Seasonal Change and its Effect on Select Water Quality Parameters in Michigan's Rouge River

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Abstract:

The **Rouge River** Watershed of Southeastern Michigan is located in a region where urbanization has led to fragmented ecosystems and decreased species biodiversity. Increased attention and research on water quality issues need to be prioritized if we want to continue to restore, preserve, and protect the river and the wide variety of species living there. This research investigated the potential effects of seasonal change (summer to fall) on select **hydrosphere** and **atmosphere** parameters. Three sites were sampled along a segment of the Middle Branch of the Rouge River that flows through North Dearborn Heights. The sites selected for sampling included one behind an elementary school, another located near a parking lot and athletic center, and the other near a banquet center. The segment of the river we sampled passes through areas that have multiple uses. The water quality parameters we collected data on included dissolved oxygen, conductivity, pH, turbidity, salinity, total solids, precipitation, and water temperature. We also measured air temperature each time we sampled. Vernier sensors were used to analyze conductivity, dissolved oxygen, salinity, temperature, and pH. A Hach 2100 N Turbidimeter was used to measure turbidity, and total solids were measured using protocols from our local Rouge Education Program. As expected, water temperatures decreased from summer to fall. This caused dissolved oxygen levels to increase. However, precipitation events had no significant effect on dissolved oxygen levels. Salinity, total solids, conductivity, and pH levels were all unaffected by cooling temperatures in the fall. As river levels increased, turbidity levels rose as well. For future research, we would like to expand and extend our research to include additional water quality parameters and collect data during different seasons. To extend the scope of this research, we hope that future researchers will compare water quality in different branches of the Rouge River.

Key Words: Rouge River, hydrosphere, atmosphere

Research Questions:

1. To what extent does the seasonal change from summer to fall and accompanying precipitation affect salinity, total solids, conductivity, pH, turbidity, and dissolved oxygen levels of the Middle Branch of the Rouge River?
2. Do significant precipitation events affect salinity, total solids, conductivity, pH, and turbidity levels in the Middle Branch of the Rouge River?

Null Hypotheses:

1. The seasonal change from summer to fall and accompanying precipitation will not affect salinity, total solids, conductivity, pH, turbidity, and dissolved oxygen levels of the Middle Branch of the Rouge River.
2. Significant precipitation events do not affect salinity, total solids, conductivity, pH, and turbidity levels in the Middle Branch of the Rouge River.

Introduction and Review of Literature:

The Middle Rouge River flows into Main Branch of the Rouge River that empties into the Detroit River and ultimately flows into Lake Erie (see Figure 1). The river flows through a very urbanized region of Southeastern Michigan that became very industrialized throughout the early 20th Century due to both the rise of automobile industry and the production of equipment to support the U.S. effort during World War II. This region became known as the "Arsenal of Democracy" as factories pumped out tanks, airplanes, bombs, and more but this was all done with little concern for water quality. (Blaime 2014).

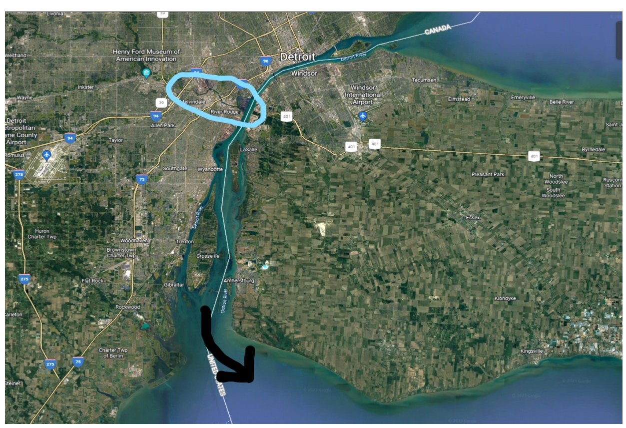


Figure 1. Satellite footage of Rouge River emptying into the Detroit River (blue) and the Detroit River flowing into Lake Erie (black). Google Earth 7.3, (2023) Detroit River 42°16'18"N, 83°06'29"W, elevation 166 M.

The Rouge floodplain however, has been preserved as a park and somewhat natural area since frequent flooding makes most types of development ill advised. This floodplain has created a wildlife corridor that has allowed even beaver to return to areas where they haven't been for several hundred years (see Figure 2). The river is sandwiched in the middle of extensively human modified landscape (Hartig 2022).

