Congressional Testimony, HABHRCA

Harmful Algal Blooms: Action Plans for Scientific Solutions

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Chairman Harris, Ranking Member Miller, thank you for the opportunity to come before the Science, Space and Technology Subcommittee on Energy and the Environment. My name is Dr. Stephanie A. Smith, Chief Scientist at Algaeventure Systems (AVS) located in Marysville, Ohio, and I am here to offer proponent testimony on the Harmful Algal Bloom and Hypoxia Research and Control Act (HR 3650), which aims to develop and coordinate a comprehensive and integrated strategy to address harmful algal blooms and hypoxia, and to provide for the development and implementation of comprehensive regional action plans to reduce harmful algal blooms and hypoxia.

It is my great privilege to bring to you the unique perspective our company has acquired regarding freshwater harmful algal blooms (FHABs), and to describe the technologies that have been developed by our company and which we would like to adapt for FHAB remediation. We further envision novel remediation approaches, and the legislation at hand could greatly influence the development of such technologies by us or other creative people. So perhaps this is the time to make one of the most important points I hope to communicate to you: **addressing FHABs will require a suite of technologies that come together to attack the problem, and which must be developed at both the fundamental and applied levels**. Our company is certainly on the applied end of the spectrum, but we fully expect to engage other scientists, inventors, entrepreneurs, and engineers to improve our own technologies so that they work in concert with those developed by others, resulting in tailored solutions for FHAB sites.

I wish to point out that compared with those we hope to engage, and to the distinguished panel you have assembled today and in years past, we are newcomers to FHABs. I am a microbiologist with broad experience in photosynthetic microbiology and microbial processes, and professional experience at both Wright State University in Dayton, OH, and the Battelle Memorial Institute in Columbus, OH. As a microbiologist I have over the years learned about HABs, the organisms, toxins, and conditions involved, while my own research focus has always been in the enzymology of bacterial carbon fixation, and bioremediation strategies and technologies that leverage natural microbial processes. I very recently joined Algaeventure Systems, which was formed in 2008 under the leadership CEO Ross Youngs. Univenture, a plastics technology and manufacturing company founded by Mr. Youngs, sought alternatives to making their products from petroleum. After intensive research exploring the opportunities presented by terrestrial-based crops including corn, soy and palm, it was revealed that only algae held the potential to sustainably yield bioplastics with the same, or better, performance characteristics than petroleum-based plastics.

Algaeventure Systems, Inc. was thus founded on the belief that algal products will be one of the strongest growth industries over the next 100 years, and that taking carbon dioxide from the air, nutrients and water from waste streams, and turning these things into useful products is absolutely necessary for a growing world population with shrinking resources. But shortly after starting this business, Mr. Youngs and his team recognized that dewatering algal biomass as part of the product cycle threatened to be an industry-crushing expense that would make algal products unaffordable in today's marketplace. Algaeventure Systems thus invented a key technology that has been selected & called "transformational" by the US Department of Energy's Advanced Research Project Agency (ARPA-E).

Termed the solid-liquid-separation system, or the SLS, this low-energy, unbelievably simple yet inarguably effective machine is one of our key technologies that we feel can be applied for recovering biomass from freshwater systems, including those which are laden with cyanobacterial biomass.

Mr. Youngs and his team more recently invented a second key technology that will operate in concert with the SLS, called the Rapid Accumulation and Concentration system, or RAC. Again, low-energy consuming and remarkably inexpensive, this machine was conceptualized because of the search for materials to which algae might attach for growth. Looking to nature, the team sought to mimic the passive capturing of planktonic microbes by the "feather duster" worm's appendages. Those research efforts led to a material that is almost like an algae-magnet; in our own test systems and others it grabs algae out of the water and with a simple mechanical squeezing action releases the algae such that the biomass is concentrated over 30-fold. When this pre-concentrated algal biomass is introduced onto the belt of our SLS system, a flaky mass that resembles fish food is produced. The biomass is then manageable, cheap to transport because it is lighter, and can be used for processing into various products.

These technologies exemplify the inventive and entrepreneurial spirit of this company, but with that said, "blue-green algae," as cyanobacteria are often called, were not part of the original plan for this algae company. Then, Summer 2010 brought several toxic FHABs to our state, and the most devastating may have been the one that hit the Grand Lakes-St. Mary's (GLSM) reservoir in the City of Celina. GLSM enjoys approximately $150-200 million in revenue as a consequence of recreational lake activities and tourists that are drawn to this 13,000-acre reservoir, which also happens to be the primary source of potable water for the city of Celina. The shutdown of Ohio's largest inland lake due to dangerous levels of a cocktail of cyanobacterial toxins (microcystin, anatoxin, cylindrospermopsin, saxitoxins) has been estimated to have cost the community $60-80 million in lost revenue. And of course there were health consequences. Numbers vary according to reports, but the Ohio EPA reported 8 confirmed human illnesses and 4 dog illnesses, including 3 deaths of dogs believed to have directly ingested the lake water. A "no contact" recommendation was placed on the lake in July, which ended the tourist season early, and created numerous and unbearable hazards for the property owners and residents.

