# Filtration rates of zebra mussels *(Dreissena polymorpha)* at differing concentrations

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Zebra mussels have been changing the waterscape of the great lakes region since they were originally introduced. They are a highly invasive species, capable of filtering large volumes of water in a relatively short time span. We wanted to see how fast zebra mussels filter nutrients out of the water in varying densities. We ran 5 different densities of zebra mussels in lab tank conditions for 8 hour periods, testing the water for nutrients every hour. Most of the nutrients we tested showed no significant change or difference, but calcium and nitratedecreased as density increased. NH4-N conversely increased as density increased and increased over time. High densities of zebra mussels can reduce the levels of calcium, which many other shell-building organisms need to survive. However, high densities of zebra mussels also provide large areas of shelter for macroinvertebrates and reduce algal biomass

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Zebra mussels have been changing the waterscape of the great lakes region since they were originally introduced. They are a highly invasive species, capable of filtering large volumes of water in a relatively short time span. We wanted to see how fast zebra mussels filter nutrients out of the water in varying densities. We ran 5 different densities of zebra mussels in lab tank conditions for 8 hour periods, testing the water for nutrients every hour. Most of the nutrients we tested showed no significant change or difference, but calcium and nitratedecreased as density increased. NH4-N conversely increased as density increased and increased over time. High densities of zebra mussels can reduce the levels of calcium, which many other shell-building organisms need to survive. However, high densities of zebra mussels also provide large areas of shelter for macroinvertebrates and reduce algal biomass.

Zebra mussels *(Dreissena polymorpha)* are an invasive bivalve species in the Great Lakes region, first introduced in to Lake St. Claire in 1986 (MacIsaac et al. 1995). Zebra mussels have had many impacts on freshwater ecosystems, including clarification of the water. Zebra mussels impact all trophic levels of the ecosystems they invade (Stewart et al. 1998). Both zebra mussels and their shells post mortem provide habitat and shelter to macroinvertebrates, increasing macroinvertebrate biomass. Crayfish and benthivorous fish may benefit from the zebra mussels energy, and in turn channel the zebra mussels up to higher trophic levels (Stewart et al. 1998). Zebra mussels also help stabilize aquatic systems, reducing algal biomass, potentially helping to prevent algal blooms (Kirsch and Dzialowski 2012).

Zebra mussels are ciliary-mucoid filter feeders with a particle retention rate of near 100% for particles > 1.5 μm (Jørgensen et al. 1984). Zebra mussels are fast filter feeders, capable of filtering the entire volume of the inner Lake Huron Saginaw Bay 1.3 times a day in 1992 (Fanslow et al. 1995).

Filtration rate for zebra mussels varies with many factors including the quantity and quality of available food, temperature (Reeders and bij de Vaate 1990), seasonal changes, and spatial variation (Fanslow et al. 1995). Rates of different studies have varied considerably. Fanslow et al. (1995) reported a three-fold difference between filtration rates in the same population of zebra mussels sampled one year apart.

Our study aimed to contribute to the pool of knowledge investigating the variation seen in zebra mussel filtration rates. We looked at several differing nutrients and ions in differing concentrations of zebra mussels. We sought to answer the question, how does filtration rate vary at differing concentrations of zebra mussels? We hypothesized that calcium, nitrate, and chlorophyll-a would decrease more in higher concentrations of zebra

mussels, and would decrease over time. Additionally, NH4N would increase over time and with higher concentrations of zebra mussels.

## Materials and Methods

Our experiment was run in a lab. We ran five different tanks containing 3 gallons of lake water from Douglas Lake at the University of Michigan Biological Station (45° 33' 37" N, 84° 40' 37" W) . Each tank was kept oxygenated with air stones. We collected our zebra mussels just off the shoreline of the Biological Station. Zero, 200, 400, 600, and 800 zebra mussels were placed into the tanks respectively.

Initial water measurements were taken shortly after addition of the zebra mussels. 50 mL of water were run through a TD-3100 laboratory fluorometer by Turner Designs, and placed in a Nalgene bottle. Samples were taken from each tank one hour apart, for a duration of eight hours. The chlorophyll filter was placed in a freezer overnight, and the bottles were stored in a refrigerator overnight, so that our samples could be run the next day. Cations and anions were run on a Thermofisher/Dionex Integrion HPIC. Silicate was analyzed using molybdenum blue method on an Alpkem FS30000 rapid flow analyzer.

