Interdisciplinary Report

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Historical evidence shows that Lake Macatawa was once known as Black Lake, and it was fed by the Black River. The surrounding area was known to be very marshy, along with many trees along the banks. This study attempts to explain why these bodies of water have such a dark color by looking at the effects of suspended solids and organics, as well as those of the bottom sediments on the optical properties of the Black River. This investigative study on the Lake Macatawa Watershed concerning the reasons for the discoloration of the Black River have shown that the water is not as dark as it once was, but there are still various processes that can lead to this discoloration. A minimal presence of organics in the Black River lead us to believe the main cause of discoloration is the amount of sediment carried within the suspended load of the river. The minimal amounts of suspended organics were determined by water filtration systems. The lack of organics in the soil was obvious through loss of ignition testing. In order to determine the cause of discoloration in the Black River, bottom sediments were collected to perform turbidity testing. Through this testing, we have investigated the discoloration of the Black River as an implication of high turbidity and silty soils. The objective of this project was to explain how this discoloration occurs from amounts of sediments carried within the suspended load of water, and how much time it takes to get this sediment to settle down to the bottom of the river bed.

In order to determine if suspended organics were the source of the discoloration in the Black River, 3-3.5 gallons of river water were taken from each of the five sample sites (see Appendix 1). The technique of vacuum filtration was used to capture any organic particles that might have been suspended in the river water samples.

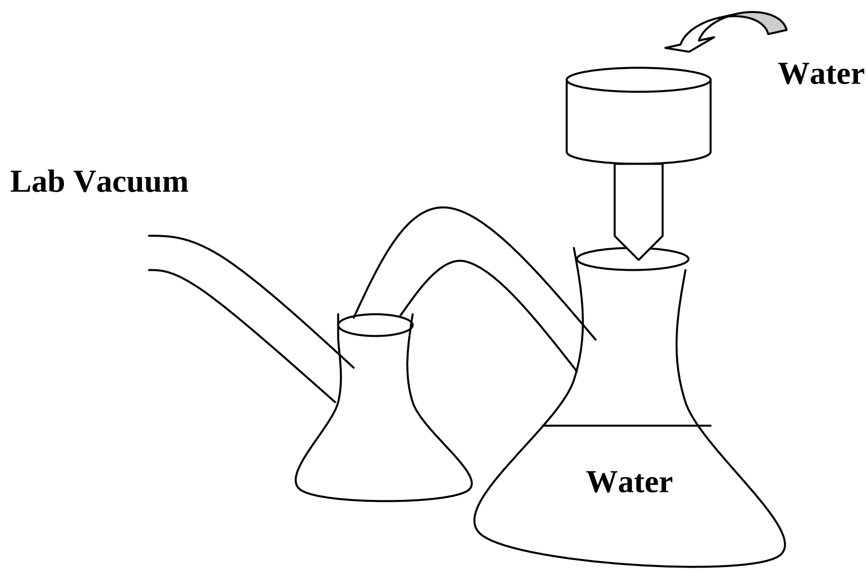

Figure 1: Vacuum filtration set-up

The water sample was run through a Whatman filter and suctioned into an Erlenmeyer flask. The suspended organics were trapped on the filter, which was then washed with methanol in order to remove the organics. This method did not work extremely well because the organics that were present were not large enough to remain on top of the filter. Instead, they were absorbed into the filter, and we were unable to remove the majority of the organics. However, it was seen that the amount of suspended organics was extremely small in the samples, and this showed that suspended organics were not directly associated with the discoloration of the Black River.

The UV-Vis spectrophotometer was used to look for any possible signatures of organic compounds dissolved into the river water samples. In order to do this, each sample was placed into standard cuvettes, and run against a blank of tap water. Each sample was scanned from 400-700nm, which showed a broad peak around 450nm. This corresponds to violet light which signified that there was a yellow discoloration in the samples, which was also visible to the naked eye. The broad peak at 450nm was a signature for this yellow discoloration because violet and yellow light are complimentary colors. However, these UV-Vis scans showed a very bland spectrum, which didn’t contain any noticeable organic compounds. This test further proved that suspended and dissolved organics do not play a significant role in the discoloration of the Black River. Because water analysis did not show anything conclusive, we decided to investigate the bottom sediments to determine if they were associated with the discoloration of the Black River.