The GLSM residents, and as we were to find, most communities that experience FHABs, seemed to be desperately asking, "Can anyone help us with this? Who's in charge of solving problems like this? Is there not a solution for this problem?" For those first questions, bear in mind that when it comes to inland lakes, excepting the Great Lakes, NOAA is not the agency that responds. Agencies of note that were assisting in the situation included the Ohio EPA, the Ohio Department of Natural Resources, Ohio Department of Agriculture, the USDA and the USGS. But perhaps the most impressive efforts came from the community itself, which formed a Lake Improvement Association (LIA), and had the leadership of key city personnel, most notably the tireless Planning and Community Development Director, Kent Bryan. It was through these community leaders that AVS was able to fully engage and become rapidly educated about HABs, and began to formulate options that might have an impact. The ODA provided financial resources to test some ideas, and due to the urgency of the situation by August of that year, the permitting process was accelerated by the EPA, the City of Celina, and the ODNR to facilitate testing of approaches. Under normal circumstances, such as where we find ourselves today in trying to implement and test new approaches, permitting can take 60 days to 6 months.

To the question of whether there was a solution to this problem, a surprising number of solutions were proposed, and many tested, but none successful. These ideas were tested at the peak of the FHAB, a nonideal time, and a demonstration that actual *remediation* of FHABs is something for which technologies do not presently exist. Among the ideas that were explored, AVS derived one from the scientific literature on marine HABs, in which addition of silica to ocean or estuarine environments was shown to stimulate growth of marine diatoms, a type of silica-requiring algae that could out-compete the toxic algae and thereby possibly stave off a HAB.[1] As early as 1971 the hypothesis had been put forth that in eutrophic freshwater systems seasonal succession of diatoms was closely linked to available silica, and that as they consumed nutrients in the water, including silica, the latter would become limiting and lead to diatom decline through the warmer months.[2,3,4] If the diatoms became limited for silica while other nutrients were still available, it could create an advantageous situation for toxic cyanobacteria. If this phenomenon were occurring at GLSM, Mr. Youngs deduced that adding silica to the lake could possibly stimulate the growth of diatoms, and give them a competitive edge over the cyanobacteria. With the time short for trying to remediate this bloom, in collaboration with Bowling Green State University (Bowling Green, OH), the City of Celina, the US and Ohio EPA, the ODNR and the Ohio Department of Agriculture, AVS led the testing of a silica amendment in a small marina in the lake. While the treatment was clearly non-harmful to the environment (one reason it was readily permitted under the rushed circumstances), it had no effect on the bloom that was in progress. When I officially joined AVS in April 2011, and our team reexamined the many factors that were stacked against this approach working (*e.g.*, the late stage of the bloom, the high temperatures, and the fact that water samples taken much later indicated that silica might not be limiting), we agreed that AVS needed better data than was currently available to design a well-thought out approach going forward.

AVS has thus initiated our own monitoring of water quality and algal diversity, to supplement what was already ongoing by the Ohio EPA at GLSM. We have added two other lakes to our monitoring program, one which has frequently experienced FHABs over the years, and a HAB-free small pond on our own property. Our assessments have already taught us that the concentrations of soluble silica in these lakes is quite high, but it remains to be seen whether the concentrations remain that high throughout the year, or what the correlation might be with relative diatom biomass in the water column samples. In fact we have also learned that the toxic cyanobacterial species dominate the biomass in the water columns of the two lakes that have previously experienced HABs, even in the months of March, April, and May when we know silica concentrations should not limit diatoms from flourishing. This means that some mitigation strategies could possibly be implemented *early* relative to the late summer HAB to limit the growth of these cyanobacteria before they get out of hand. Likewise, perhaps a comprehensive strategy would combine early-season approaches with bloom remediation in July-August, so that technologies

[1] Egge and Aksnes. (1992) Mar. Ecol. Prog. Ser. 83:281-289.
[2] Kilham, P. (1971) Limnol. Ocean. 16(1):10-19.
[3] Gibson et al. (2000) Freshwater Biol. 45:285-293.
[4] Kristov et al. (2000) Hydrolog. Processes. 14:283-295.

applied in the latter have a greater probability of success when applied on a less severe bloom. We do not yet know whether a condition could be created wherein diatoms, or some other algal species, could be stimulated to outcompete cyanobacteria. We plan to continue our monitoring for a full year to cover a complete seasonal cycle, and if we can find the funding we will add other lakes and analyses to our program. Our resources are currently too limited to have a full sampling regimen that yields a thorough scientific analysis of these lakes, but our observations are nonetheless enlightening and we look forward to sharing them with others as we process the data.