We analyzed our raw data using IBM SPSS Statistics (version 22), to determine which of our tested variables contained any significance. We then analyzed the potential variables via linear regression, testing both time and density against our variable, using R and R commander version 3.2.3.

## Results

Chlorophyll-a, SiO2, Fluoride, Chloride, Sulfate, Bromide, Phosphate, Sodium, Potassium, Magnesium, and NO3-N were not statistically different between treatments (Tukey's Test). Nitrite's 800 tank statistically differed from the other tanks ($p < 0.001$ for all; figure 1). Nitrate's 0 tank statistically differed from the other tanks ($p < 0.001$ for all; figure 2). NH4N's 0 tank statistically differed from the 200 ($p = 0.03$) 600 ($p = 0.005$), and 800 ($p < 0.001$; figure 3) tanks. Calcium's 0 tank statistically differed from the other tanks ($p < 0.001$ for all; figure 4).

Nitrite's variation was not accounted for by density ($R^2 = 0.017$), nor time ($R^2 = 0.046$). Nitrate's variation was partially accounted for by density ($R^2 = 0.486$; Figure 5), but not time ($R^2 = 0.018$). NH4-N's variation was partially accounted for by density ($R^2 = 0.343$; Figure 6) and time ($R^2 = 0.39$; Figure 7). Calcium's variation was partially accounted for by density ($R^2 = 0.486$; Figure 8) but not time ($R^2 = 0.010$).

## Discussion

The large majority of what we tested for did not change significantly with zebra mussel density. One of the major components of lake water, chlorophyll-a, that we expected to see change did not, which contrasts what Qualls et al. (2007) found in Green Bay, WI, and disagrees with our hypothesis. NH4-N changed with both density and time, although the factor of time might be due to factors besides filtration via zebra mussels. A portion of ammonium may be oxidized to nitrate if oxygen is present in a system (Lavrentyev et al. 2000).

We found that density played a role in the variation in calcium, however. Zebra mussels rely heavily on calcium, unable to survive if calcium concentration is low, and thriving if in excess (Hincks and Mackie 1997). Time did not play a role in calcium's

variation, however, suggesting that the rate of filtration is slow, or we did not run our experiments long enough.

Our experiment was run similarly to Fanslow et al. (1995) in that we tested once an hour for 8 hours. They reported that the amount of time was sufficient for chlorophyll, but we did not see significant results in chlorophyll. Given that, it may be that the amount of time was insufficient, which could be applied to experiment as a whole. If that is the case, zebra mussel density might influence more than just calcium, nitrate, and NH4-H, as our results suggest, but it takes longer to see significant change.

Lab conditions, or the inability to acclimate to them in the time we offered may have skewed our results. Reeders et al. (1989) offered some evidence that zebra mussels show unnatural filtration rates under laboratory conditions. Nichols (1992) offered counter evidence that zebra mussels were adaptable to lab conditions if ammonia levels were low (< 1 mg/L), which we were unfortunately unable to test for. Jørgensen et al. (1984) gave their bivalves, including zebra mussels, a minimum of 6 months to acclimate to laboratory conditions, whereas we offered no acclimation time.

Zebra mussels reducing the amount of calcium available may adversely affect other shell-building organisms which rely on calcium such as clams and snails. Snails use calcium to build their shells, and in increasing levels of calcium, snails are able to withstand more dramatic adverse affects of other problems, such as highly acidic water (Ewald et al. 2009).

Figure 1. Nitrite concentration (mg/L) over time in 5 concentrations of zebra mussels.

