The Effects of Aerosols on Water Quality

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Abstract

This project focuses on the question; what is the effect of aerosols on water quality at the SFX pond? The hypothesis states if there are higher levels of aerosols, then the DO levels will be lower, and the temperature, electrical conductivity, and pH levels will all be higher. Aerosols are tiny particles in the air directly linked with the Air Quality Index (AQI). Data was collected outside by observing the cloud coverage, observing which way the wind was blowing, and measuring the Aerosol Optical Thickness. The pond water was then collected and tested for temperature, DO, pH, and conductivity, along with a protected bucket of water added as a control. The hypothesis was partially supported by the data. Dissolved oxygen and conductivity did not seem to be directly affected by the aerosols. When aerosols were high, ph was low, and when the aerosols were low, pH was high. Further data collection will be done to find a correlation. When aerosols were high, temperature was high, and when the aerosols were low, temperature was low. This could be because of stored up warm water below the surface of the pond but future data collection will hopefully lead to a more clear explanation. This applies to the real world because it affects people and it can contribute to Global Warming and air quality. Healthy air and water quality are necessary for human and other animal and plant life. It also shows how humans are affecting water with physical and gas pollutants.

Keywords: dissolved oxygen, electrical conductivity, temperature, pH, air quality index, and aerosols

The Effects of Air Pollution on Water Quality

Question

What is the effect of aerosols on water quality at the SFX pond?

Hypothesis

The hypothesis states that if there are higher levels of aerosols, then the DO levels will be lower, and the temperature, electrical conductivity, and pH levels will all be higher.

Introduction and Research

Aerosols are tiny particles in the air directly linked with the Air Quality Index (AQI). Aerosol Optical Thickness (AOT) is the measurement of urban haze, smoke particles, desert dust, sea salt, and other particles distributed within a column of air from the instrument to the top of the atmosphere. Some particles are naturally produced, like from volcanoes or sand. Most of these particles though, are human made. Human caused examples are; plastic, pesticides, hair spray, chimney smoke and soot, factory smoke, the list goes on. Aerosols are the cause for the haze that is often seen in Gettysburg and many parts of the world. The larger the particles, the less solar energy that reaches Earth's surface. AOT is measured with a sun photometer which is pointed directly at the sun. AOT is the measurement of the thickness of the amount of particles in a particular solar beam between the Earth and the sun. The largest voltage reading during the testing is recorded. They increase haze, decrease visibility, and affect air quality. Aerosols can be taken with either a handmade sun photometer from Drexel University, but in most cases it is taken with a Calitoo sun photometer (NASA, 2005).

Water quality includes the measurements that are carried out in order to make sure that local water is within its healthy range. Water quality is important because if measurements are off by too much then they can cause illness in livestock, aquatic life and pollution to other bodies of water that they flow into. There are various ways to measure water quality. Water temperature is the measurement of the temperature in a given body of water. This measurement could vary due to sun exposure and heat. pH is the measurement of the molar concentration of hydrogen ions in a given body of water. The measurement could vary depending on proximity to acidic material or runoff (roads, agricultural fields). Dissolved Oxygen (DO) is the measurement of the amount of oxygen, specifically dissolved oxygen, in a given body of water. Fish and other aquatic life breathe dissolved oxygen so if there is a lack of it, it could poorly affect the local fish population. Electrical conductivity is the measurement of how strongly water resists or conducts electrical current in a given body of water. This measurement is directly linked to pH because if the pH is low (less hydroxide ions, less acidic) the conductivity will be lower, and if the pH is higher (more hydroxide ions, more acidic) the conductivity will be higher. This is because the more ions present, the more electrical conductivity that will occur (GLOBE, 2019).

Aerosols enter the water through the water cycle. Rain is formed around a molecule in the atmosphere such as an aerosol molecule. When it rains, the aerosol molecule, now part of the raindrop, enters bodies of water directly (through rain) or through runoff once the rain hits the ground. Aerosols could have many effects on the water body. They could cause fluctuation in temperature, conductivity, pH, and DO. They could affect aquatic life (access to oxygen and clean water, their habitat (destruction do too to much sun or too little sun) , or their source of food (could be another aquatic life organism or plants that are affected the same way habitat is).

This project is important to fishermen because it can alert them as to whether or not the fish they are catching have been swimming in excessive amounts of water chemicals and the possibility of the fish being edible. This project is also important to farmers who may use water from ponds or streams to irrigate their crops or to provide water for their animals. These measurements could alert them to whether or not their crops could be contaminated by excessive amounts of water chemicals or whether or not their animals are drinking water with possible pollution contaminants. This project applies to the real world because it affects real people and it can contribute to finding solutions to problems such as global warming and air pollution. If global warming is not stopped, then sea levels will rise. Land will begin to disappear because of the rising sea levels and that means homes will be destroyed (NASA, 2005).

This experiment is designed to test the question what is the effect of aerosols on water quality at the SFX pond? The independent variable is the level of aerosols not because they were physically being changed but rather they changed on their own from day to day. The dependent variables measured are conductivity, pH, temperature, and DO. The control in this experiment was the bucket of pond water added in with the last few sets of data in order to see if there was a comparison between pond water and pond water that was sheltered from the surrounding elements. The bucket was sat on the little playground and an umbrella was fastened to it in order to prevent the sun and precipitation from entering. It was not used during the entire experiment because its use was suggested by Dr. Pippin. There was also a delay because keeping the bucket full, safe, and the umbrella securely in place took a few attempts. Once things were secure and reliable, data was then collected. The hypothesis states if there are higher levels of aerosols, then the DO levels will be lower, and the temperature, electrical conductivity, and pH levels will all be higher.

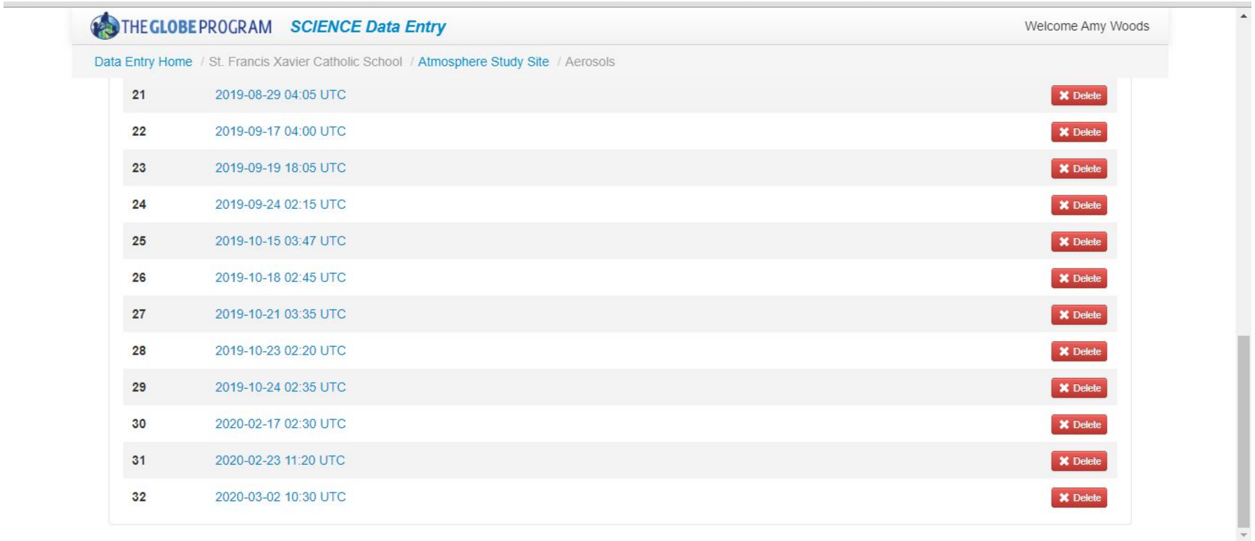
Image 1

Location of Pond Collection

Note. This is the pond where the data was collected. This site is made up of mowed grass with taller unmowed native plants and grass surrounding the mowed/cut pathway. The pond is in a rural area with farms and pasture land on the north and west sides, a small housing development on the south side, and a forested area with a creek to the east side. The location experiences a humid, continental climate. The coordinates of this site are 39.856862, -77.225900 with an elevation of 100m.