Figures 2 and 3. Photo evidence of the return of the North American beaver (*Castor canadensis*) to the river right behind one of our school district's elementary schools. The photos above demonstrate the importance of indicator and keystone species like the beaver that require safe water to thrive.

Although our high school science department has been making bi-annual water quality measurements on the river, no longitudinal monitoring has been made with the intent of analyzing the potential effects of seasonal change and precipitation in this branch of the river. Our school is part of the Rouge Education Project that monitors in October and May along with several other local schools. Our research was developed to see how various weather conditions and precipitation events contribute to potential changes in river water quality throughout several seasons.

This GLOBE research seeks to create a database for future investigators to compare throughout subsequent years as climate changes going forward. Rouge River water quality not only contributes to the local health of our watershed, it also impacts regional Great Lakes water quality as well. Water temperature, for example, plays "an important role in the overall health of aquatic ecosystems, including water quality issues and the distribution of aquatic species within the river environment" (Markarian 1980). Roads, industry, and buildings can all play a significant role in decreasing river water quality. When the Rouge River receives large amounts of stormwater runoff due to the watershed's extensive impermeable surfaces, it can impact numerous water quality parameters. Analyzing the impacts of runoff on water quality over a long period of time will hopefully lead to changes in how our local population perceives the river and how they can help to remediate its many problems. The Rouge River flows through our area's backyards, parks, and roadsides, making it a visible reminder of why we need to treat it more responsibly. Increasing water quality might mean it will make local individuals more likely to recreate there – bringing back canoeing, fishing, and hiking. The current state of the Middle Branch of the

Rouge River often makes it unpleasant to be around. With continued documentation and research, hopefully plans can be enacted to bring the river back to much of what it used to be like.

Research Methods:

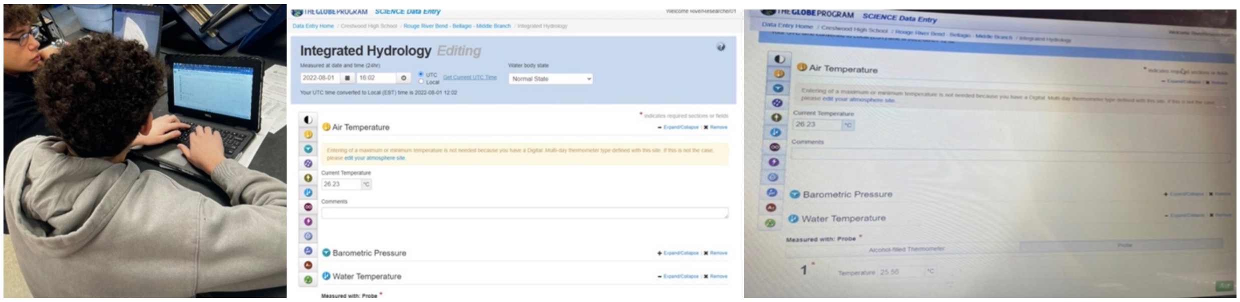
To investigate seasonal change, our research was planned to take place from early August through late November. This period of time was selected so our data would be taken during some of the warmest months through autumnal decreases in temperature. Three research sites were selected along a roughly one-mile strip of the Middle Branch Rouge River off of a road that runs parallel to the river through the floodplain. All sites were located so that safe access and collection of samples could easily be taken. The microclimate characteristics of these sites were all similar, due to their close proximity to each other in the riparian zone of the river. The sites were all also within ten meters of a road or parking lot.

Each site's location was precisely determined using GPS coordinates. Two of the sites had not been previously defined as GLOBE sites. Before moving forward, these sites had to be carefully defined. Our team sampled a total of 18 times between August and November, roughly two times a week. Each site was sampled at roughly the same time of day near Solar Noon. Once the water samples were collected, we followed GLOBE protocols and immediately measured dissolved oxygen, pH, conductivity, and salinity using the Vernier Lab Quest 2 and Vernier GoDirect probes. Instruments were calibrated prior to taking the measurements. The air temperature and water temperature of the river were determined using an approved Vernier temperature probe. For each site, after collecting about one liter of water samples from the middle of the river, the dissolved oxygen in milligrams per liter (mg/L) and percent saturation, and water temperature in degrees Celsius (°C) was immediately tested using the Vernier LabQuest 2. pH, conductivity in microsiemens per centimeter (μS/cm), and salinity in parts per trillion (ppt) were also determined at the site using approved Vernier GoDirect instruments. Since the samples might have settled in the time between collection and measurement, samples were shook before measurement to ensure greater accuracy in results. Three representative measures of each individual parameter were obtained and averaged in order to achieve a more representative result of each parameter.