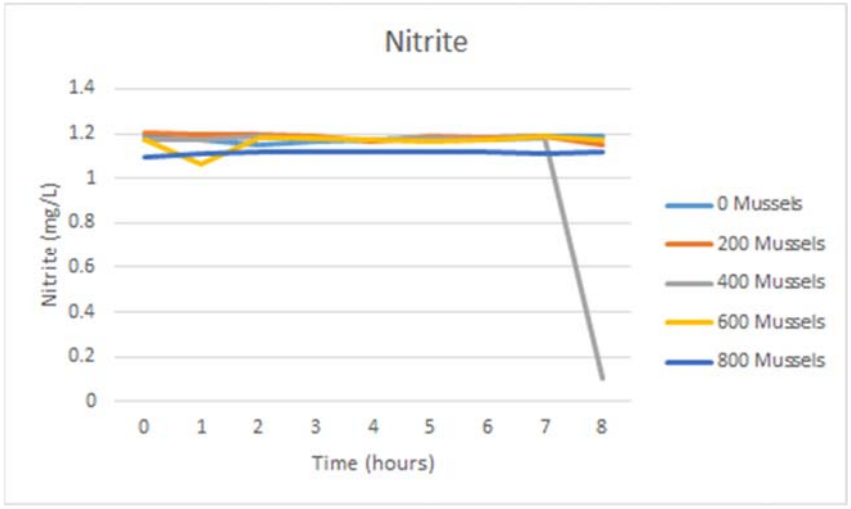
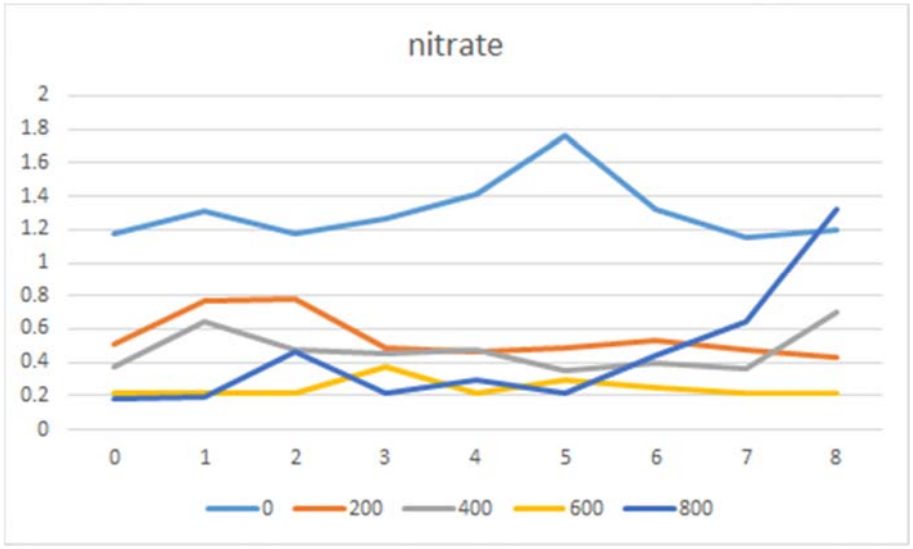



Figure 2. Nitrate concentration (mg/L) over time in 5 concentrations of zebra mussels.




Y axis is in mg of Nitrate. Each number associated with a line is a number of zebra mussels.

Figure 3. NH4N concentration (µg/L) over time in 5 concentrations of zebra mussels.

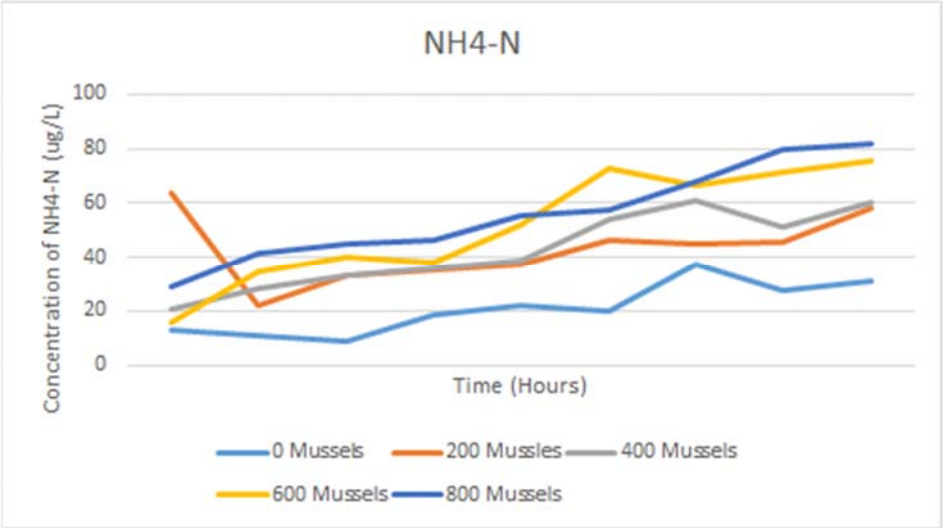
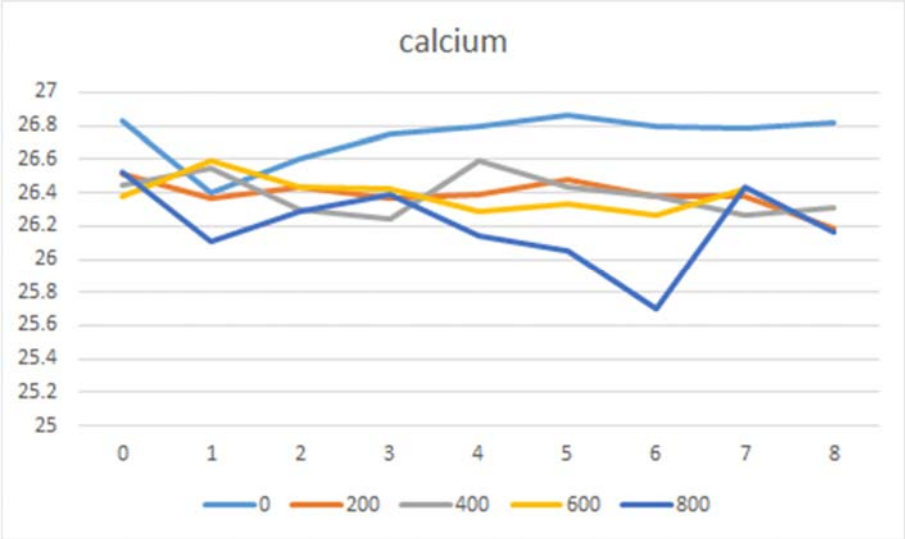