Image 2

Screenshot of Entered GLOBE Data



THE GLOBE PROGRAM SCIENCE Data Entry Welcome Amy Woods

Data Entry Home / St. Francis Xavier Catholic School / Atmosphere Study Site / Aerosols

21	2019-08-29 04:05 UTC	Delete
22	2019-09-17 04:00 UTC	Delete
23	2019-09-19 18:05 UTC	Delete
24	2019-09-24 02:15 UTC	Delete
25	2019-10-15 03:47 UTC	Delete
26	2019-10-18 02:45 UTC	Delete
27	2019-10-21 03:35 UTC	Delete
28	2019-10-23 02:20 UTC	Delete
29	2019-10-24 02:35 UTC	Delete
30	2020-02-17 02:30 UTC	Delete
31	2020-02-23 11:20 UTC	Delete
32	2020-03-02 10:30 UTC	Delete

Note. This shows a screenshot of aerosol data entered. Surface temperature data was also entered.

Materials

- 1 DO probe [Xtech]
- 1 DO kit [LaMotte]
- 1 Calitoo [cnes and Tenum]
- 1 Conductivity probe [LaMotte]
- 1 temperature probe [Vernier]
- 1 pH probe [Jellas]

Procedures

To test the hypothesis measurements were taken once a week for three months on Tuesdays or Thursdays if the clouds were permitting. Measurements were collected at the pond across from SFXC School. There were a total of eight dates of collection, with 3 trials for DO due to kit contents and 5 trials for all other parameters collected in the allotted data collection time. The following are the steps that were taken to carry out the experiment. Data collection was dependent on the sun because aerosols cannot be measured if there are clouds blocking the sun, it is not possible to determine if the measurement is reflecting the cloud particles or actual aerosols.

The first step is to remove tools from the storage area in the classroom (back table). The second step is to walk to the pond at the far end of the property (close to main road and housing development). The third step is to set tools down. The fourth step is to record date, time, and name on the data sheet. The fifth step is if clouds are permitting (not blocking the sun) remove aerosol Calitoo from supplies and take data. Line the instrument up with the sun so that the sun spot is in the target area. Before use allow the Calitoo to connect to nearby satellites. Click three times to record the data in the Calitoo. Then later the data can be retrieved by holding the button down till mode reading appears. Record data on data sheet. The sixth step is to remove pond water in a bucket (trying not to disturb sediment) and let sit for 1 minute. The seventh step is to measure water quality. A suggested order to carry these measurements out in would be DO first so that more oxygen from the air around is not added to the test, temperature second because it could cool down or heat up due to the surrounding temperatures, conductivity next in order to not add anymore particles, and pH last because it is not as sensitive to surrounding forces. These are all based off of the hopes that the surrounding forces will not cause too much of a fluctuation in the testing results. The measurements should follow GLOBE Protocols and the data should be recorded as measurements progress. The eighth step is to pour all chemicals in a chemical waste bin as testing is finished to be disposed of properly later. The ninth step is to pour all remaining untouched pond water back into the pond. And the tenth step is to pack up tools and return them to their storage.

The independent variable is the level of aerosols. The dependent variables are water temperature, DO, electrical conductivity, and water pH. The controls for this experiment are the locations of the testing water type, cloud conditions, and the method of testing. The control group is the bucket of pond water that was added in for the last few tests. It was covered by an umbrella and sat on a mulched playground. This was done to protect it from being directly exposed to precipitation like it would have been if it had been left in the pond.

The following protocols were used to carry out the aerosol and water quality measurements. They were all taken from GLOBE and were utilized to discover a possible correlation between aerosols (air quality) and water quality.

Dissolved Oxygen

The first step is to warm up the probe as described in the probe manual. The second step is to lower the tip of the probe into the water body that you are sampling and slowly move it back and forth. If you are measuring a stream or river and the water is moving past the probe, you can just hold the probe in place. The third step is that when the reading has stabilized, record the dissolved oxygen in your water body on your Hydrosphere Investigation Data Sheet. The fourth step is to repeat the readings two more times and record the dissolved oxygen under Observers 2 and 3. The fifth step is to check to make sure that the three readings are within 0.2 mg/L of one another. If they are not, continue taking readings until the last three are within 0.2 mg/L of one another. The sixth step is to apply the salinity correction (if appropriate, not in this experiment). The seventh step is to calculate the average of the three (adjusted if salinity correction applied) Measurements. The last step is to rinse the electrode with distilled water and blot dry. Cap electrode to protect membrane and turn off meter (GLOBE, 2019).

Aerosols

The first step is to determine whether or not the sun is blocked by clouds and if not turn the sun photometer on. If the sun is covered aerosol data cannot be obtained for that day. The second step is to hold the instrument about chest-high or, if possible, sit down and brace the instrument against the knees. The third step is to adjust the orientation of the sun photometer until the sunlight spot is centered in the target area. Be sure the pointing is stable before the voltages are recorded. Small movements of the sun photometer will cause the voltage to vary by a few millivolts. The fourth step is to click through each screen, making sure the dot is centered and all information has stabilized so it is properly measured and recorded within the Calitoo. The fifth step is to repeat all steps 4-9 four more times, making sure to hold the button at the last screen to ensure all data is recorded in the Calitoo. The sixth step is to turn off the sun photometer. (GLOBE, 2019).

Electrical Conductivity

The first step is to rinse two 100-mL beakers two times with sample water. The second step is to pour about 50 mL of water to be tested into two 100-mL beakers. The third step is to remove the cap from the probe end of the meter. Press the On/Off button to turn it on. The fourth step is to rinse the probe with distilled water. Blot it dry. Do not rub or stroke the electrode while drying. The fifth step is to put the probe in the water sample in the first beaker. Stir gently for a few seconds. The sixth step is to take the probe out of the first beaker. Shake gently to remove excess water, then put it into the second beaker without rinsing with distilled water. The seventh step is to leave the probes submerged for at least one minute. When the numbers stop changing, record the value on the Hydrosphere Investigation Data Sheet by Observer. The eighth step is to calculate the average of the three observations. The ninth step is to rinse the probe with distilled water, blot dry, and put the cap on the meter. Rinse and dry the beakers and sample bottle (GLOBE, 2019).

Water Temperature

The first step is to put the probe or the into the sample water to a depth of 10 cm. The second step is to leave the probe in the water for three minutes. The third step is to read the temperature on the meter without removing the probe from the water. The fourth step is to let the thermometer probe stay in the water sample for one more minute. The fifth step is to read the temperature again and record it on the data sheet. Repeat steps 1-5 two more times. The sixth step is to calculate the average of the five measurements. The seventh step is to make sure all temperatures are within 1.0˚ C of the average. If they are not, repeat the measurement (GLOBE, 2019).

pH

The first step is to pour 50 mL of sample water into the 100-mL beaker, and uncap meter. The second step is to put the electrode part of the meter into the water. The third step is to stir once with a meter. Do not let the meter touch the bottom or sides of the beaker. Wait for one minute. If the pH meter is still changing numbers, wait another minute. The fourth step is to record data without removing it from water. The fifth step is to repeat steps five times. The sixth step is to remove the meter, rinse and blot dry, and cap the probe (GLOBE, 2019).