Figure 4 (Left), Figure 5 (Middle), and Figure 6 (Right). Visualization of 3 sites. Figures 4, 5 and 6 show the sites where the water was sampled. Figure 4 (Left) shows the Parr Wayside site (42.347119°, -83.276754°), Figure 5 (Right) shows the Hype at Hines site (42.344241°, -83.268515°), and Figure 6 shows the Bellagio Bend site (42.342994°, -83.27145°). Proximity to roads and densely vegetated banks can be seen at all three sites.

To determine turbidity and total solids, water samples were collected and taken to our high school for analysis. Instead of a turbidity tube we used the HACH 2100N Turbidimeter. This instrument is the same one commonly used at sewage treatment plants. Clear test vials were carefully filled with samples of river water from each site. The samples were then placed into the turbidimeter measure each sample in Nephelometric Turbidity Units (NTU). To measure total solids, empty 50-mL beakers were weighed, then carefully filled with 40-mL of agitated river water. After weighing, they were placed in an oven to evaporate the water over a 24-hour period, then massed again after all water had evaporated and the beakers had cooled from the oven. To obtain results in milligrams per liter (mg/L), some calculation was required. We subtracted the difference in beaker weight, divided that number by forty (40), and multiplied that result by one million (1,000,000) to obtain the total solids. After the total solids and turbidity results were obtained and averaged, the data was compiled and entered in a spreadsheet then uploaded directly into the GLOBE website database. The data was then analyzed and interpreted for trends and/or patterns.



Figures 7 and 8. GLOBE data entry. All data that was obtained using GLOBE protocols was entered into the GLOBE database. The data that was submitted was on air and water temperature, conductivity, dissolved oxygen, salinity, and pH.

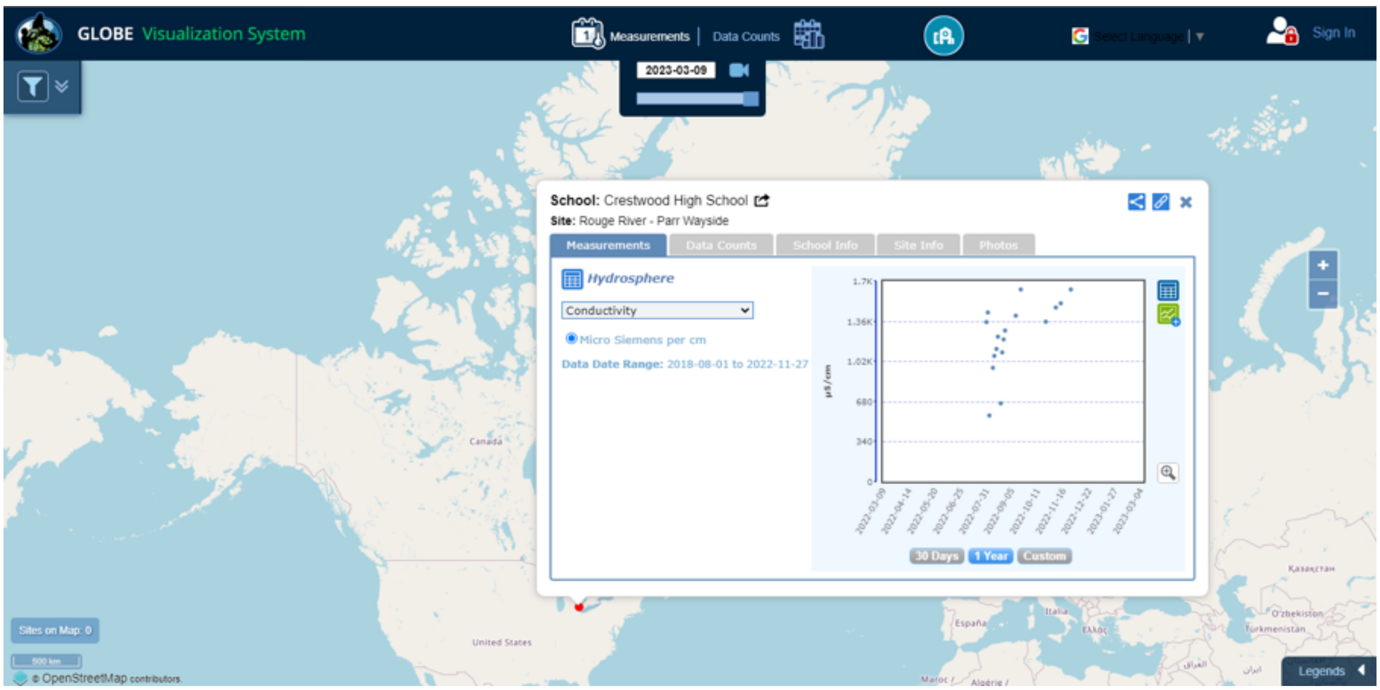
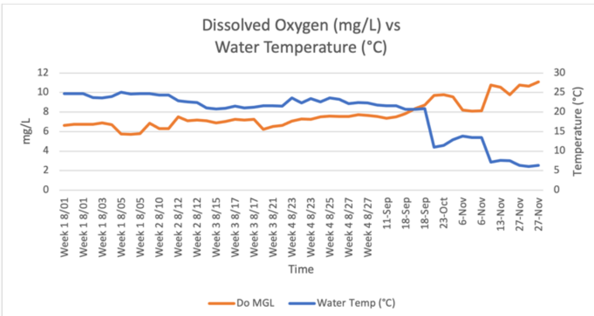
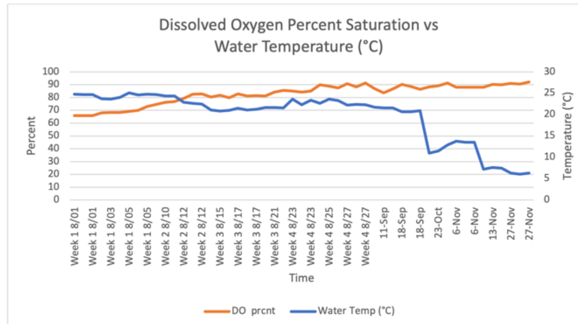