Figure 4. Calcium concentration (mg/L) over time in 5 concentrations of zebra mussels.




Y axis is in mg of calcium. Each number associated with a line is a number of zebra mussels.

Figure 5. Linear regression of nitrate concentration (mg/L) plotted against zebra mussel density.

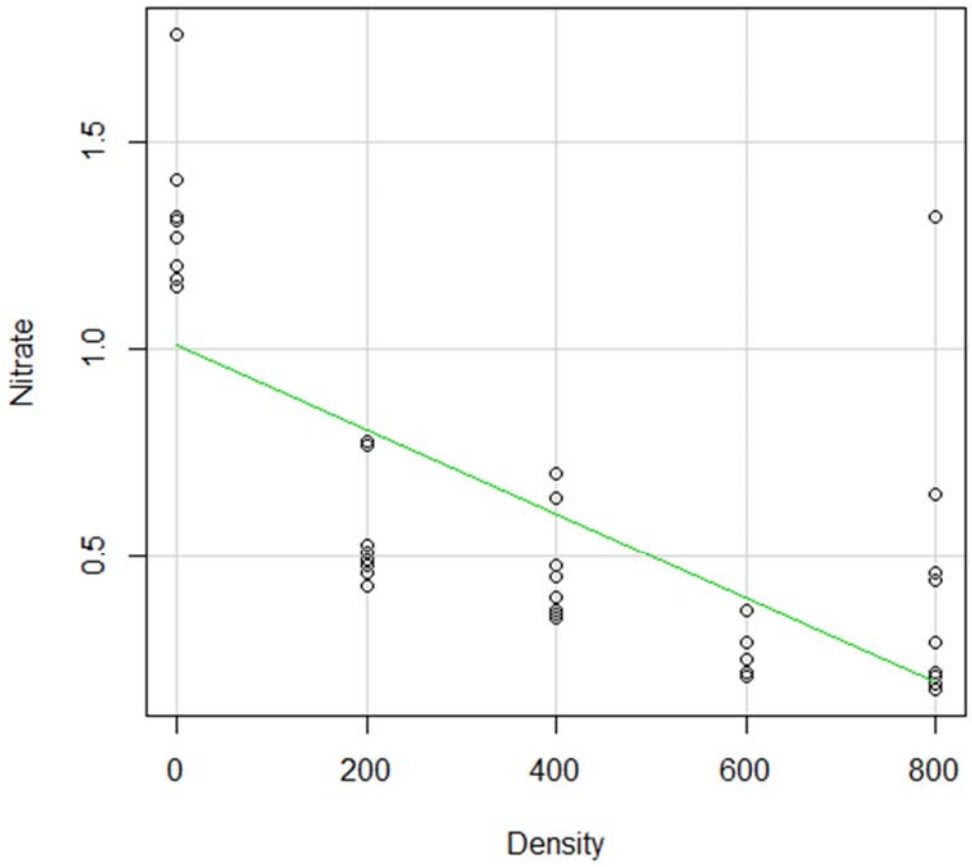


Figure 6. Linear regression of NH4N concentration (µg/L) plotted against zebra mussel density.