Data Summary

Temperature (°C), Conductivity (uS/cm), pH, and DO (mg/L), vs. Aerosols

Table 1

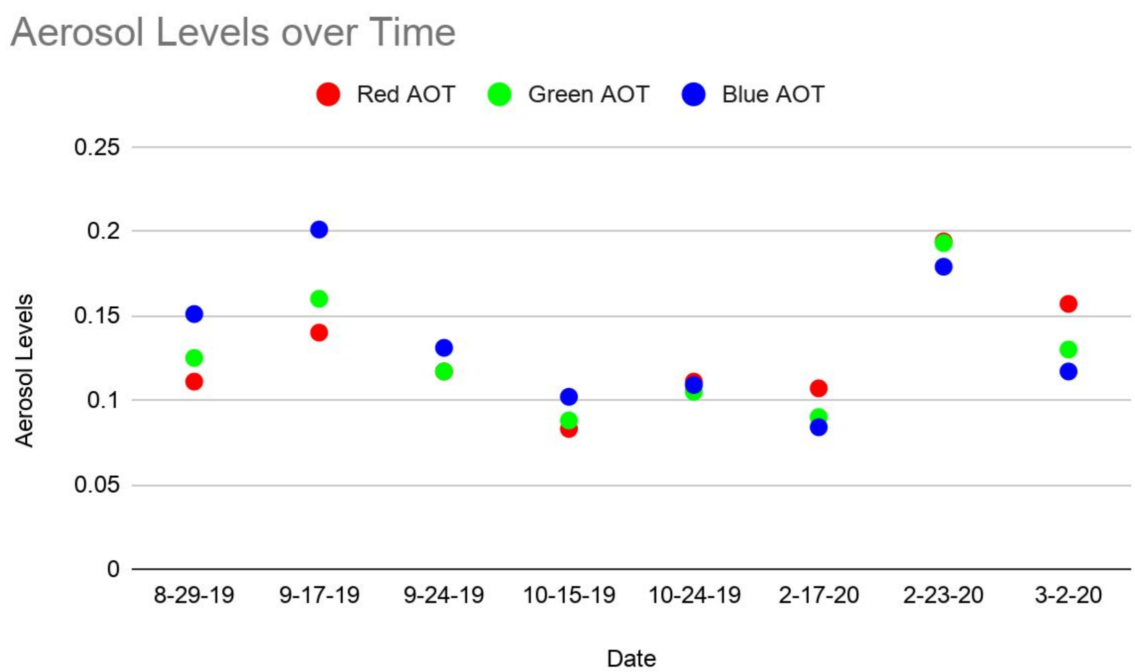
Data Table Showing AOT, DO, Temperature, Conductivity, and pH Values

Date	Red AOT	Green AOT	Blue AOT	DO Tests 1-5	Temp. Tests 1-5	Cond. Tests 1-5	pH Tests 1-5	Time
8-29-19	0.111	0.125	0.151	7	27.7	119.2	7.5	4:05
	0.108	0.121	0.147	7	27.6	120.7	7.5	
	0.107	0.12	0.147	7	27.7	122.7	7.5	
	0.109	0.121	0.147	7	28.5	122.4	7.5	
	0.107	0.119	0.146	7	28.1	123.8	7.5	
9-17-19	0.14	0.16	0.201	3.74	30	117.8	5.6	4:00
	0.143	0.161	0.199	3.74	30	117.6	5.3	
	0.142	0.155	0.195	3.74	30	118.3	5.2	
	0.149	0.169	0.209	3.79	30	117.7	5.2	
	0.15	0.165	0.208	3.73	30	117	5.2	
9-24-19	0.117	0.117	0.131	9	26.6	117.3	7.5	4:25
	0.154	0.154	0.173	8.6	26.5	117.7	7.6	
	0.116	0.118	0.138	8.4	26.6	117.9	7.6	
	0.112	0.138	0.158		26.4	117.5	7.6	
	0.078	0.073	0.086		26.5	117.5	7.6	
10-15-19	0.083	0.088	0.102	3.6	22.9	111.7	8	3:47
	0.078	0.084	0.098	3.2	22.7	110.3	8	
	0.078	0.084	0.098	4	23	109.6	7.9	
	0.078	0.083	0.097		23	109.8	7.9	
	0.077	0.083	0.097		22.8	110.2	7.9	

Note. This data table displays all of the data collected for AOT and water quality.

Figure 1:

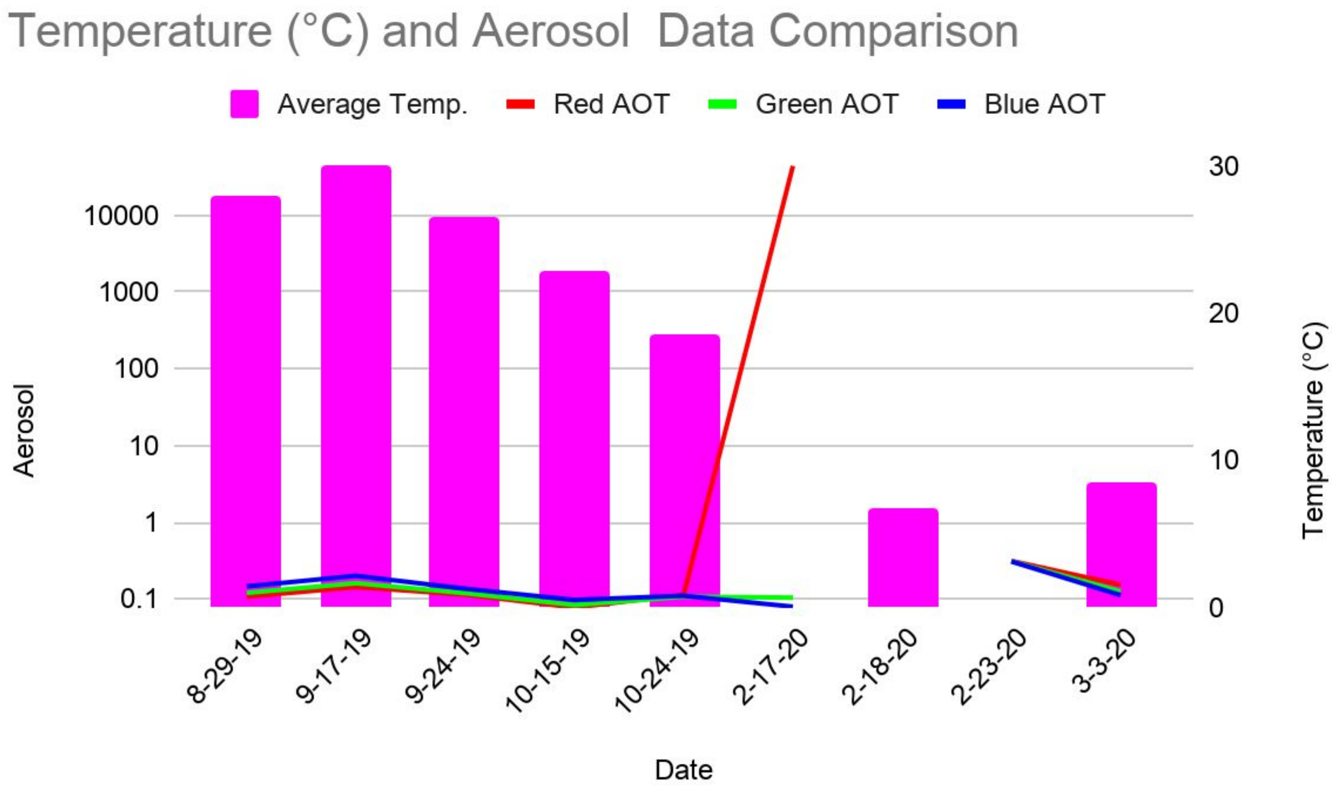
This graph shows the aerosol measurements collected throughout the project.



Note: This graph displays the aerosol data collected over the past three months. The significance of the dots is that when the dots on the graph are farther apart, that means that the aerosol particles are small. When the dots on the graph are close together, the aerosol particles in the air are larger, which can cause more respiration issues and atmospheric effects. The aerosols followed a pattern of increase and then decrease.