Figure 9. GLOBE visualization evidence. Conductivity values are shown in this visualization (from GLOBE website).

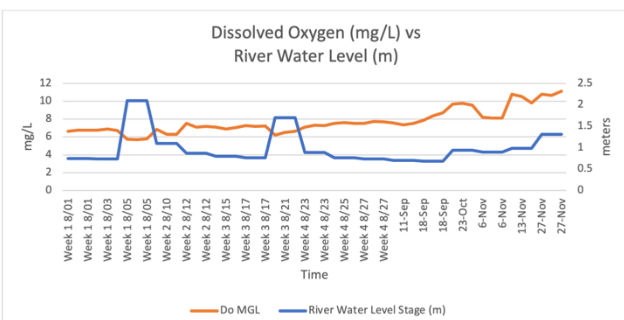
Results:

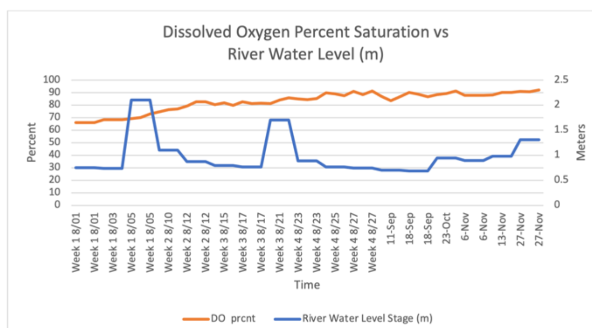
Each of the water quality parameters that we measured were graphed in order to visualize trends over the time period that data was collected. In our findings, negligible differences were observed between each site, so values for each parameter were averaged to see larger trends over the mile of the river where data was obtained from.



