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The Use of Chloramines to Eradicate Quagga Mussel Larvae

Trea LaCroix¹ and Kumud Acharya²

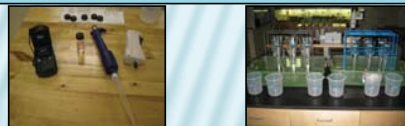
Abstract

Quagga Mussels, *Dreissena bugensis*, are a growing problem in the western United States, particularly in their ability to infest underwater infrastructures and clog water intake pipes and screens of power and treatment plants. Chlorine has been found to be the most effective chemical to get rid of veligers (planktonic larval form of quagga mussels) in the pipes. However, chlorine leaves a residue called trihalomethane, which is a carcinogen at higher concentrations. The purpose of this project is to test the effectiveness of an alternate chemical, chloramines (chlorine and ammonia), which leaves behind little to no residual trihalomethane. Upon experimentation with various dosages of chloramines, it was found that 1.0 mg/L effectively kills approximately 97% of the veligers after an exposure time of approximately 4 hours. Our results provide critical information needed to replace the use of harmful chlorines in drinking water systems.

Introduction

Quagga Mussels were discovered in Lake Mead Nevada in 2007 and have since spread to other western waterways (CA, NV, AZ, UT, CO); the highest densities being in Lake Mead and Lake Mojave. Once the mussels have established themselves in an aquatic system they obstruct underwater infrastructures such as dams and can clog water intake pipes and screens reducing pumping capabilities for power and treatment plants, costing companies, industries and communities millions. Quagga mussels are prodigious water filterers that have the ability to reduce the phytoplankton causing changes in water transparency ultimately resulting in trophic level changes in the food web.

Quagga Mussels are highly polymorphic and have the ability to adapt rapidly to extreme environmental conditions. Veligers (planktonic larval form of quagga mussels) allow them to easily infest new areas. Recently, scientists have hypothesized that chloramines (chlorine and ammonia) instead of chlorine can be used as an effective alternate disinfectant with little to no harmful residual trihalomethane. Results of this project will not only provide important information on the use of chloramines but also have potential to develop a new economical and safer way of treating veligers in water treatment facilities.



Methods

Three dosages of chloramines (0.50 mg/L, 0.75 mg/L and 1.0 mg/L) were tested on veligers. These dosages were chosen through communication with Southern Nevada Water Authority (SNWA), the agency providing water services to the city of Las Vegas, and preliminary trial and error experiments. There were three replicates of each dosage and 3 controls (with veligers) without the chemical addition. There were also two chemical controls for each dosage (6 total) without veligers.

The first experiment focused mainly on a short term exposure time (5 and 10 minutes). This is due to the fragile nature of the animals, and unstable nature of chlorine for long periods of time in carbonate rich Lake Mead water. The 24 hour reading was taken to ensure that the system displayed 100% mortality. The second experiment looked at an intermediate exposure time (4 hours) to see the difference after a longer time period compared to the shorter exposure.

Veligers were sampled from the Lake Mead Marina in the mornings of the day of the experiments. Vertical tows were conducted using a 63 µm plankton net by submerging the net approximately 10 meters below the surface of the water from the dock. Approximately 15-20 tows were performed depending on veliger density on the sampling day. The samples were then placed in 250 ml sample bottles and transported back to the lab in a cooler. The lights were turned off while handling the animals and for the duration of the experiment to reduce stress on the animals. Water from the tows was then filtered with a 120 µm mesh filter, to eliminate larger zooplankton. The filtered water with veligers was then pooled into a large container to homogenize the sample and then was placed in 12 500 ml imhoff settlement cones, each filled to 250 ml. The cones were then treated with chloramines with desired residual chlorine concentration. A Hach pocket colorimeter was used to measure Cl_2 residuals after the addition of the chemical at initial, 5 minutes, 10 minutes, 4 hours (Exp. 2) and 24 hours after exposure. The Number of live and dead veligers are counted using a gridded slide 5 and 10 minutes after exposure to allow the veligers to become comfortable enough to swim on the slide. They are also counted after 4 hours and 24 hours to check for survivability over time. Each treatment is staggered to ensure that each is exposed for the same amount of time.