Figure 2:

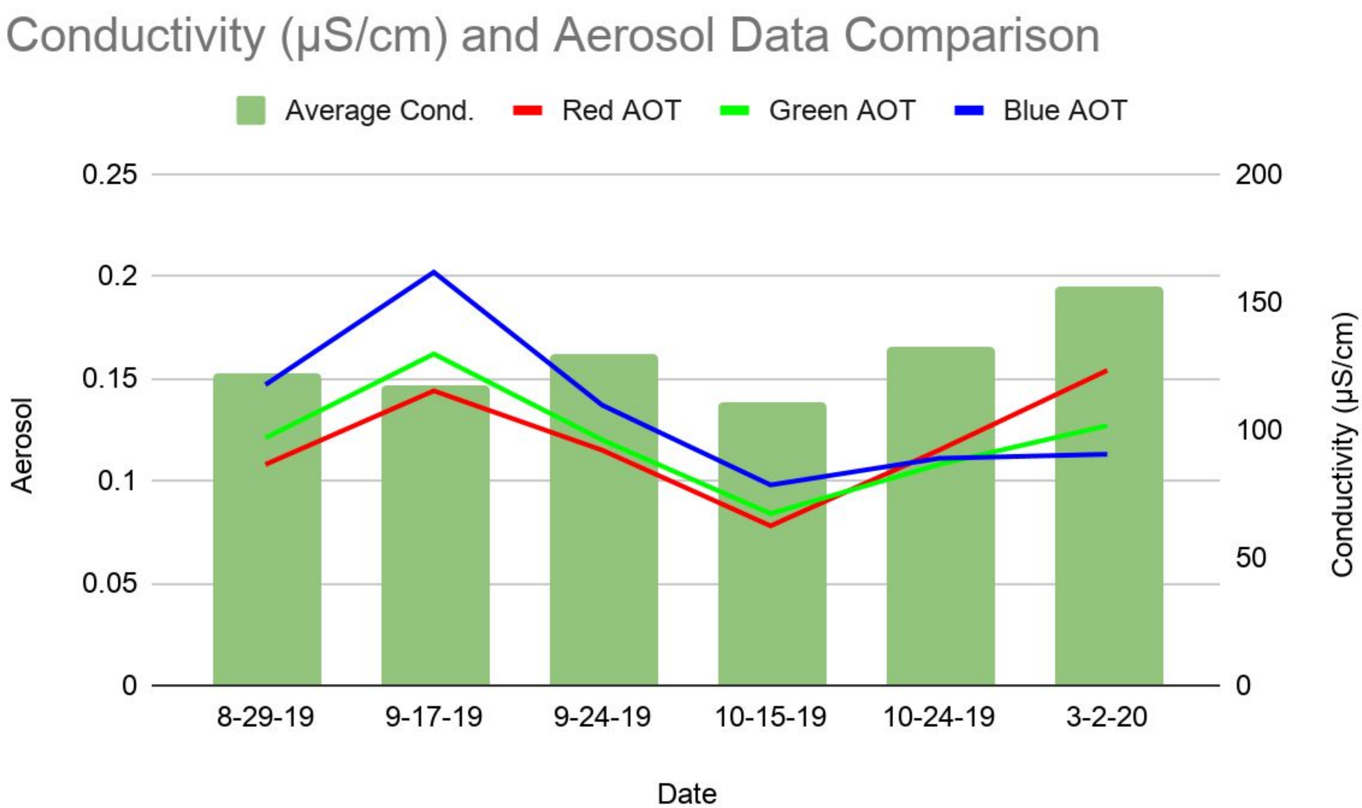
This graph displays the data correlation between aerosols and temperature.



Note: This graph shows the correlation between aerosols and temperature data collected over the past three months. It is visible that when there were higher levels of aerosols then the temperature was higher and when there were lower levels of aerosols the temperature was lower. This is most likely because of the warm surface water mixing with colder bottom water and keeping the water more consistent even though the amount of aerosols caused air temperature to be lower. September 17th showed a correlation between high aerosol levels and higher temperatures.

Figure 3:

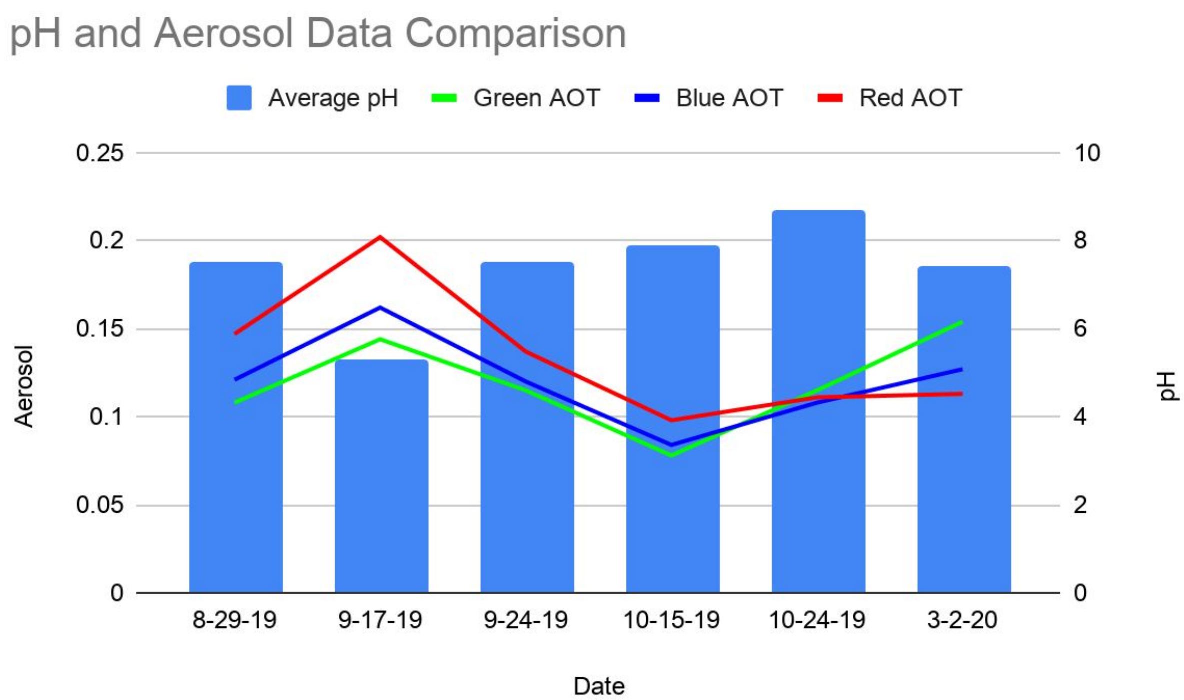
This graph shows the data correlation between aerosols and conductivity.



Note: This graph shows the correlation between aerosols and conductivity data collected over the past three months. There was no clear relationship between conductivity and aerosols, so more data will need to be collected to see if there is an observable relationship between the two.

Figure 4:

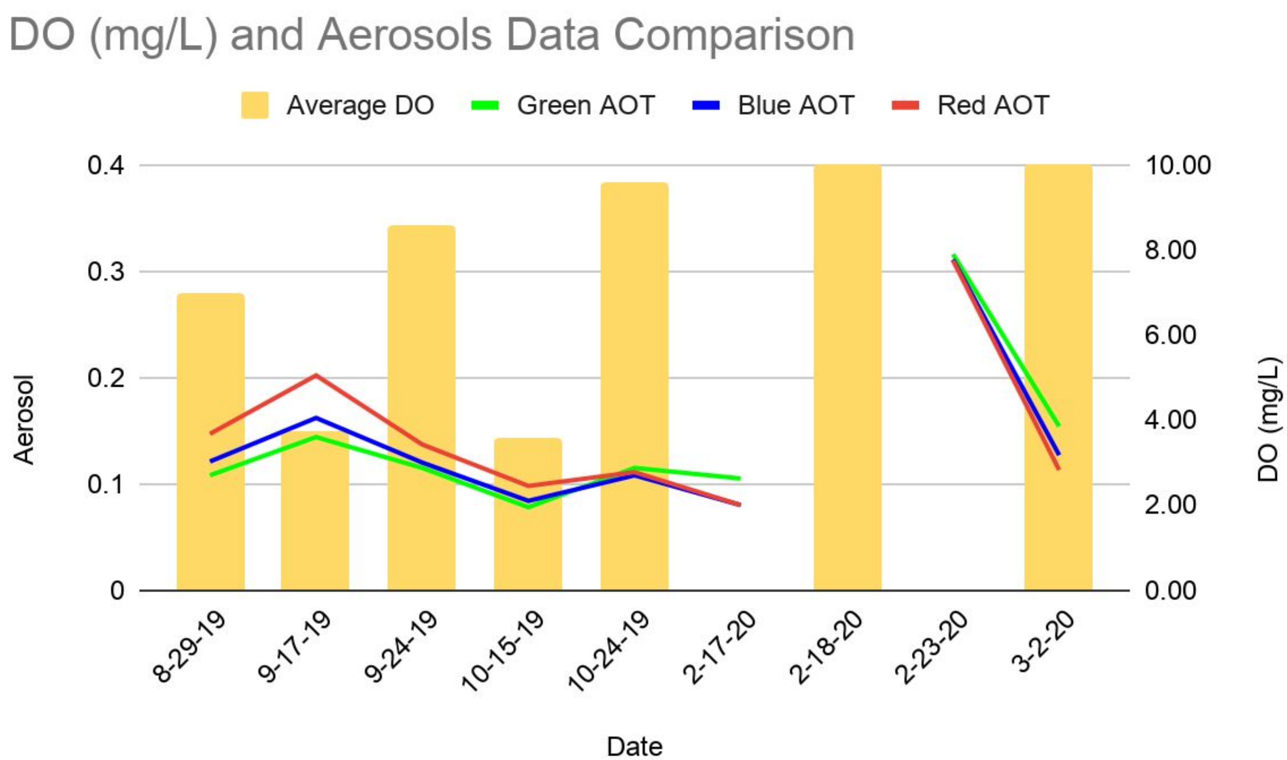
This graph shows the data correlation between aerosols and pH.