Two liters of bottom sediments were taken from each of the five sites in the Black River. Loss of ignition testing was performed to analyze the total amount of organics in the bottom sediments. These samples were dried for 24 hours at 120°C to remove all of the water from the sample. They were then placed in a muffle oven at 500°C for four hours to burn off organics. The sediment samples were then weighed to determine the amount of organics present.

Sample	% Organics
Apple Avenue	2.2%
Mini Golf	1.6%
Railroad Tracks	0.5%
Zager Pools	0.4%
Window on the Waterfront	1.9%

Table 1: Loss of Ignition test results

These results show that there is not a large amount of organic material in the sediments, and thus does not seem to play a major role in the water discoloration.

Separation and weighing of different size fractions within sediment was done in order to determine the percentage of fine particulate matter and to classify the material. Each sample was sieved for approximately ten minutes using a sieve stack containing standard ASTM sieves 3.5,7, 20, 50, 70, 100, 170, 230, 325, and 400. All samples classify as a Sand according to the standard soil classification diagram (see Appendix 2).

Sample	% Sand	% Silt	% Clay
Apple Avenue	96.00%	3.00%	1.00%
Mini Golf	99.20%	0.50%	0.30%
Railroad Tracks	99.70%	0.10%	0.20%
Zager Pools	99.90%	0.05%	0.05%
WOTW	95.40%	2.40%	2.20%

Table 2: Sieving test results

Both the Apple Avenue and Window on the Waterfront sites contained more silt and clay sized particles that the other locations, which was verified by the results of the suspended solids test.

The suspended solids test was done by mixing 100 mL of sediment with tap water, and then shaking it up until the sediment and water were completely mixed. The sand sized particles were allowed to settle out, and the remaining water containing the silt and clay sized particles was suctioned off into an aluminum weigh boat. This was weighed, and then placed in the drying oven at 120°C for 24 hours to dry it. They were pulled out and weighed again to measure the total amount of suspended fine particulates.

Sample	weigh boat weight (g)	boat and sediment weight (g)	dried weight (g)	total suspended sediments (g)
Apple Ave	1.0731	12.9901	1.7496	0.6765
Mini Golf	1.0828	11.3422	1.2132	0.1304
Railroad Tracks	1.0763	11.8882	1.1263	0.05
Zager Pools	1.0875	12.7621	1.1254	0.0379
WOTW	1.0716	11.1359	1.2957	0.2241

Table 3: Suspended solids test results

This test showed that the Apple Avenue site, Mini Golf site, and Window on the Waterfront site contained the finest particulates. This verifies the results found by sieving the samples. These results suggest that any fine particulates that are being washed into Lake Macatawa are likely coming from the Apple Avenue and Mini Golf branches of the Black River, which combine downstream to account for the elevated amounts at Window on the Waterfront.

In order to look at what effect the bottom sediments have on the turbidity of the Black River, a test was needed to look at how much time it took for sediments to settle out of the water if they were disturbed. This was done through gravity separation. 90mL of sediment was combined with 160mL of river water in a graduated cylinder. This was shaken up and then allowed to settle out. To determine the total amount of time that it took for all of the sediment to settle, a pop can was placed behind the cylinders. When the can could be clearly seen through the water above the settled sediment, the total settling time was estimated.

