Water quality of the Hirase river and nitrogen purification experiment

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ABSTRACT

We, Ikuta High School Science Club, have been conducting water quality surveys of the Hirase River near the school since 2017. We are investigating water temperature, pH, COD, NH_4^+, NO_2^-, and NO_3^-. Our research question is how the effects of climate, river topography, and river vegetation affect water quality. This year, we set a new goal to test whether aquatic plants are effective at purifying nitrogen. We use pack tests to conduct water quality studies and to determine the absorption of ions by plants. In addition, we made a map of the surrounding area by walking about 4 km from the water source of the Hirase River to the school in order to examine the state of the surrounding terrain. As a result of this study, it was found that the water quality of the Hirase River was related to precipitation and agricultural land. And that aquatic plants were effective in purifying nitrogen. We will continue to conduct water quality surveys and we want to work on experiments to improve water quality.

key word: Water quality improvement

1. Research Questions and Hypothesis

There is an Ikuta green tract of land near our high school, Ikuta high school. These areas have many forests where various types of animals, such as birds and insects inhabit. Also, the Hirase river is running very close to our school. We have done research of water quality from 2017 as an activity of GLOBE. Previously, our high school students did research a water quality at the request of neighboring residents. Therefore, the neighbors very interested in the Hirase river. We will confront the natural environment by examining the water quality of nearby rivers. From there, we look to global environmental change and this investigation is so significant that we can obtain a solution. We will be able to notice changes in the global environment by continuing the river water quality survey. We made a hypothesis in which water quality can change as the seasons change. In fact, our water quality surveys show that the river has recently been high in nitrogen concentration. It has a negative effect on fish because a lot of No_2- in the water consume a lot of oxygen in the water. No_3- is essential for plant nutrition, but they take a negative impact on the environment at high concentrations. We examined the cause and decided to think a way to remove nitrogen.

Figure1. Picture of the Hirase River in Kawasaki, Japan on March 2015

A kind of weeds called the “Brazilian Waterweed” live in the Hirase river, and we decided to use it for experiments. So we made a hypothesis that Brazilian Waterweed was effective in removing nitrogen in the water, and conducted an experiment to verify this. While we have done water quality surveys, we conducted experiments to raise new questions, develop hypotheses and test them.

Figure2. Students are conducting water quality surveys, Japan on October 2017

Water quality surveys are conducted once a week in the same place, at almost the same time of day, following the GLOBE protocol. Also, we did experiments using Brazilian Waterweed several times to obtain reproducibility. Through this experiment, we were able to show some direction although it was not clear why water quality data fluctuated. Also, we verified the absorption and growth of nitrogen in the water by Brazilian Waterweed by several experiments.

2. Research and Method

The location of the water quality survey and the covering of the land are shown on the map. As for the observation site, a river flows over the soil and is reinforced in place with concrete. As a climatic feature, there is much rain from spring to autumn, but especially in June and September, and it dries at high temperatures and high humidity in summer.