Note: This graph shows the correlation between aerosols and pH data collected over the past three months. It is visible that when there were higher levels of aerosols, then the pH levels were lower and when there were lower levels of aerosols, then the pH levels were higher. September 17th shows the correlation of high aerosol levels and low pH. The other dates show the low aerosol, high pH relationship.

Figure 5:

This graph shows the data correlation between aerosols and DO.



Note: This graph shows the correlation between aerosols and DO data collected over the past three months. There was no clear relationship between DO and aerosols, so more data will need to be collected to see if there is an observable relationship between the two.

Figure 6:

AOT Graph

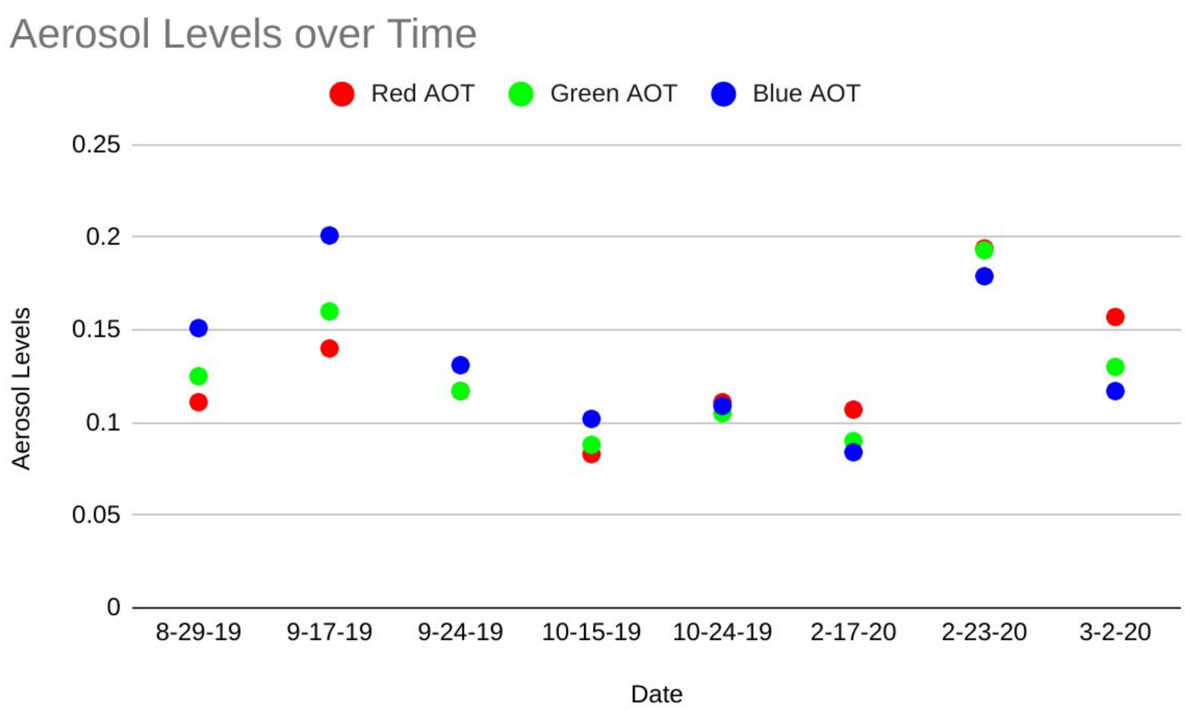
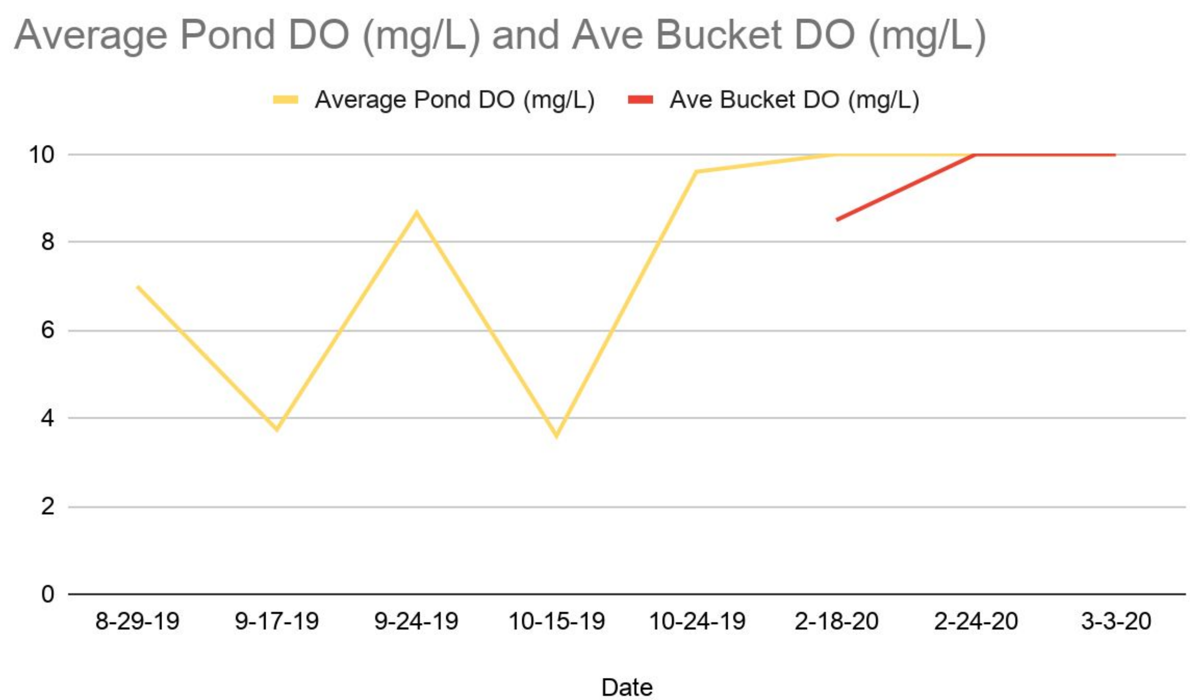


Figure 7:

DO Comparison Chart



Note: This graph shows the correlation between aerosols and DO of pond water that was protected from the entrance of aerosols (rainwater).

Figure 8:

AOT graph

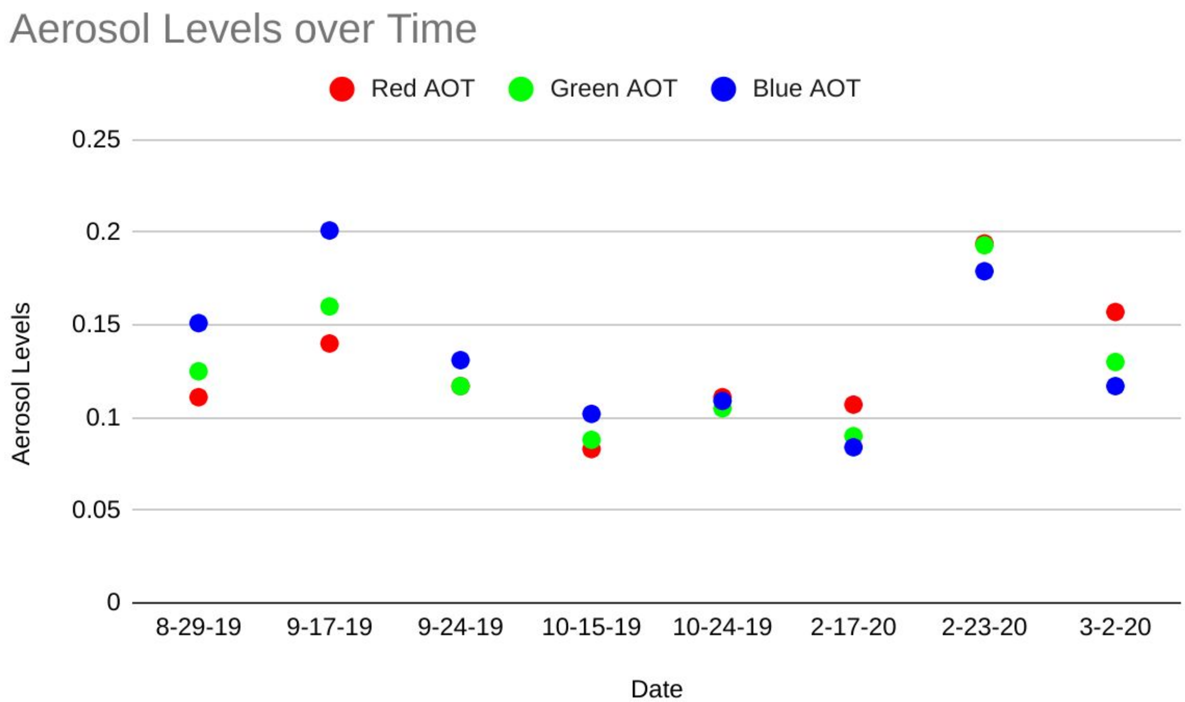
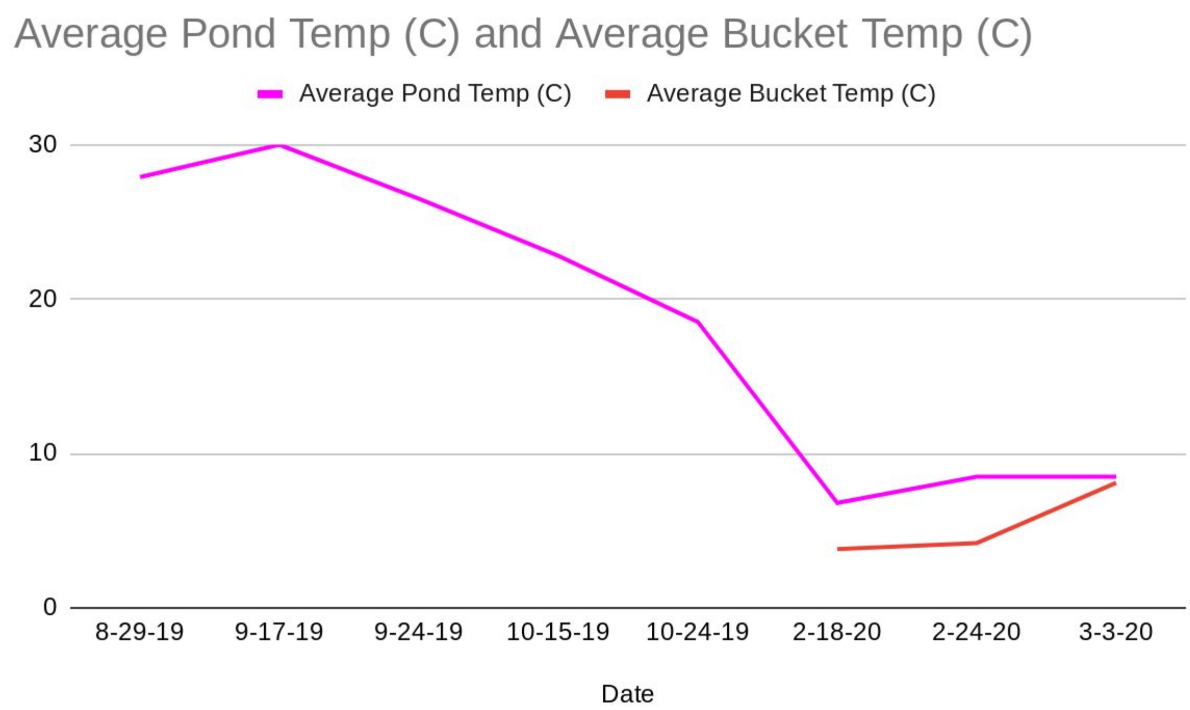


Figure 9:

Temperature comparison chart



Note: This graph shows the correlation between aerosols and temperature of pond water that was protected from the entrance of aerosols (rainwater).

Figure 10:

AOT chart

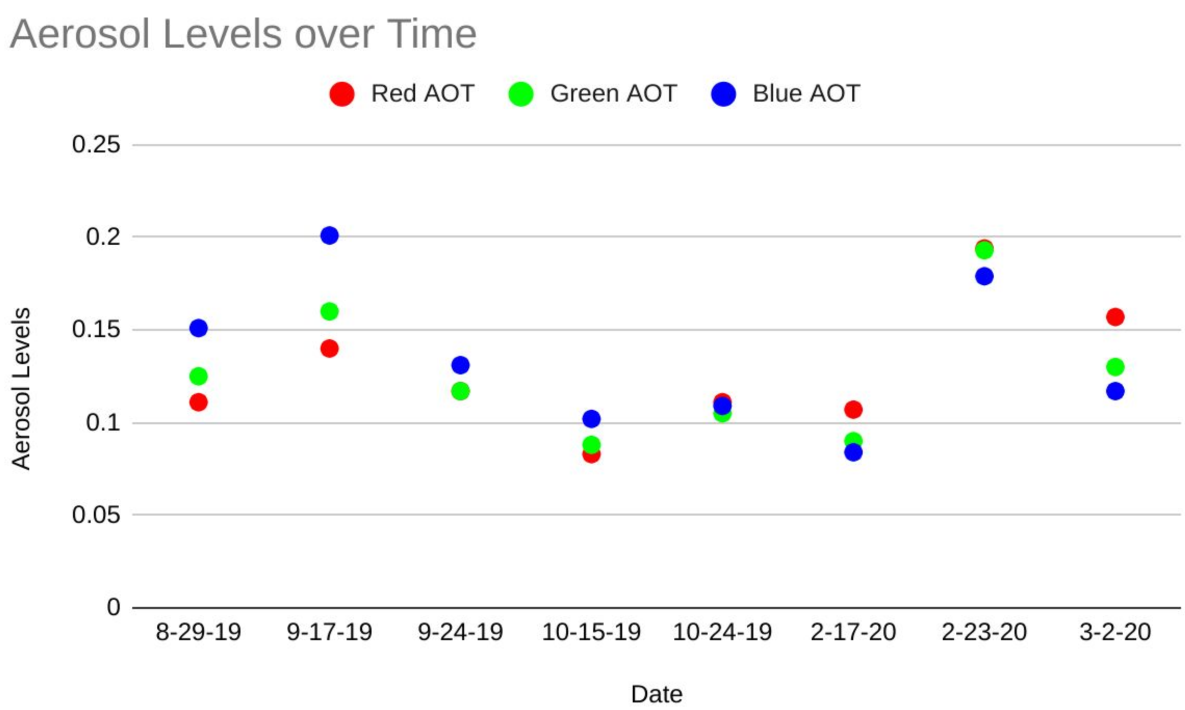
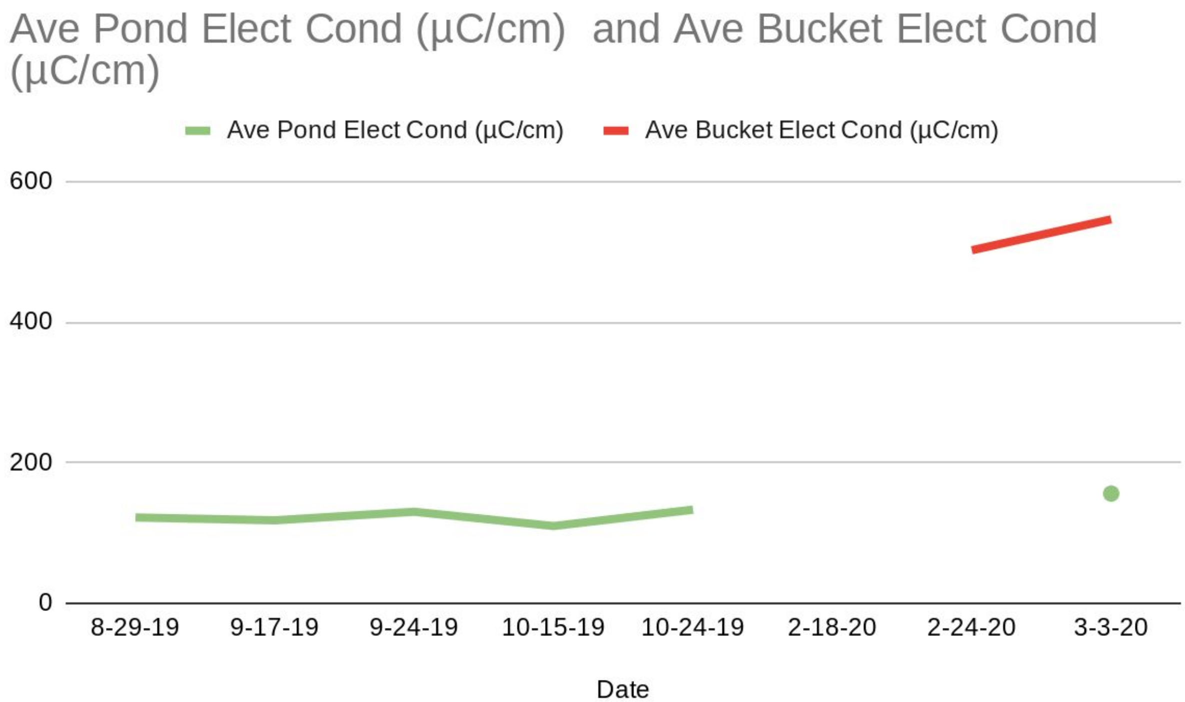