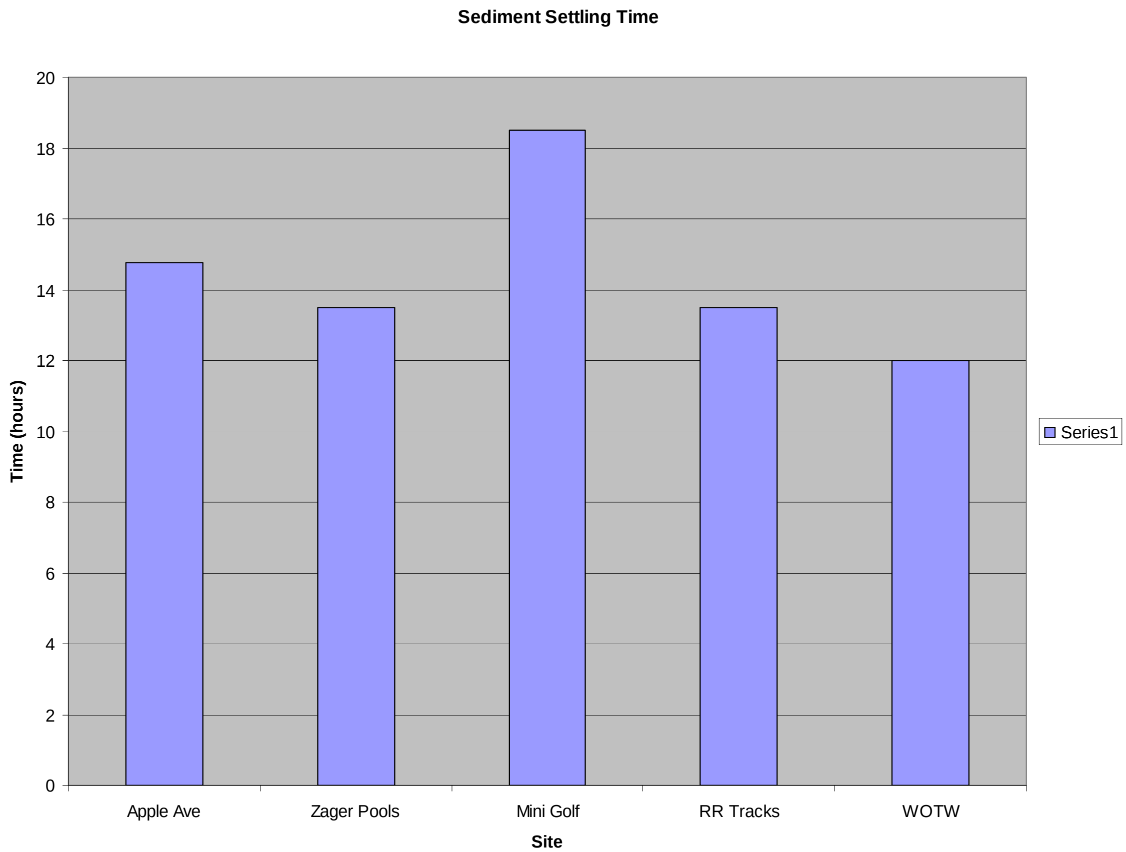

Figure 2: Gravity Separation Analysis

Our results showed that the Mini Golf site took the longest time to settle out at just over eighteen hours, while the shortest was the Window on the Waterfront site at right around twelve hours.

Since fine particulates take the longest amount of time to settle out of water, a test was needed to monitor this over time. This was done using a light transmission test with a spectrophotometer. To do this 90mL of sediment was shaken with 160mL of water, and the sand sized particles were allowed to settle out. Following this, the water containing the fine particulates was poured into a small vial. The light transmission test was run against a blank of tap water for 33 hours. This test works by passing a beam of light at various lengths through the vial to a receiver on the other side. The amount of light that passes through is recorded as the percentage of light transmitted.

The samples fell into two distinct groups after 33 hours: those with 30-35% total light transmission (Apple Avenue and Mini Golf), and those with a range between 60 and 80% total light transmission (Zager Pools, Railroad Tracks, and Window on the Waterfront). When this data was compared to the gravity separation results, it was seen that something was settling out after the fine particulates because the percent light transmission continued to increase long after our gravity separation results indicated that all of the sediment particles would have already settled out.

After performing light transmission and gravity separation tests on the sediment samples from the Black River, a distinct color change occurred in the water saturating the sediment. All of the sediment samples had turned the surrounding water a variety of shades of yellow. In order to determine the source of this yellow color, a sample of the discolored water was mixed with an acetone and methylene chloride solution. Because the water sample rose to the top of the solution, it was determined that the yellow discoloration was organic in nature. This organic component in the soil is quite possibly tannins released by decomposing plant material.

The results of our water sample analysis have shown that the discoloration of the Black River is not associated with suspended organic material. Both vacuum filtration and UV-Vis spectroscopy did not show any prevalence of organic material in the water from each of our five sites. These findings lead us to believe that the discoloration of the Black River results from suspended silt and clay sized fractions in the bottom sediments from when the river bottom is disturbed. This was determined through suspended solids testing as well as gravity separation and light transmission analysis. These showed that suspended bottom sediments and fine particulates take a significant amount of time to settle out which increases the turbidity of the Black River. The disturbance of these sediments also releases an organic compound (most likely tannins) present in the bottom sediments. This organic component colors the water distinctly yellow, which is the natural color of the Black River. Since the water overlays dark sediments, there is an optical illusion that the Black River is actually black in color. This optical illusion misleads beliefs that the Black River is black, but our findings have determined that the discoloration of the Black River is a result of suspended sediments in the water causing a turbid appearance, as well as an organic compound released from the sediments upon suspension into the water column.

References

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