As for new technologies to combat FHABs, our company now plans to develop our SLS and RAC in a way that would allow them to be deployed in lakes for the recovery of biomass, and we want to explore the possibility that the biomass could in fact be put to good use, turning a potentially disastrous scenario into a positive, and possibly even revenue-generating scenario. Both technologies were developed with eukaryotic algae that are approximately 5-10 times larger than typical cyanobacterial cells. In addition to having smaller cells, cyanobacteria can be filamentous, forming fibrous mats on the surface of the water or adhered to rocks and sediments. These properties require that our technologies undergo some additional research and development to efficiently capture this type of biomass. The City of Celina is allowing us to do some testing at their lake to see how the RAC in particular will operate with cyanobacterial biomass, which we all anticipate will reappear in force this summer. This work is in part is being funded by the Air Force / Air Force Research Laboratories.

We also have a novel concept in development for diverting the nutrient-laden waters of these eutrophic lakes into a controlled algal growth system, wherein the biomass generated could be used for biofuels or other algal products. Nutrient removal and recovery is an intense area of interest in the scientific community and is viewed as an important long-term strategy to reducing HABs[5], and we believe that deliberate culturing of useful algal species can be one of many successful approaches to that. We do not yet know whether our own approaches of utilizing the SLS, RAC, and our algal culturing system can have a significant impact upon heading off or remediating a FHAB, especially one of the magnitude experienced by GLSM last year. But we are confident that FHABs can be approached with our technologies in combination with those developed by others towards a positive outcome.

Finally, I would be remiss if I did not point out that we are a small business, and in order for us to pursue solutions to FHABs with the same inventiveness and intensity we bring to all of our pursuits, we must be able to finance it. We are reaching the end of the funds we had available to develop some of our technologies directed at FHABs, and that is in no small part why we believe this legislation is so important. Applying creative solutions in a way that positively impacts our world and communities, while still supporting a successful business model that will create jobs and products, is a core mission of our organization, and we would like FHAB remediation to be part of our business model.

In closing, our organization arrived at FHABs as an area of interest not through years of scholarship directed at this specific topic, but rather through the recognition that FHABs are a devastating problem for inland lake communities and economies, in need of creative solutions and technologies. The

[5] Paerl, H. (2008) Chapter 10 *in* Cyanobacterial Harmful Algal Blooms: State of the Science and Research Needs. Editor K. Hudnell. Springer Science + Business Media, LLC. New York, NY.

Summer of 2010 at GLSM, and the monitoring and experiments we have conducted since then, not only support the point made at the beginning of this treatise regarding collaborative technology development, but also bring out several others that are directly relevant to the legislation at hand, and which I want to leave you with:

1. As stated earlier, *addressing FHABs will require a suite of technologies* that come together to attack the problem, and which must be applied at both the fundamental and applied levels.
2. Far *less appears to be known about FHABs than about marine HABs* and how they might be addressed, and strategies for addressing HABs in marine systems will not necessarily translate to freshwater systems.
3. It is our opinion, through this past year's experiences, that there is currently *insufficient assessment of HAB prevalence in inland lakes* to truly understand the magnitude of the problem or the damaged economies. [6]
4. It appears that more is known about *monitoring and prevention* of HABs (both marine and freshwater), *than about control and mitigation*. We believe that more needs to be done to address *ongoing* HABs, especially in freshwater environments, and those writing in the scientific literature have also pointed to the need for more to be done in the area of remediation.[6]
5. The current level of *funding*, which we understand to be on the order of $36M *may be insufficient for addressing the needs* we point out in this testimony, when one considers that most of those funds may be spent on marine environments, and the cost of developing mitigation or remediation strategies. The funding level also does not appear to match the magnitude of the damages assessed, even as the single example (GLSM) provided in this testimony demonstrates.

Chairman Harris, Ranking Member Miller, thank you once again for the opportunity to testify before you today, and at this time, I welcome any questions from members of the subcommittee.

[6] Dodds et al. (2009) Env. Sci. Technol. 43:12-19.