Figure 11:

Electrical Conductivity comparison chart



Note: This graph shows the correlation between aerosols and Electrical Conductivity of pond water that was protected from the entrance of aerosols (rainwater).

Figure 12:

AOT chart

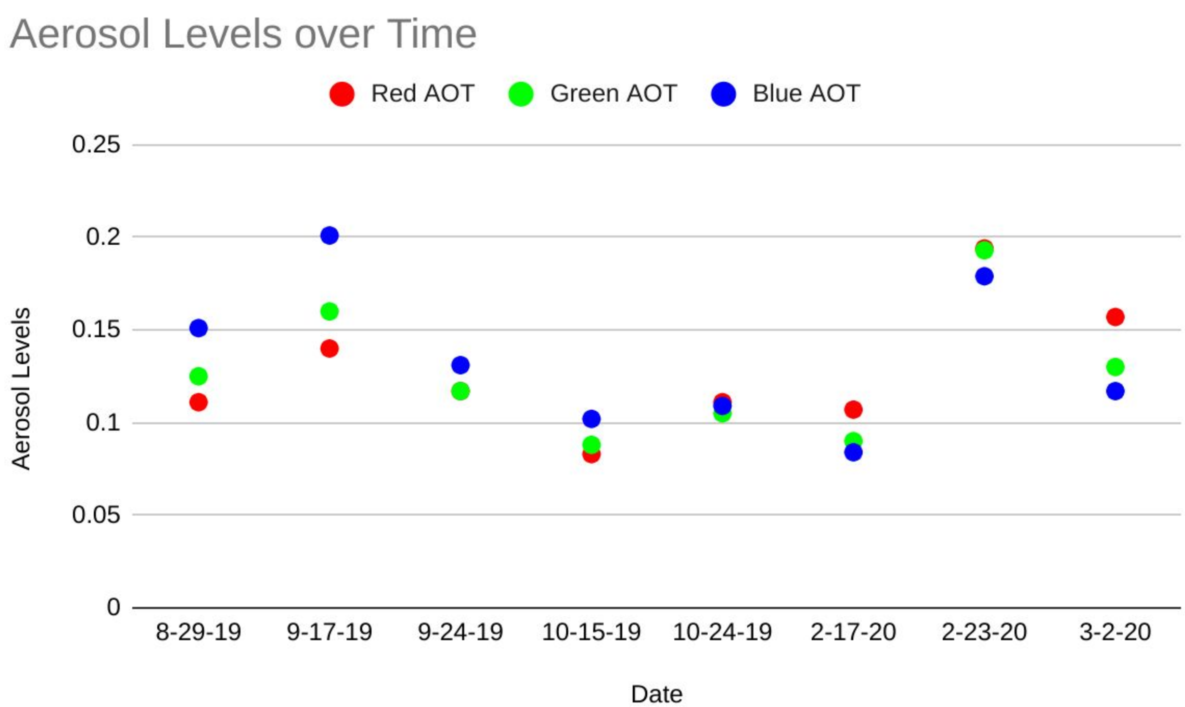
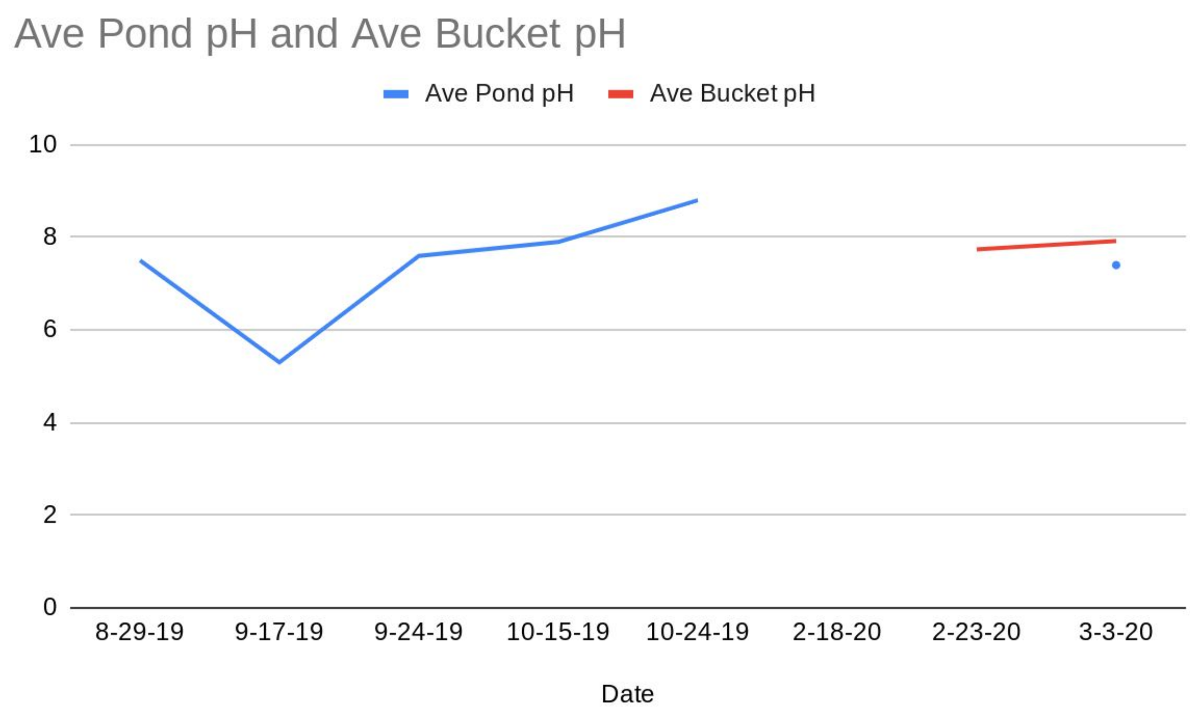


Figure 13:

pH comparison chart



Note: This graph shows the correlation between aerosols and pH of pond water that was protected from the entrance of aerosols (rainwater).

Discussion and Analysis

It seemed that when aerosols were higher, the temperature of the water was also higher. This was seen on September17th when aerosols averaged out to 0.169 and temperature averaged out to 30ºC, which was the highest temperature reading in the entire testing period. This could be because when the Earth cools down, the surface water remains warm. This warm surface water mixes with other cooler water at the bottom of the body of water and keeps it at a more consistent temperature unlike Earth going from hot to cold in a few hours because water retains and loses heat slower than land. In the atmosphere, when there are a lot of aerosols, the outside temperature is generally cooler because the aerosols prevent the Sun's energy rays from reaching Earth's surface, thereby heating the air closest to the ground, which then travels upward.

