Atlantium
Illuminating Water Technologies

CASE STUDY

Hydro-Optic™ Technology
HARMFUL ALGAL BLOOM CONTROL

Texas Fish Hatchery Treats Toxic Golden Alga with Hydro-Optic™ Ultraviolet Disinfection

Fish production at the Texas Parks and Wildlife Department (TPWD) Dundee Fish Hatchery was adversely affected by massive fish kills from P. parvum (golden alga/GA) , and source water for two TPWD freshwater hatcheries was problematic for fish rearing and fingerling production. After implementing ozone treatment for GA control at one of its hatcheries, TPWD found that a great deal of care was needed to eliminate the residual ozone from the treated stream. In 2018, TPWD undertook a bench scale test of Atlantium's Hydro-Optic™ (HOD) UV technology to determine effective UV doses to eliminate GA cells and toxicity. The trials were followed by a pilot study at the Dundee State Fish Hatchery to evaluate the efficacy of the HOD UV technology to manage toxic GA blooms in situ. The study demonstrated the ability of the HOD UV technology to address GA HABs without producing residual disinfectant.

It has been estimated that the costs related to harmful algal bloom (HAB) species, a small subset of algal species that produce toxins and/or bloom to excess, amount to US$82 million per year in the U.S. due to fishery income losses, decrease in recreational opportunities and tourism, public health costs, and expenses for monitoring and management. All U.S. coastal states have experienced HABs events. For more than 30 years, however, fish kills associated with the HAB species *Prymnesium parvum (P. parvum)* have increased in the inland waters of Texas and other parts of the U.S. (Sager et al., 2008).

Golden Alga in Texas Waters

In 2001, *P. parvum* (aka golden alga/GA) fish kills began to wreak havoc across Texas waters, affecting numerous state water bodies and negatively impacting fisheries, aquaculture and local economies (Southard et al., 2010). Fish production at the Texas Parks and Wildlife Department (TPWD) Dundee Fish Hatchery was adversely affected by massive fish kills from GA, and source water for two TPWD freshwater hatcheries (Dundee and Possum Kingdom) was problematic for fish rearing and fingerling production.

From 2003 to 2007, the TPWD expended more than US$2M in state and federal grant funds to support internal and external research efforts aimed at understanding and controlling toxic GA blooms (Southard et al., 2010). The TPWD investigated several control treatments to aid in the development of management strategies that allow fish production and prevent the spread of the alga into unaffected hatcheries and state water bodies.

For pond water treatment, ammonium sulfate, copper-containing algaecides, and potassium permanganate were reviewed for GA control. For incoming hatchery source water and intensive culture systems, low-pressure ultraviolet (UV) light at 193-220 mJ/cm^2 or ozone at 0.4-1.2 mg/L for six minutes destroyed *P. parvum* and reduced (or eliminated) ichthyotoxicity (Barkoh et al., 2010). It was determined that a combination of UV and ozone treatment will provide the best results; however, successful treatments depend on dosage relative to GA cell density and toxin concentration (Barkoh et al., 2010).

In 2012, the TPWD implemented ozone treatment for *P. parvum* control at the Possum Kingdom Fish Hatchery. While effective at GA control, a great deal of care was needed to eliminate the residual ozone from the treated stream to guarantee no impact on fish.

Bench Scale Test of HOD UV for Toxic Golden Alga Bloom Management

After learning about Atlantium Technologies' novel Hydro-Optic™ ultraviolet (HOD UV) medium pressure technology in 2018, TPWD undertook a bench scale test on Aug. 8, 2018, using a collimated beam apparatus (CBA) and laboratory-grown *P. parvum* culture to determine effective UV doses to eliminate GA cells and toxicity.

These trials were followed by a pilot study on Dec. 5-6, 2018, at the Dundee State Fish Hatchery to evaluate the efficacy of the HOD UV technology to manage toxic GA blooms in situ. The goal of the study was to determine the approximate HOD UV dose needed to eliminate GA cells and effectively manage toxicity during toxic HAB episodes.

Atlantium supplied a trailer-mounted pilot HOD UV system to accommodate a flow rate of 23 gpm (5.2 m^3/hr). The pilot system was designed to treat water with UV transmittance (UVT) values as low as 70% UVT and installed at the Dundee Fish Hatchery Pond #10 where elevated levels of GA were present in early December 2018. Basic water quality parameters such as dissolved oxygen (DO), pH, salinity, and temperature were taken from the toxic pond prior to testing each day and determined to be non-factors and safe for the FHM fry (Table 1).