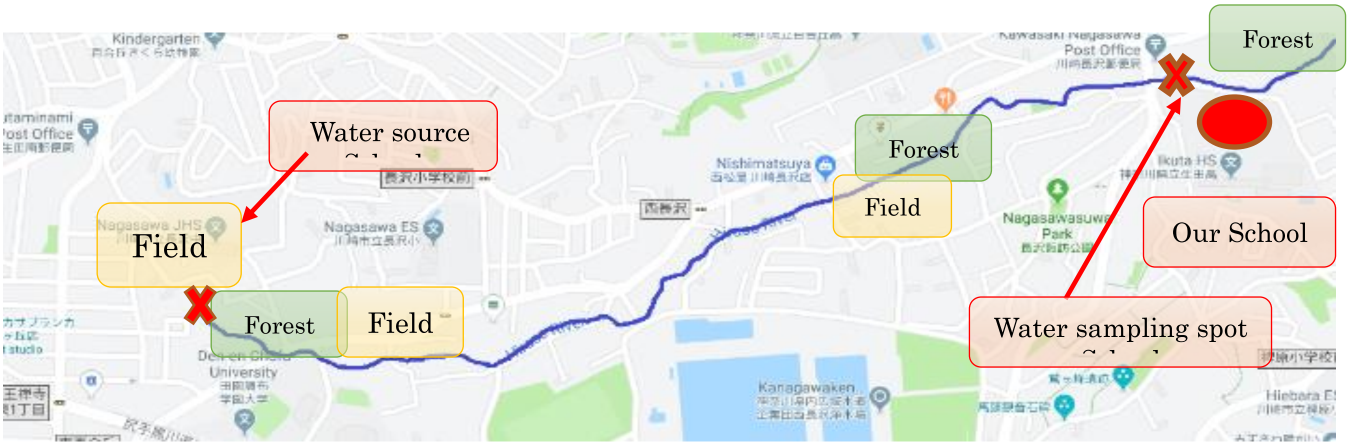

Figure3. Map of the Hirase River in Kawasaki, Japan

The measurement locations for land cover and water quality surveys are shown on the map. (figure3) About the measurement locations, the river flows on the soil and is reinforced with concrete in some places. The climate is characterized by heavy rains from spring to autumn. Especially in June and September, precipitation increases. Therefore, it is hot and humid in summer and dry in winter. First, we will explain how to collect water quality data. Once in a week, we conduct a water quality survey of the Hirase River at the locations marked with a cross on the map. (figure3) Then the water temperature and pH are measured. pH is measured using a pH pen. Usage follows GLOBE's protocol. Before starting the measurement, we calibrate the pH pen by soaking it in pH7 buffer at school for 10 minutes and perform calibration for 5 minutes at the measurement locations. After collecting water and bringing it back to school, COD, NH_4^+, NO_2^-,and NO_3^- are measured using the principle of colorimetry. The actual measurement method uses a pack test and records each density by a change in color. Secondly, we will explain the method of nitrogen purification experiment using Brazilian Waterweed. The following procedure was used to test the hypothesis that Brazilian Waterweed was effective in removing nitrogen. Two tanks containing $NH_4^+$and NO_3^- are prepared. One has the Brazilian Waterweed, and the other was empty. Each of them was subjected to a pack test in order to measure the concentrations of NH_4^+ and NO_3^-, and the changes were examined. The same experiment was performed about three times to prove the accuracy of the data. As a previous study, we were able to find a paper on Brazilian Waterweed. It introduced an experimental method in which dry weight was measured to prove that Brazilian Waterweed absorbs nitrogen and grows. Based on that, we grew Brazilian Waterweed in two tanks, one with NH_4^+ and NO_3^-, and the other with nothing. Then, an experiment was conducted to compare the differences in weight when they dried.

3. Results and Discussion

Figure 3 to Figure 5 show the results of the water quality survey. All units in these graphs are expressed in mg/L except for pH.

