

USING BIOLOGICAL CONTROL FOR INVASIVE ZEBRA AND QUAGGA MUSSELS

By Seth Donrovich

Since their introduction to North America in the mid-1980s, invasive zebra and quagga (dreissenid) mussels have been ravaging their newly adopted ecosystems. Dreissenid mussels have a high fecundity and ability to readily disperse due to their unique microscopic free-floating veliger (larva) life stage, causing rapid colonization of any water system they invade.

These tiny mollusks have severely degraded ecosystems, inhibited recreation, and wreaked havoc on industries dependent on surface water for manufacturing or drinking and irrigation water. In fact, the cost over 10 years for treating intake pipes, water filtration equipment, and power plants' operating costs for zebra mussel damages is estimated at \$3.1 billion dollars.

While effective in controlling mussels, chemical control options may be damaging to infrastructure, require detoxification prior to discharge, necessitate significant permitting, entail long application times, and are toxic to non-target organisms and the environment. Mechanical control options are point-based and require a large upfront capital investment. Physical removal is likewise time-consuming and expensive.

Zequanox® molluscicide, commercially developed by Marone Bio Innovations, Inc., a provider of bio-based pest management and plant health products for the agriculture, turf and ornamental and water treatment markets, is the first fully biological control option specifically targeting invasive zebra and quagga mussels in all life stages. As a biological control, there are no lasting impacts to the environment, negligible effects on non-target organisms when used as directed, and



Mixing Zequanox at the DeCew II Generating Station.

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minimal safety concerns for workers.

The active ingredient in Zequanox is composed of dead cells of the soil microbe, *Pseudomonas fluorescens (Pf)*, which is ubiquitous in North American freshwaters and soils. Strains of *Pf* are commonly used in the manufacturing of food enzymes, pharmaceuticals, agricultural protection products, and even in the production of food. The *Pf* microbe in Zequanox is not genetically modified and is designated at Biosafety Level one, deeming it to be of the lowest possible risk to human health and the environment.

The active ingredient, combined with biological, food grade inerts, creates a wettable powder end product that has the appearance of freeze-dried coffee or granular cocoa powder. The formulated end product is mixed with on-site water to form a slurry which is then injected into the macrofouled water system. Unlike chemical control options, the invasive mussels respond to the *Pf* as a food source and will continue to filter feed in the presence of Zequanox, effectively consuming the product along with their regular planktonic diet. Once ingested, the product will rupture the stomach lining of the mussels, causing mortality.

This unique mode of action allows for mortalities to occur over a period of time, generally several days to several weeks, which can prevent a massive shell-debris slug that could occlude, for example, critical system heat exchangers. The product is safe and easy to apply, only requiring standard mixing and injection equipment and the use of basic personal protective equipment, e.g., eye protection and a dust mask, while mixing and loading the Zequanox when creating the slurry.

Zequanox is non-corrosive, biodegradable, and requires only short application times of 2 – 6 hours, therefore causing no disruption to normal facility operations. Treatments can help prevent unexpected outages and ensure continued system operation for industrial facilities. Waters treated with the product can be used immediately after application. In addition, there are no lasting effects to water quality and ecosystem health.

It is Pest Management Regulatory Agency (PMRA) registered for use in hydroelectric facilities in Canada, with both expanded enclosed system and open

water registration packages submitted to PMRA in early 2018.

CANADIAN DEMONSTRATION PROJECT

As part of the Canadian registration package, and to help bring the product to market in Canada, a large-scale demonstration project occurred at Ontario Power Generation's DeCew II Generating Station, located in St. Catharines, Ontario,

between 2009 and 2012.

During the final phase in a series of product efficacy trials in 2012, the entire service water system was treated, targeting full adult mussel control at high product concentrations. Product efficacy was evaluated using bioboxes, which are small aquarium-like structures that receive treated system water, as a mesocosmic representation of the service water system. *continued overleaf...*

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tem. Zebra mussel mortality reached as high as 94% at 150 ppm of active ingredient concentration.