%UVT	85 % – 86.5 %
Temperature	7.4 – 8.6 ºC
pH	8.6 – 8.7
DO	8.9 – 9.8 mg/L
Salinity	1.9 ppt

Table 1: Water Quality Parameters at TPWD Dundee Fish Hatchery Pond #10

The HOD UV technology was evaluated using different doses ranging from approximately 60 mJ/cm^2 (typical for zebra mussel veliger treatment) to 484 mJ/cm^2. Incremental studies were done on dose rates of approximately 60, 120, 240, 360, and 480 mJ/cm^2 (and some levels between) for two trials conducted at the site.

At the start of the study, raw (untreated) water was evaluated to ensure GA cells and high toxicity (≥25 ichthyotoxic units/ITUs) levels were present. Controls were used to ensure the dilution water and/or cofactor solution did not contribute to mortality in the bioassays. The bioassay was adapted from Israeli aquaculturists who detected lethal (water sample by itself) and sub-lethal levels of toxicity (by addition of cofactor and diluted sample plus cofactor) (Ulitzer and Shilo, 1964). Test organisms are typically seven to 10-days old Fathead Minnow (FHM) fry, which are commonly used organisms to detect aquatic toxicity. The bioassay is conducted at 28°C, the temperature that GA toxins are most active. The bioassay is run for two hours to generate a quick result that monitors hatchery ponds for impending toxicity so that mitigation can be undertaken to prevent fish mortality (Southard and Fries, 2005).

The TPWD reviewed mortality of the FHM fry for all HOD UV treatment levels at two hours using the standard bioassay (undiluted sample, undiluted sample + cofactor, 1/5 dilution + cofactor) to determine ITUs. Toxicity levels also were evaluated as percent mortality of FHM fry in undiluted samples at six hours and 24 hours post-treatment.

Cell counts were estimated using a hemacytometer pre- and post-HOD UV treatment to determine efficacy in GA cell destruction. For all HOD UV doses tested (approximately 60-484 mJ/cm^2), GA cells were eliminated in all trials (Figure 1). The HOD UV dose rate (60 mJ/cm^2) commonly used to inactivate zebra and quagga mussel veligers was also effective at GA destruction (Pucherelli and Claudi, 2017). This dose rate would be useful in eliminating both GA cells and potential dreissenid veligers from hatchery source waters when GA toxic blooms are not occurring.

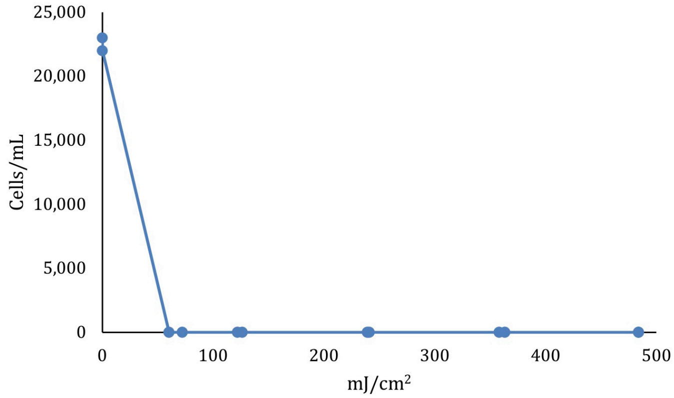

Figure 1: GA Cell Density (cells/mL), Varying HOD UV Doses

The HOD UV dose of 240 mJ/cm² was needed to significantly reduce highly toxic conditions (≥25 ITU) to acceptable levels (<5 ITU) and 484 mJ/cm² was effective to completely detoxify (0 ITU) GA toxic pond water (Figure 2). This UV dose correlates to the level determined to eliminate acute toxicity levels (two hours post-treatment) in collimated beam apparatus (CBA) testing conducted on Aug. 8, 2018. CBA testing showed that an HOD UV dose of 200 mJ/cm² was able to detoxify the *P. parvum* cultures grown in the lab.

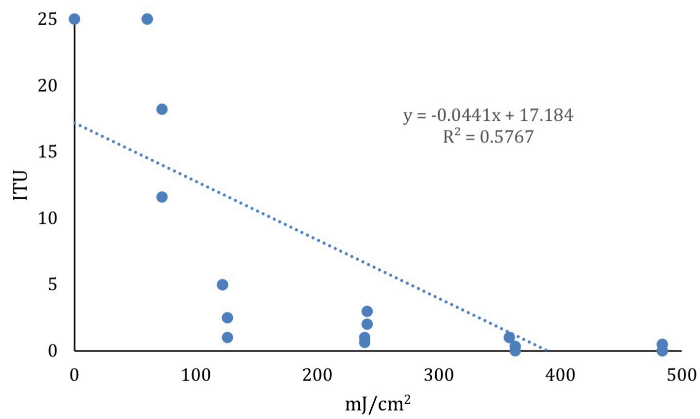

Figure 2: Ichthyotoxic Units (ITU) at Two Hours, Varying HOD UV Doses

TPWD also evaluated percent (%) mortality of the undiluted sample by itself at six hours (Figure 3) and 24 hours post-treatment (Figure 4) to ensure treated water did not possess any sub-acute toxin levels. For both six and 24 hours post-treatment, HOD UV doses of approximately 240 mJ/cm² and greater were deemed safe and non-toxic to FHM fry.

