmer	$3,000
valves and piping	$3,000
electric winch and crane	$1,400
electrical wiring supplies	$2,000
miscellaneous	$4,000
cellulose mixing tank	$1,600
construction cost	$5,000
Project Operating Costs	$129,425
Operators (2 operators, 2 - 8 hr shifts, 6 days/week, 4 weeks/month)	$46,080
Management (1)	$19,200
Fuel	$10,752
Consumables (cellulose, etc)	$23,281
Travel during project	$4,000
Overhead	$26,112
Total project cost (4 months)	$300,425
Cost per day	$3,129