Results

A one-way analysis of variance (ANOVA) was performed to test overall effect of treatments on veligers. Tukey's HSD pair wise test was used to compare the effect of different dosages on veliger activities. Statistical analysis was done separately for each treatment (5 min, 10 min and 4 hrs). Values < 0.05 (95% confidence level) were considered significant. The significant differences are indicated with different letters (capital for 5 min, bold capital for 10 min and small for 4 hrs) in the figures 1 and 3. Percentages of veligers swimming were calculated on the basis of number of swimming out of the total number present. This percentage was then corrected with the average control percentage for each of the time periods. Statistical analyses were carried out using JMP software (SAS Institute, Cary, North Carolina).

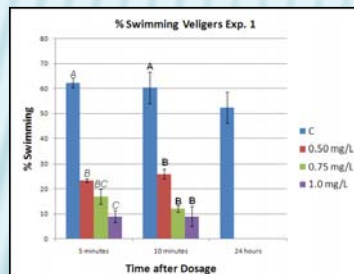


Figure 1: Number of swimming veligers for experiment #1. Experiment #1 had 5 min and 10 min exposure times.

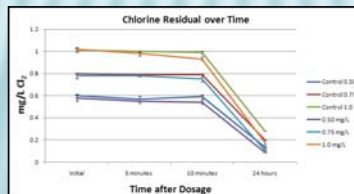


Figure 2: Residual chlorine concentration through the duration of experiment #1.



Dose mg/L	Experiment #1		
	5 minutes	10 minutes	24 hours
Control	62%	60%	52%
0.50	22%	28%	0%
0.75	17%	12%	0%
1.00	9%	9%	0%

Table 1: Percent of swimming veligers for experiment #1.

Dose mg/L	Experiment #2			
	5 minutes	10 minutes	4 hours	24 hours
Control	61%	66%	56%	60%
0.50	40%	28%	26%	0%
0.75	34%	28%	10%	0%
1.00	10%	5%	3%	0%

Table 2: Percent of swimming veligers for experiment #2.

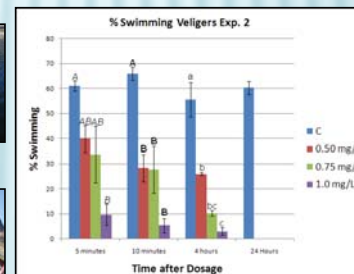


Figure 3: Number of swimming veligers for experiment #2. Experiment #2 had 5 min, 10 min, and 4 hour exposure times.

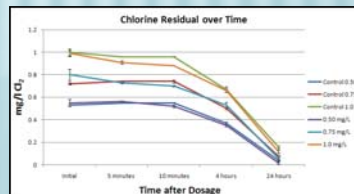


Figure 4: Residual chlorine concentration through the duration of experiment #2.

Discussion

- Both experiments display differences in percentages between the control and the dosed veliger water indicating that the chloramines are having a negative impact on the survivability of the veligers (tables 1 and 2).
- In the first experiment the statistical analysis of the percentages swimming shows that there is a significant ($p < 0.05$) effect of the treatment, however effects varied between the dosages (figure 1). 1.0 mg/L had the highest effect after 5 minute exposure time.
- In the second experiment both 0.50 mg/L and 0.75 mg/L display no significant difference between the control and the dosed water after 5 minutes.
- All three dosages are significantly different than the control in 10 minute exposure does.
- 4 hours after exposure, all three dosages are significantly different from the control, 0.75 is similar to both 0.50 and 1.0, but 0.50 and 1.0 are significantly different from each other.
- Most effective treatment dose in both experiments proved to be 1.0 mg/L. Each replicate either had 0 swimmers or only 1 swimmer which was of larger size and was clearly negatively affected by the chemical because swimming was reduced and only the movement of cilia was observed.
- After 24 hours there was a complete mortality in all dosages.
- 4 hour exposure time was chosen in the second experiment because the residence time from intake to final treatment in water treatment plants is approximately 4 hours.
- The chlorine residues for the control and dosed veliger water follow a similar trend (figures 2 and 4). Chlorine concentrations in dosed water was stable for both short exposures (5 and 10 min). The concentration slightly declined in 4 hours but there was very little chlorine left after 24 hours (< 0.3 mg/L).

Conclusions

With the significant differences in swimming between the controls and the dosed water it can be concluded that chloramines are toxic to veligers. It can also be concluded that 0.50 mg/L, 0.75 mg/L and 1.0 mg/L will cause complete mortality after a time period of 24 hours however this is not viable in treatment plants. After a time period of 4 hours 1.0 mg/L is very close to causing full mortality and may be the threshold value to cause complete mortality. It would be advisable to dose above 1.0 mg/L to achieve complete mortality of veligers in a system.



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