IMPROVEMENTS TO ZEQUANOX

Significant improvements have been made to Zequanox since the early product implementation phase. Product development, including investigating different treatment protocols, has led to full mussel annual control being achieved with a

lower active ingredient concentration of 100 ppm. With ongoing product optimization trials, this target concentration for full control can be reduced even further.

Moreover, low concentration, frequent (every two to three weeks) maintenance treatments of 10 ppm active ingredient or less have been developed to target the settlement phase of the mussels, thereby preventing new mussels from attaching to surfaces within a water system.

This treatment program stems from the dreissenid mussel life cycle, which includes the approximate three week free-floating veliger stage, before the mussels begin attaching to a solid surface. Treating over this settlement season not only limits the amount of new mussels in the system, but also steadily reduces the adult population over the duration of the treatment program. These maintenance programs can be customized based on the infestation level in a water system and the desired level of control. Regulations allow for up to 50 ppm of active ingredient concentration to be applied at a frequency of every two weeks for this treatment program.

TREATMENT AT POWER GENERATION FACILITY

This customizable maintenance program was commercially realized with eight, biweekly low concentration treatments occurring from June to October, 2017. This was designed to be conducted during a time period when the water temperature dictated high levels of mussel activity. This maintenance treatment program occurred at a power generation facility on the Great Lakes, which was experiencing both invasive zebra and quagga mussels in the once-through cooling system, affecting critical heat exchangers, including the surface condensers and boiler feedwater pump lube oil coolers.

Previous mussel control from thermal water circulation was prohibited due to recent permitting changes and the facility was searching for a safe, effective, and reliable solution to improve performance and reduce maintenance costs brought about by the mussel infestation. The facility chose Zequanox as a highly efficacious and environmentally friendly solution to their invasive zebra and quagga mussel issue.

During the treatment program, Zequanox was metered into the system, individually into two units (unit 7 & 8), for a period of two hours during normal facility operations. Therefore, the product application did not require any deviation from normal system operations. Product concentration was targeted at approximately 10 ppm of active ingredient for each of the treatments, with concentration regularly monitored throughout the



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application time.

Similar to the demonstration trials at DeCew II, bioboxes were used to determine the efficacy of the treatment program, with each unit having a biobox placed at a predetermined location downstream of the injection point. The biobox for unit 7 was placed at the approximate midpoint of the system, while the unit 8 biobox was placed near the terminus of the system. Over the course of the treatment program, cumulative adult mortalities indicated over 90% kill in the treated system collectively.

Juvenile mussel settlement was monitored using eight, 0.125 inch thick, hair cell ABS plastic plates (4.375 inches x 4 inches), nested at a 15 degree angle on a clear acrylic base and placed perpendicular to the biobox flow to encourage settlement. In addition to the two treated bioboxes placed in units 7 and 8, an additional set of settlement plates was placed in a control biobox, located upstream of the injection point to monitor settlement in the absence of Zequanox.

Over the course of the entire treatment program, the unit 7 biobox saw a 95% reduction in mussel settlement, while the unit 8 biobox saw a 52% reduction.

The facility plans to continue their zebra and quagga mussel maintenance treatment program, ensuring fluid power generation and continuing to limit their maintenance costs.

A recent distributor partnership with Solenis LLC for enclosed water systems in Canada and the U.S. has made full service Zequanox treatments in industrial facilities as convenient as ever. Solenis will provide complete customer service, from designing treatment programs specific to the facility, to providing mixing and injection equipment, to conducting on-site application, monitoring, and consultation.

Further product optimization will not only continue to streamline enclosed industrial system treatment programs, but also tailor the product for use in both semi-enclosed and open water systems. ■

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Zequanox being applied at Round Lake in Petosky, Michigan. Photo: Holly Henderson Photography

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