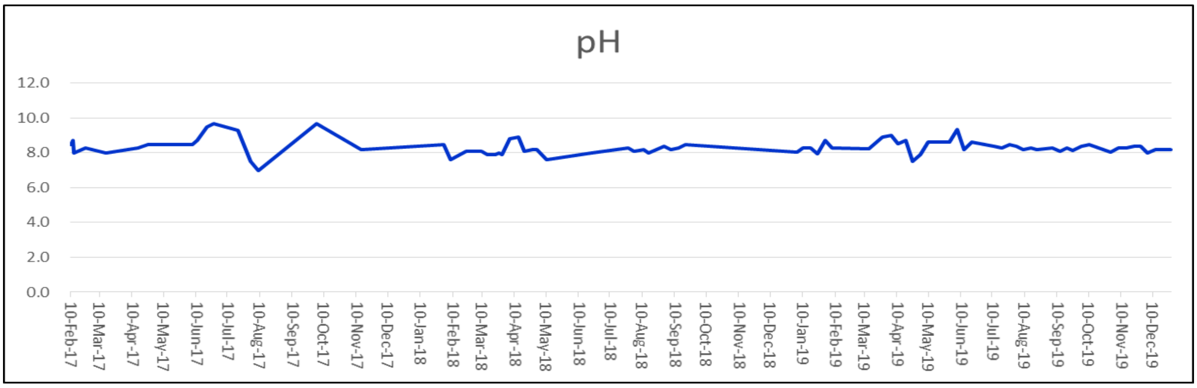

Figure4. Aging of pH

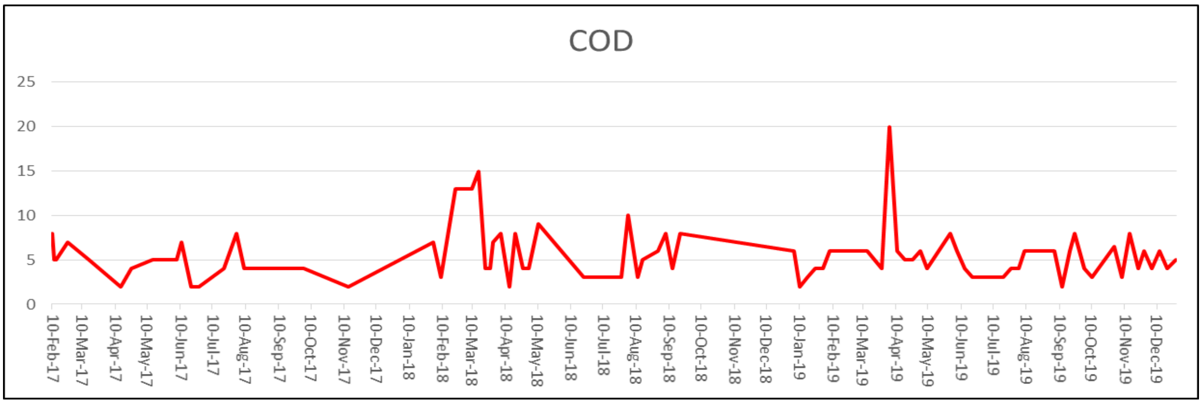

Figure5. Aging of COD

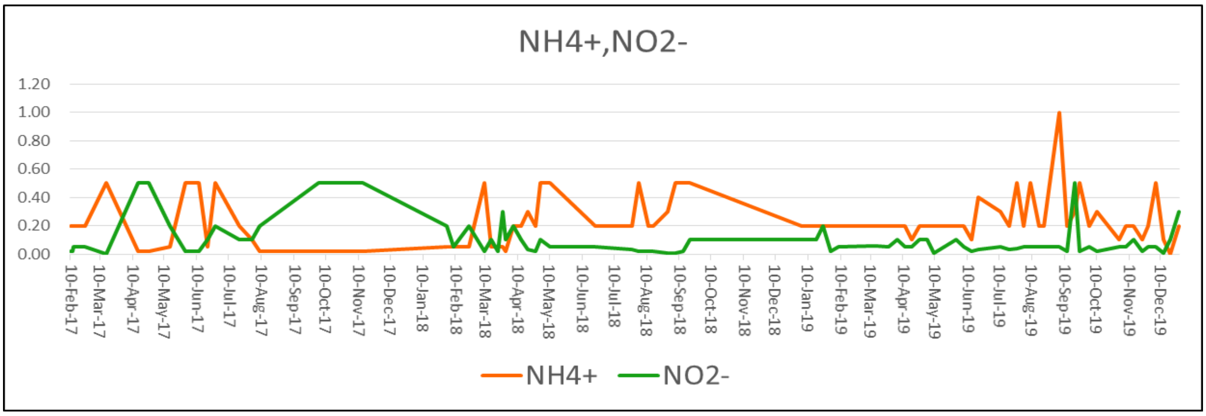

Figure6. Aging of NH_4^+、NO_2^-

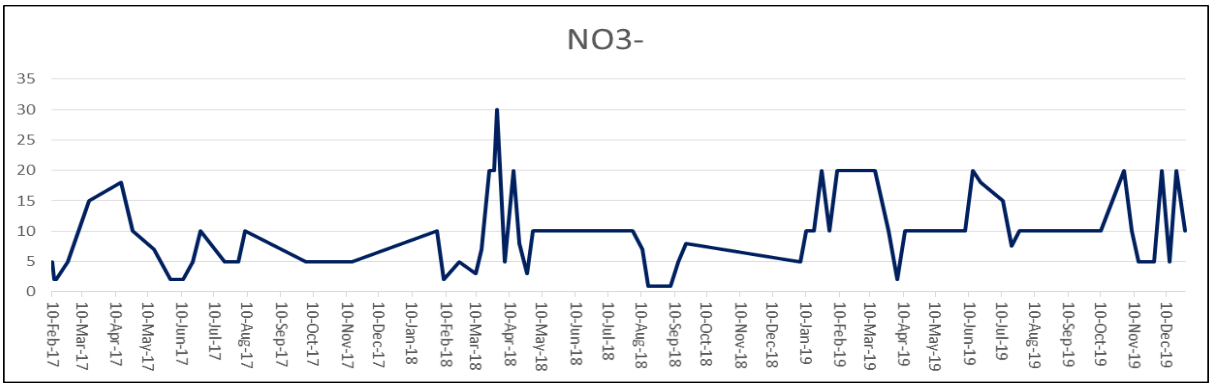

Figure7. Aging of NO_3^-

Basically, pH did not change significantly at around 8.0 throughout the year. This value seems to be related to the pH of Japanese soil (Figure 4). The COD increased and decreased every one or two months and tended to increase in the spring(Figure 5). $NH4^{+}$ values fluctuated between 0.2 and 0.5, with low fluctuations in 2017 and 2018 in February, increasing in March, and decreasing in April, with significant fluctuations at the turn of the season. Conversely, the value of 2019 has been increasing since summer. There was a significant change in $NO2^{-}$ about once every six months, and there was a tendency for $NO2^{-}$ to increase as NH4+decreased (Figure 6). $NO3^{-}$ tended to increase in the spring until 2018, but in 2019 it remained higher after rising in the spring (Figure 7). In early March 2018, all figures except pH were trending badly. An examination of the weather at this time showed that the amount of precipitation per day was higher in August, and the amount of rainfall per hour was higher in August than in March. However, the precipitation per 10 minutes was higher in March. We thought that the heavy rain would degrade the quality of the water. "According to our hypothesis, there was some connection between seasonal change and water quality. We thought that the water quality would easily deteriorate, especially in the spring, when fertilizing the fields.

Figure8. Picture of Brazilian Waterweed.

The photo above is the Brazilian Waterweed used for the experiment. This Waterweed is called Ohkanadamo in Japan in Japanese. First, two water tanks containing NH4+ and $NO3^{-}$ are prepared. Then, one side was filled with Brazilian Waterweed, and other was not filled with it, and the ion concentration was measured. The graph below shows the result.

The first experiment was conducted in May 2018, the second in January 2019, and the third in September 2019. The graph for the tank without Brazilian Waterweed is omitted because there was almost no change in concentration.