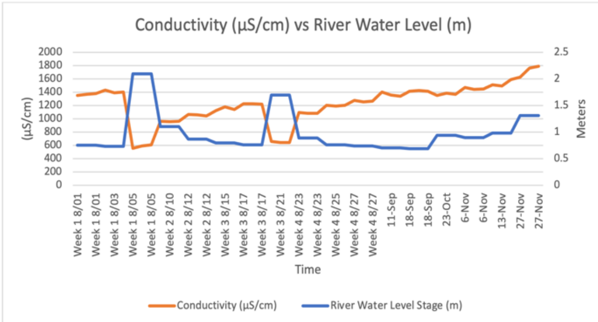


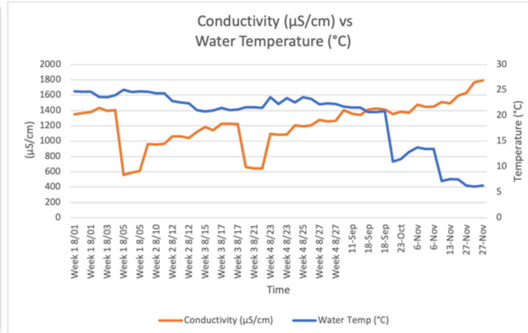
Figures 9 and 10. Dissolved oxygen vs water temperature. Both left and right graphs display dissolved oxygen versus water temperature in degrees Celsius. The left graph displays dissolved oxygen in mg/L, and the right graph displays dissolved oxygen in % saturation (orange lines). In both graphs, dissolved oxygen and water temperature displayed clear inverse correlation. Typically, as water temperature decreased, dissolved oxygen levels increased.



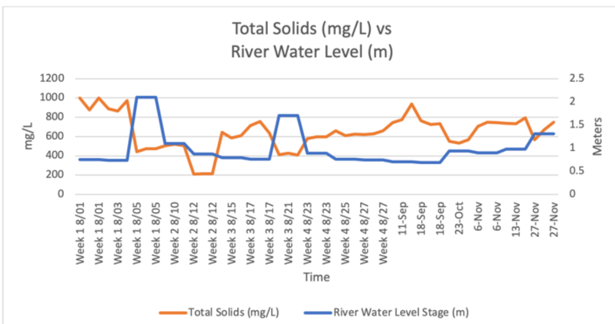


Figures 11 and 12. Dissolved oxygen vs river water level. Both left and right graphs display dissolved oxygen versus river water level in meters. The left graph displays dissolved oxygen in milligrams per liter (mg/L), and the right graph displays dissolved oxygen in % saturation (orange lines). Dissolved oxygen in mg/L and % saturation averaged through all sites were shown to have no significant correlation to the river water level. As the river water level increased sharply (blue spikes), the dissolved oxygen levels (orange) did not react significantly.





Figures 13 and 14. Conductivity vs river water level and water temperature. The left graph displays conductivity in microsiemens per centimeter (orange line) versus river water level in meters, while the right graph displays conductivity versus water temperature in degrees Celsius. The left graph displays an inverse correlation in the event of a sudden rise in river water level, but otherwise direct correlation. However, conductivity shows no significant correlation to temperature (right). As the temperature dropped, no significant change in conductivity was observed.



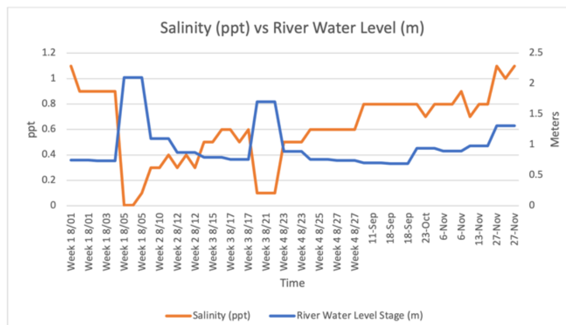
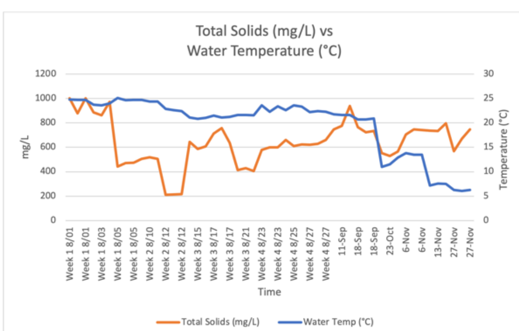
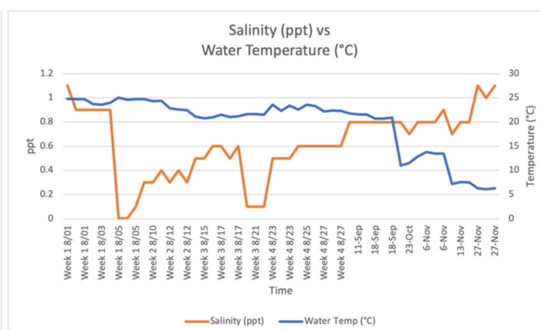
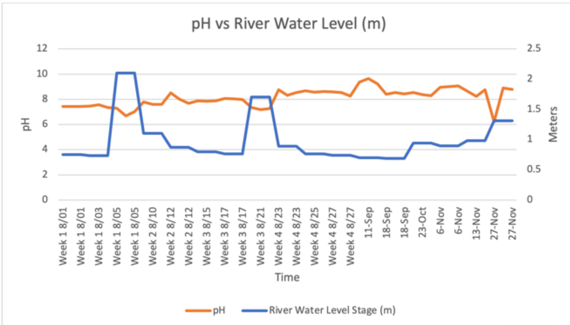