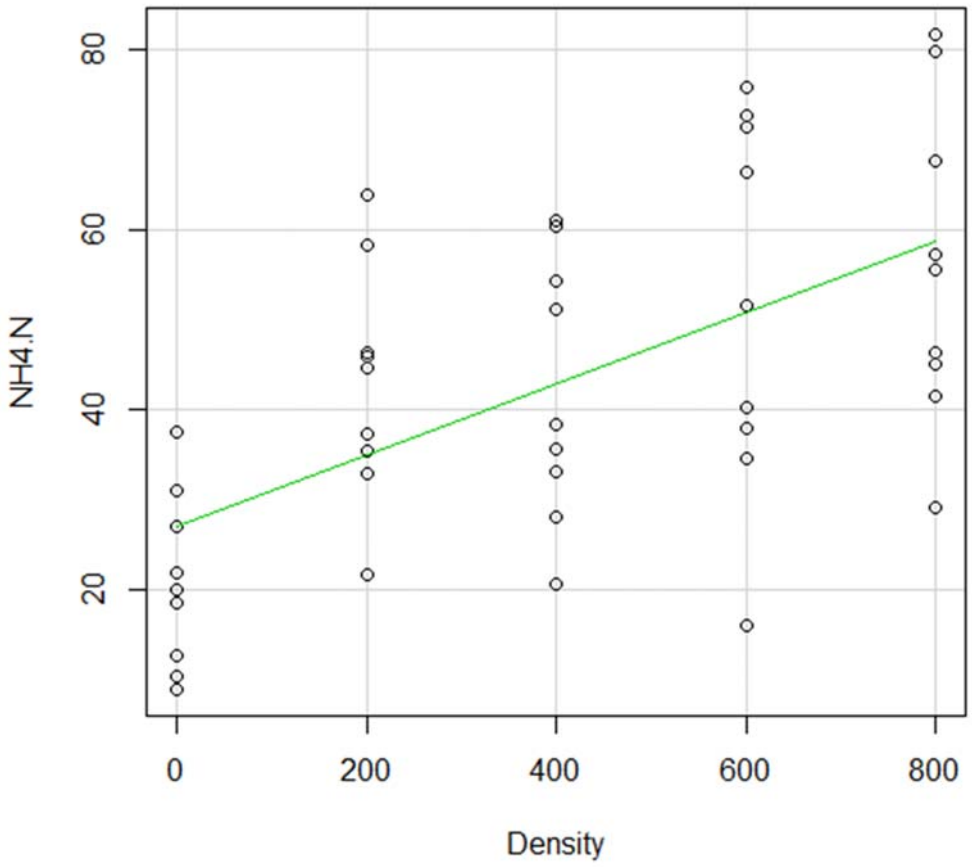


Figure 7. Linear regression of NH4N concentration (µg/L) plotted against time.