A correlation also appeared between pH levels and aerosols. It seemed that when the aerosol levels were higher, pH levels were lower. This was seen on September 17th when aerosols averaged out to 0.169 and pH averaged out to 5.3, which was the lowest pH reading in the entire testing period. Further research and data will be needed to see why this pattern occurred and if it will appear again

Aerosols did not seem to affect DO or conductivity at all during the testing period, but further data will be collected to see if a pattern appears. The current measurements seem to be all over the place. At one point, on September 17th, there looked to be patterns for both DO and conductivity, but when the aerosols dropped again, the measurements did not do the same thing they had done on the previous low aerosol day. That is why future data is needed to determine if there is a correlation.

Conclusion

This project focuses on the question; what is the effect of aerosols on water quality at the SFX pond? The hypothesis, which states, if there are higher levels of aerosols, then the DO levels will be lower, and the temperature, electrical conductivity, and pH levels will all be higher, was not supported by the data. The hypothesis was slightly supported by the data as no significant change happened with dissolved oxygen and conductivity. The pH did the opposite of what was hypothesized but the temperature followed the pattern that was hypothesized. The dissolved oxygen and conductivity did not seem affected by the aerosols so further data collection will be done to see if there is a correlation between the two. When the aerosols were high, pH was low for an unknown reason and the temperature was high most likely because of warm surface water mixing with cold bottom water evening out the temperature. When aerosols were low, pH was high and the temperature was low. September seventeenth is when all of the patterns were seen with temperature and pH. That day, aerosols averaged out to 0.169, temperature reached its highest at 30°C, and pH reached its lowest at 5.3. Aerosols was at its highest measurement as well, which led to the temperature reaching its highest data point and pH reaching its lowest data point.There may have not been a long enough lag between when the aerosols were measured and when the water was measured so that the aerosols actually had time to enter the water due to air and surface water mixing. In further data collecting, this problem has been addressed by adding a 24 hour lag time between the two different testings to make sure the aerosols have time to mix with the water. There may have also been a few unnoticed clouds that may have been in front of the sun during aerosol measurements so further and more in depth cloud reading will be carried out in further data collection. A bucket was added as a control for the water quality. There was not a lot of data collected due to the umbrella that was supposed to prevent precipitation interference kept blowing off and the bucket would need reset again. Further data will continue to be collected in order to get a better understanding of the story this data is trying to tell as it relates to aerosol values.

In conclusion, the hypothesis of this experiment was not supported by the data, but further data collection will take place to see if patterns or correlations appear. For further data collection purposes a revised hypothesis was made. It states; When aerosol levels are higher, temperature levels will be higher, pH levels will be lower, and DO and conductivity will not really be affected though a correlation is still possible.

Application

In future data collecting PM2.5 and AQI will be added in to see how they may or may not affect DO, temperature, conductivity, and pH. This project will be slowly advanced through different additions of measurements for further competitions such as GLOBE SRS and GLOBE IVSS. This project applies to the real world because it affects real people and it can contribute to problems such as global warming and air quality, which in turn may have an impact on water quality. Healthy air and water quality are necessary for human and other animal and plant life. If global warming is not stopped, then sea levels will rise. Land will begin to disappear because of the rising sea levels and that means homes will be destroyed. It also shows how humans are affecting water (oceans, lakes, rivers), not just with physical pollutants (plastic and other litter), but also with the gases that we release to help us through everyday life (NASA, 2005).

Badge Selection

STEM Professional- I have listed all of the ways that Mr. Todd Toth and Dr. Pippin, have helped me more accurately collect my data for my project.

Data Scientist- I have analysed my data and I have compared my measurements with other measurements of my own, and compared my measurements with historical data taken by me last year.

Pictures

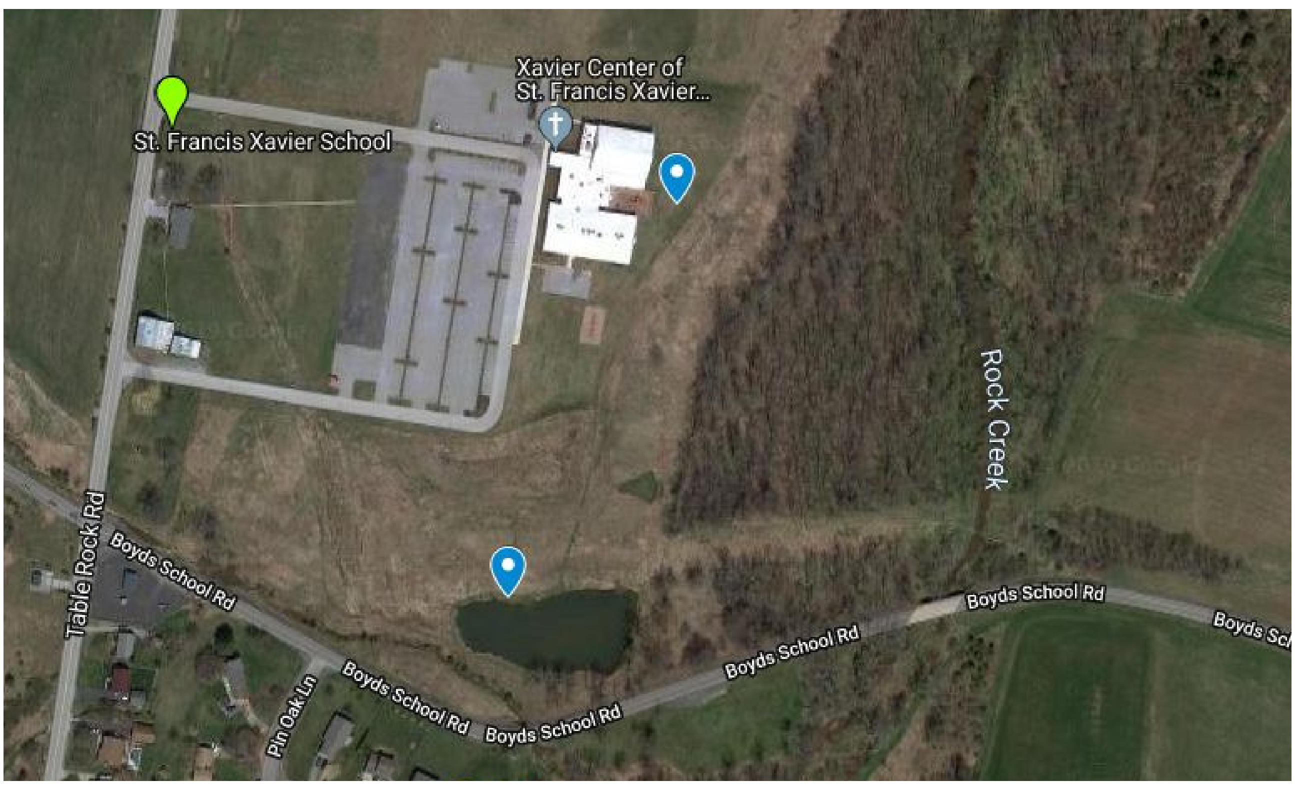


Image 2: *This shows an aerial view of the testing sites at SFXCS.*

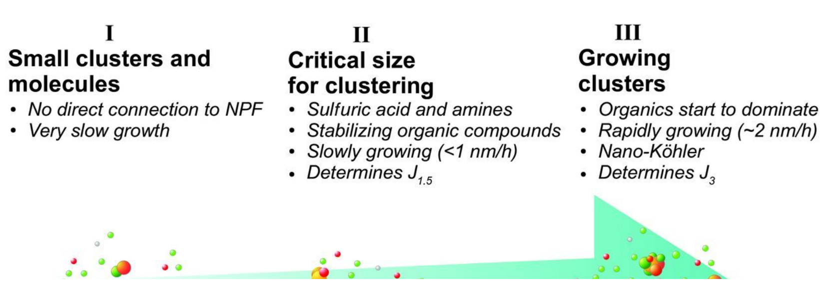


Image 3: *This image shows an Atmospheric Aerosols Nucleation Scale.*

Image 4: *This is a picture of my former teacher and I carrying out water quality measurements.*

Image 5: *This is an image of me taking the temperature of the pond water.*

Image 6: *This is an image of the pond that water quality measurements were taken in.*

Citations

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