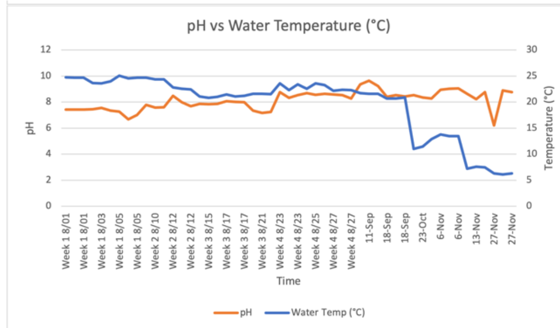
Figure 15. Salinity and Total Solids vs River Level. The left graph displays salinity in parts per trillion and the right graph displays total solids in grams per liter (orange lines). Both of these parameters show the same correlation to the River Water Level (blue lines) as conductivity. In the event of a sudden rise in River Water Level (blue spike), there is inverse correlation, but otherwise, the correlation is direct. As water levels increased steadily, total solids and salinity increased as well.



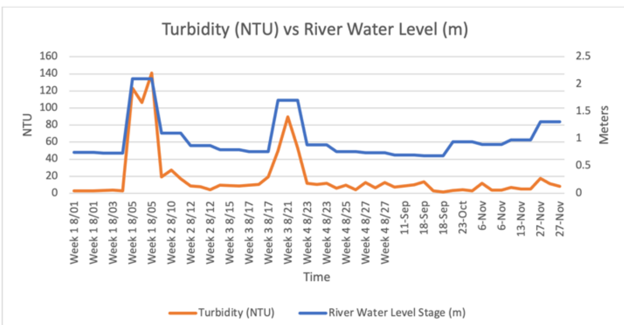


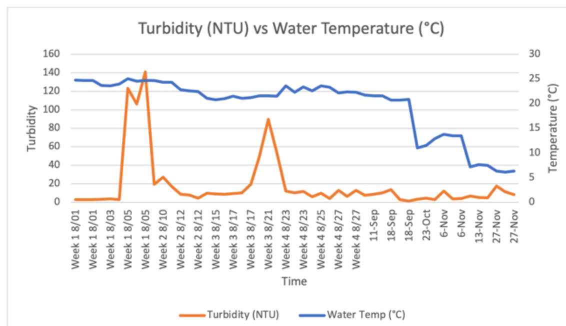
Figures 16 and 17. Salinity and Total Solids vs Water Temperature. The left graph displays total solids in milligrams per liter (mg/L), while the right graph displays salinity in parts per trillion (ppt) Unlike their correlation to the water level, Salinity in parts per trillion (ppt) (orange line) and total solids in milligrams per liter (mg/L) show no significant correlation to the temperature. As the temperature dropped, no significant change in total solids or salinity were observed.





Figures 18 and 19. pH vs River Water Level and Water Temperature. The left graph compares pH to river water level in meters, and the right graph compares pH to water temperature in degrees Celsius. The left graph displays that the correlation of pH and river water level was the same correlation as total solids, conductivity, and salinity. In the event of a sudden rise in river water level (left) (blue spike), correlation was inverse. Otherwise, the correlation was direct. However, there was no significant correlation shown between pH and Water Temperature (right). As temperatures decreased, no significant change in pH was observed.





Figures 20 and 21. Turbidity vs River Water Level and Water Temperature. The left graph compares turbidity in NTU to river water level in meters, while the right graph compares turbidity to water temperature in degrees Celsius. The left graph displayed that turbidity measurements (orange line) displayed a direct correlation to the River Water Level. Typically, as the River Water Level increased (blue line), so did the turbidity. However, there was no significant correlation shown between Turbidity and Water Temperature (right). As temperatures dropped, no significant change was observed in Turbidity.