For all HOD UV doses tested (approximately 60-484 mJ/cm²), GA cells were eliminated in both trials. The HOD UV dose rate (60 mJ/cm²) commonly used to inactivate zebra and quagga mussel veligers was also effective at GA destruction. A HOD UV dose of 240 mJ/cm² significantly reduced highly toxic water (≥25 ITU) to acceptable levels (<5 ITUs). Approximately 484 mJ/cm² was needed to completely detoxify GA toxic pond water (0 ITU) after two hours post-treatment. Zero mortality occurred at six and 24 hours post-treatment in undiluted treated samples at HOD UV doses ≥240 mJ/cm².

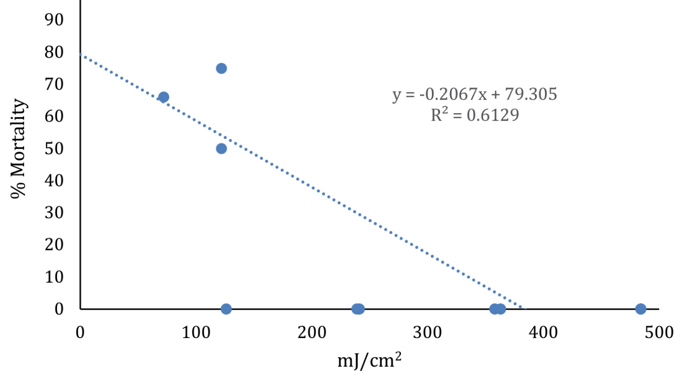

Figure 3: FHM % Mortality at Six Hours, Varying HOD UV Doses

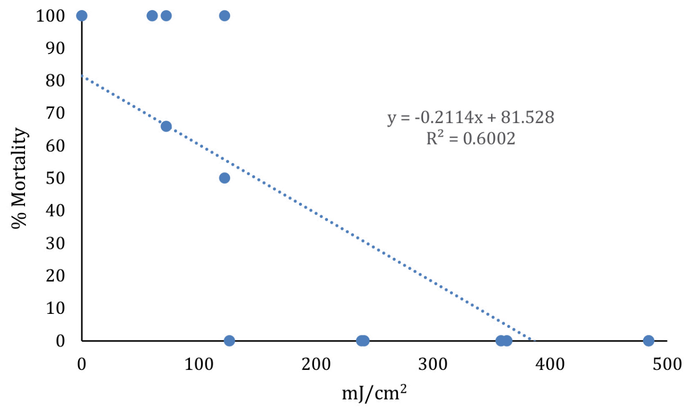

Figure 4: FHM % Mortality at 24 Hours, Varying HOD UV Doses

This UV dose level correlates to levels determined in collimated beam apparatus (CBA) testing conducted on Aug. 8, 2018, before the HOD UV pilot study (Dec. 5-6, 2018). CBA testing showed that a HOD UV dose of 200 mJ/cm^2 was able to detoxify the *P. parvum* cultures grown in the lab.

Environmentally Friendly Disinfection Solution

The pilot study demonstrated the ability of the HOD UV technology to address GA HABs. A HOD UV dose rate of approximately 240 mJ/cm^2 removed GA toxicity during toxic episodes while lower doses, approximately 60 mJ/cm^2, eliminated GA cells.

Unlike ozone treatment that requires a great deal of care to eliminate the residual ozone from the treated stream to guarantee no impact on fish, UV treatment does not produce a residual disinfectant. As a result the HOD UV will have no deleterious impact on fish within the dose range tested.

As a physical process, HOD UV does not have the inherent engineering, installation, and operational limitations of ozone. Ozone is plagued with off-gassing problems that negatively effect operating staff health and require excessive labor to operate the system. Furthermore, ozone requires a high cost of construction and capital equipment investment when compared to the HOD UV.

Fisheries facilities interested in treating toxic HABs will benefit from evaluating the HOD UV technology as a proven, non-chemical, and environmentally friendly disinfection solution.

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