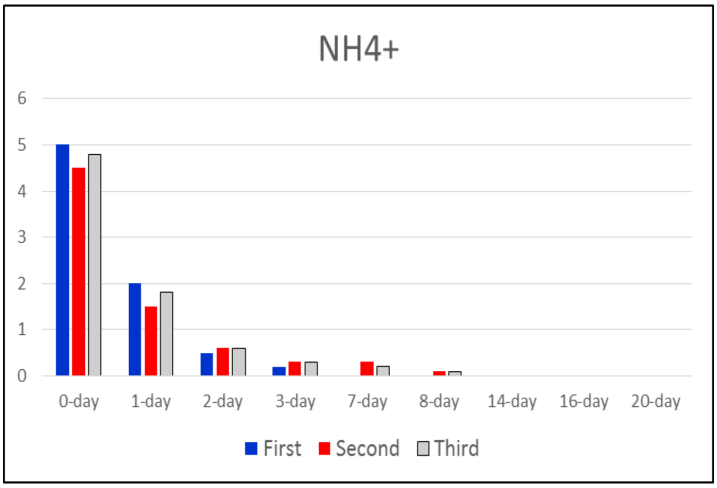

Figure9. Changes in NH4＋ after the experiment

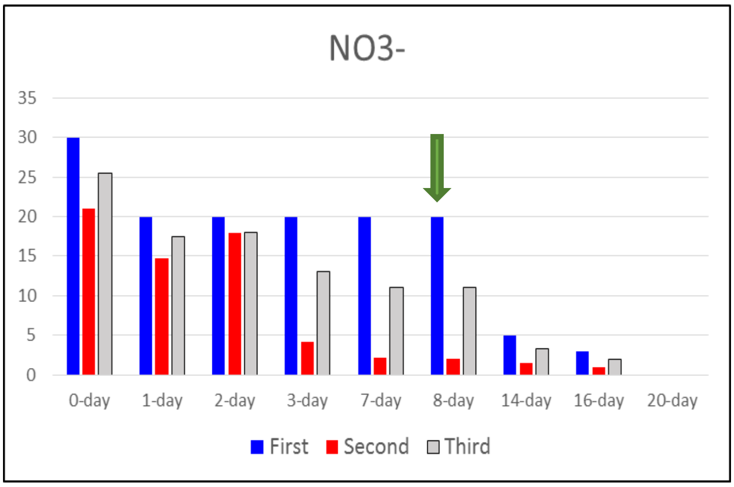

Figure10. Changes in NO3－ after the experiment

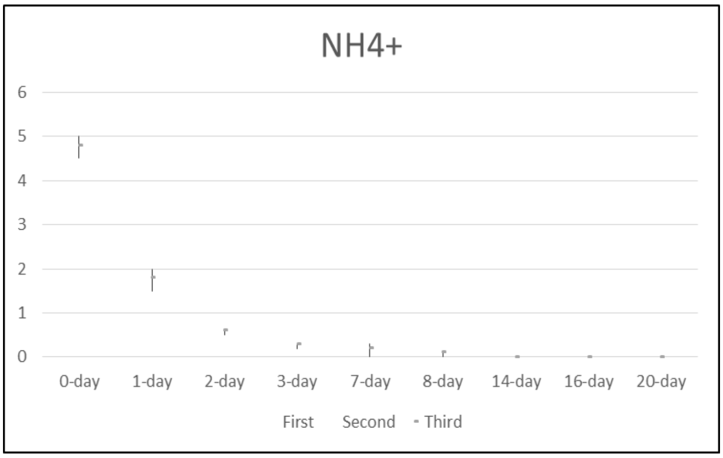

Figure11. Chart of Data Scattering（NH_4^+）

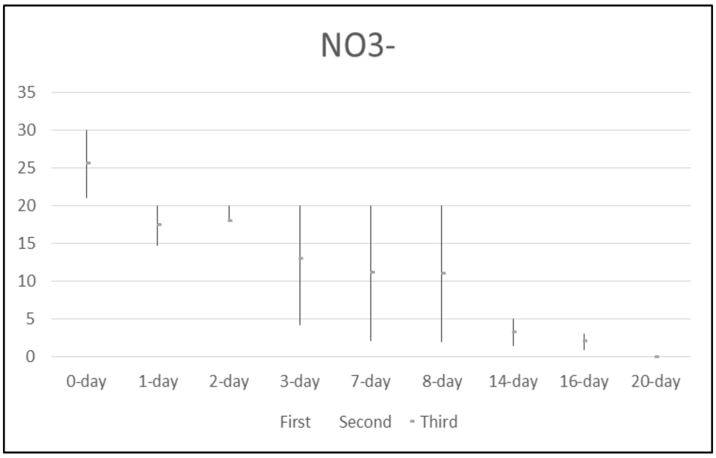

Figure12. Chart of Data Scattering（NO_3^-）

It was not very easy to start the experiment at the same concentration, but the ion concentration was reduced in all three runs. In the first experiment, the weather was cloudy and rainy, and the room was dark, so the nitric acid concentration initially dropped only slightly. However, since the light was applied halfway, the concentration of NO3- decreased. (The part indicated by the figure10 arrow)Variations in data from three experiments are shown on graph 11 and 12. The variation in the NH4+ concentration did not vary much, but the NO3- concentration varied. This is probably because the first experiment was exposed to light on the way, and the second experiment was conducted in January, so the sunshine time was short and the NO3- absorption took a long time. The results were also presented at the globe International Student Conference in Ireland in 2018, one of the globe teachers pointed out whether the decrease in nitrogen concentration is a result of microbial effects. In response to this advice, a new experiment was performed to demonstrate that Brazilian Waterweed absorbed the reduced nitrogen concentration. The following table shows the results of this experiment. How NH_4 + and NO_3- affect the growth of Brazilian Waterweed, they were raised for 10 days, weighed and compared.

NH_4^+,NO_3^-	No Ion
8.07 g	**6.40 g**

Table1. First experiment results

NH_4^+	NO_3^-	No Ion
10.77g	**10.28g**	**9.17**

Table2. Second experiment results

From the results of the first experiment, it was found that Brazilian Waterweed was growing in a water tank where NH_4^+ and NO_3^- existed in the water(Table1).

This result is consistent with the content of the previous research paper we referred to. According to the results of the second experiment, it is considered that Brazilian Waterweed grew slightly larger in the tank with NH_4^+ than in the tank with NO_3^-(Table2); however, the measurement of dry weight is tough, so large errors may occur depending on conditions. Therefore, we cannot draw conclusions without further experiments. These results support our hypothesis that Brazilian Waterweed is effective in removing nitrogen in the water.