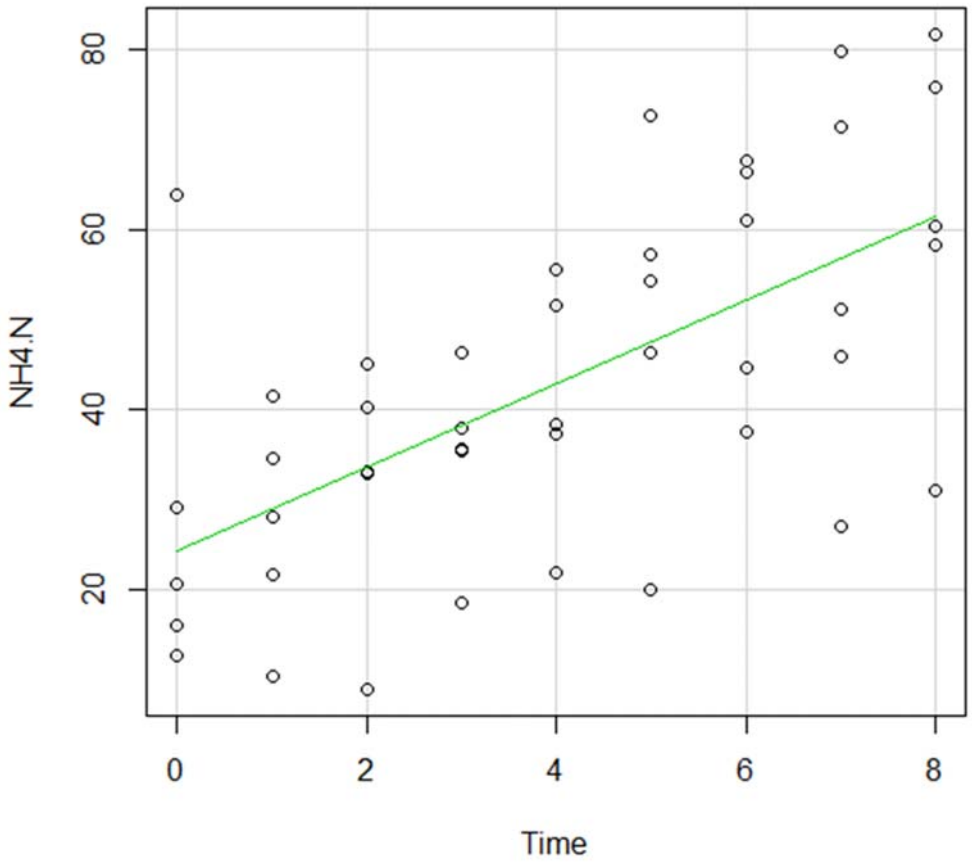
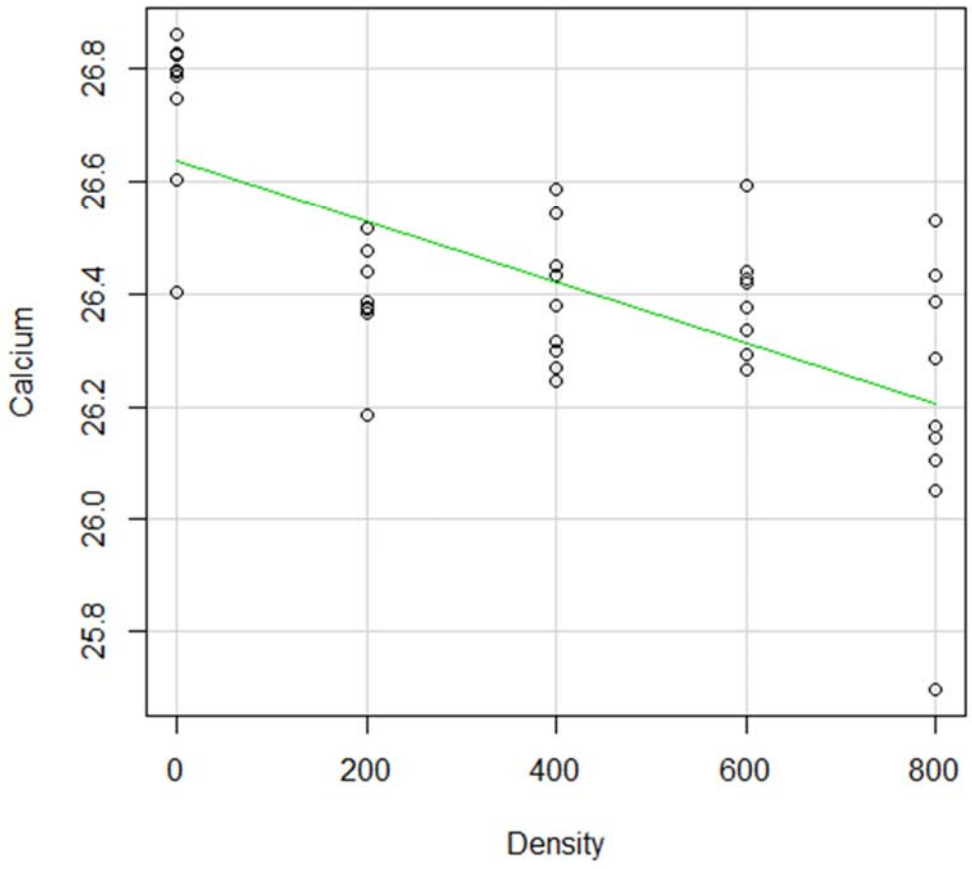


Figure 8. Linear regression of calcium concentration (mg/L) plotted against zebra mussel density



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