The Effects of Selenium on the Death Rate of Brine Shrimp

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ABSTRACT

In small quantities, selenium can be beneficial to most organisms. At higher concentrations, however, selenium almost always becomes toxic. In recent years, this problem has manifested itself in the form of agricultural run-off in farmlands in the west. This research sought to quantify at what concentration selenium began to have a lethal effect and the maximum concentration in which any brine shrimp could remain alive. Experimentation began with hatching brine shrimp and letting them grow for about eight days. They were then divided into groups with two or three hundred in each. A measured amount of sodium selenate was added to each group with the exception of the control group. After eight days, the number of live shrimp was counted. It was found that a general negative linear relationship existed between the number of remaining live shrimp and the concentration of selenium. The best estimate of the concentration at which no shrimp can live is between 15mg/liter and 16mg/liter.

Keywords: Selenium, Brine shrimp

INTRODUCTION

Scientists know that selenium is an important micronutrient for most organisms. A selenium deficiency can cause a shortened life span and premature cuticle deterioration in Daphnia (Keating and Dagbusan, 1984). In humans, a deficiency can cause Keshan disease, a cardiac disorder, and in rats, alters the glutathione level in plasma (Whanger, 1996). Selenium may also help prevent certain types of cancer such as prostrate cancer (Clark et al 1998). Psychologists have also found that in humans, selenium can decrease some mood disorders (Psychology Today 1996).

The concentration at which selenium is beneficial is small, however. A high concentration of selenium is toxic to most organisms. In the early eighties, we learned how high levels of selenium can directly harm the environment. Increased irrigation leached naturally occurring selenium from the soil into reservoirs and rivers. The buildup caused negative effects in the fish and waterfowl (Banuelos, et al, 1997). In a freshwater reservoir after two years of an increased selenium level, there were no longer many species of fish living. Of those species that remained, most experienced physiological disorders such as sterility (Lemly, 1985). A study was done on the effects of selenium in marine fish by directly injecting selenium into the fish. The results were the same as in fresh water fish with the lethal dose being at a low concentration (Yauuxun and Moro, 1996). Research is still being preformed to find the best way to reduce selenium in the soil.

My research looks at how a marine organism, Artemia (brine shrimp), is able to survive living in an environment that has increased levels of selenium. Brine shrimp can be found in great numbers in lakes with high salt content such as the Great Salt Lake in Utah. Adult female shrimp can either reproduce by laying cysts in which the embryo can exist indefinitely, or they can lay eggs in which the nauplius larvae hatch a few hours later. The nauplii can molt up to 15 times as they mature to adult brine shrimp. They reach adult size in about 12 days, and their life span after that is about three months under good conditions. Females can hatch as many as 300 nauplii every four days. Their main food source is algae although they can feed on diatoms and other small particles. Populations of brine shrimp can survive in harsh conditions. If their environment becomes too harsh such as in the winter when the water temperature drops, females will start producing cysts. The cysts will stay dormant and will not hatch until conditions are right again such as in the spring. The goal of this research is to determine at what concentration selenium becomes toxic for brine shrimp, and if it will completely kill off a population.

MATERIALS AND METHODS

Brine shrimp eggs were obtained from Carolina Biological Supply Co.(Burlington, NC). The eggs came with a premeasured amount of salt for one liter of water. The eggs were hatched in a one-liter beaker with an aerator and a fluorescent light shining on the beaker continuously for the first 24 hours. After they hatched, the florescent light was removed, and they were exposed to normal room light during the day and no light at night. The aerator was in use at all times except for periods of time when they were being counted. At most, the aerator was not used for two hours at a time. The shrimp were fed once every day with special brine shrimp food, consisting mostly of algae, from the Carolina Company. After eight days, the hatched nauplii, immature shrimp, were separated into five different containers. The number of shrimp in each container was in order as follows: 306, 311, 314, 304, and 312. The salinity of each container was 30 ppt. Nine days after hatching, sodium selenate was added to the containers in the following order of concentrations: 0mg/l, 1mg/l, 2mg/l, 4mg/l, and 8mg/l. Eight days after the selenium was added, the number

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of live shrimp was counted. The method for counting shrimp was as follows. Approximately 10 ml of water containing the shrimp was dipped out of the container in a petri dish. The water was examined with a flashlight and the number of shrimp in the petri dish was counted. This was done until all of the water was dipped out of the container to make sure all shrimp were counted. The entire procedure was repeated again in a second trial with different sodium selenate concentrations. The order of concentrations was as follows: 0 mg/l, 6 mg/l, 8 mg/l, 12 mg/l, and 15 mg/l. The number of shrimp in each container was in order as follows: 202, 199, 199, 202, and 202.

RESULTS

The results are displayed in Figures 1 and 2. The horizontal axis shows the concentration of sodium selenate in miligrams per liter. The vertical axis displays the number of shrimp alive after eight days in water containing selenium. Figure 1 shows data from the first trial, and Figure 2 shows data from the second trial. The single line shown for the 0 and 12 mg/l concentrations in Figure 2 indicate that 0 shrimp remained alive.

DISCUSSION

In the control group, more shrimp were counted after the selenium was added than before. It is a small difference however, and can be attributed to error in counting. Brine shrimp are very small and are difficult to count. In the first three groups with the 1mg, 2mg, and 4mg concentrations, the results are as expected. The number of live brine shrimp decreases with an increasing selenium concentration. The fourth group with the concentration of 8 mg has unexpected results. Instead of a number of shrimp less than 60 as would be expected from the linear pattern thus far, there are more alive than the first group with the smallest concentration of selenium. It is unlikely that this phenomenon is due to a counting error. The counting was more accurate after the eight days of selenium because the density of shrimp in each container decreased. If there was an error in the number counted going in, it is unlikely that the actual number of shrimp was so much greater that it would produce such a big difference in the results. The most plausible explanation is that more shrimp hatched after they were put into different containers. There was a day lag period between the time that the shrimp were divided among the five containers and when the selenium was actually added to the water. There might have been some unhatched cysts from the original batch that was transferred with the water to the new container. Container five would have had a greater chance of getting the cysts because it was last and would have received water closest to the bottom from the original container. If we choose to ignore the 8 mg group, the graph would look like figure 3. The correlation between

Figure 1  Survivorship in first trial

Figure 2  Survivorship in second trial

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Figure 2  Survivorship in second trial
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Figure 3  Regression line of first trial

Figure 4  Linear regression in second trial

Figure 5  Linear regression of combined trials

Figure 6  Linear regression in second trial

Using both trials and averaging the overlapping concentrations, we get a graph that looks like Figure 5. The correlation is –0.766. It would be predicted that the maximum amount is 12.78 mg/l. We have also seen that this cannot be correct because of the results from trial 2. According to the data, it seems like the prediction of just under 16 mg/l is the most accurate estimate. The correlation is strongest with this graph, and it made a prediction that the results cannot contradict. Further testing would be needed to verify this estimation.

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LITERATURE CITED

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