4. Conclusion

From the graph, we were able to notice the conditions under which water quality values changed. The numbers fluctuated largely in the summer when much rain falls in a short time, and in the spring when the temperature changes daily.It was found that the season and weather conditions affected the water quality of the river.There is farmland near where we conduct water quality surveys.During the time of fertilizer application, the concentration of nitrogen in the Hirase River water increased. From this, we know that the surrounding farmland will affect the water quality of the Hirase River.In the aquarium where the Brazilian Waterweed was bred, the concentrations of NH4 + and NO3- in the water decreased, and the Brazilian Waterweed in the aquarium grew significantly.We have confirmed that these phenomena of lowering in water are not due to microbial effects, but due to Brazilian Waterweed absorbing them as nutrients.

We also confirmed that when we illuminated Brazilian Waterweed, the concentration of NO3- in the water was reduced, so that the absorption of NO3- by Brazilian Waterweed might have something to do with photosynthesis.Some of the experiments we performed were born from ideas from other countries' GLOBE teachers.Thanks to them, we were able to come up with a new experiment. We are very grateful to them. However, as mentioned above, weighing dry Brazilian Waterweed requires very sophisticated techniques. Besides, the measurement may cause a large error.Thus, in the next experiment, we will measure the length of Brazilian Waterweed growth over time, not the weight of Brazilian Waterweed.We will continue to experiment with the absorption of nitrogen in the water.

We will continue to measure the water quality of the Hirase River as a GLOBE participant school and plan ways to solve other water quality problems.

We will keep contributing to improving the water quality of the Hirase River.

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