River levels were fairly low the entire research period. There were only two distinct precipitation events with some runoff during the collection period. These results most likely would have been distinctly different had there been no drought.

Discussion:

As the seasonal climate shifted from warmer summer conditions to cooler fall conditions, the changes in temperature and accompanying precipitation affected salinity, total solids, conductivity, pH, turbidity, and dissolved oxygen levels of the Middle Branch of the Rouge River. We found that dissolved oxygen levels decreased, typically, as temperatures decreased in the Middle Branch of the Rouge River in Dearborn Heights, Michigan. We found an inverse correlation between dissolved oxygen and water temperature. However, when we analyzed the dissolved oxygen levels in relation to the river's water level, no correlation was found. In general, we concluded that temperature was the only factor measured that affected dissolved oxygen levels, with precipitation yielding no change. In contrast, all other parameters measured showed no correlation to temperature, but rather correlation to the factor of river water level. The other parameters measured (Salinity, total solids, conductivity, pH, and turbidity) all showed a significant correlation to the change in water level (precipitation). Salinity, total solids, conductivity, and pH were found to all have the same correlation to the water level. The correlation found was contingent upon the intensity of the precipitation. The parameters show an inverse correlation in the event of a sudden rise in river water level, which was unexpected, but we believe that this may have been due to the large riparian zones surrounding the river, increasing surface absorption. Otherwise, these parameters displayed a direct correlation. We concluded that in the event of significant rain (defined as $\geq$1 meter of river water level increase over $\leq$1 day(s)), salinity, pH, total solids, and conductivity all decrease, but in the event of a steady gain of river level (defined as $\leq$1 meter of river water level increase over $\geq$3 weeks), these parameters increase. We also found that turbidity directly correlates to water level, regardless of precipitation intensity.

The data analysis provided clear results. We rejected each of the null hypotheses. There is clear evidence, from our research methods, that the seasonal change from summer to fall and accompanying precipitation significantly affected salinity, total solids, conductivity, pH, turbidity, and dissolved oxygen levels of the Middle Branch of the Rouge River. We found that significant precipitation events, in fact, did affect salinity, total solids, conductivity, pH, and turbidity levels, and that the seasonal drop in temperature from summer to fall affected dissolved oxygen levels in the Middle Branch of the Rouge River. Due to these consistent correlations, we rejected each of the null hypotheses.

A possible source of error in our data is human error. In the beginning weeks of our research, our team, having limited experience with the apparatus, contributed to some human error. In some of our first weeks of data collection, in the event of a sensor being incorrectly calibrated or giving extreme readings, we did not know how to calibrate and reset instantaneously in the field. This led to the group taking samples at a later time in the laboratory. Although not much longer later (the samples being measured ≤1 hour after measurement at most), this caused samples to be less representative of actual river conditions, possibly altering readings for parameters measured immediately after collection (Salinity, pH, dissolved oxygen, and conductivity). In comparison to other hydrologic IVSS GLOBE research on the Rouge conducted by former students of Crestwood High school, their results were somewhat different. This may have been due to unorthodox weather conditions significantly impacting the data collected. In the time period of our water sampling, there were uncharacteristically low levels of precipitation, as Michigan had its twenty-second driest summer on record, according to the NOAA. This could have altered the river water, giving unusually high or low readings for some parameters. The differences between data collected in previous years with ours provides a substantial reason why continued monitoring is warranted over a longer time period.

Conclusion:

It had been originally planned and intended that we collect and test water samples to analyze the parameter change in the event of major precipitation. However, in the time period that we researched, there were only 2 significant rain events. The 2022 summer period was significantly dry, and to create a full analysis based on two events would not be very representative of the data. We also realized that we could extend our research to cover a broader topic. As a result, we decided to base our research upon seasonal change, analyzing changes in precipitation as well as temperature, as the research period took place in the months of the transition from summer to fall (August to November).

After completing our research, we came to the conclusion that select parameter levels consistently significantly change as seasons change. The continuance of periodically monitoring parameters of the river, especially in the event of environmental stressors, such as rain and seasonal change, is essential in monitoring the health of the river, in order to protect the river and detect issues before they may develop into further issues. Algal bloom, eutrophication, and other issues can affect the river, and surrounding areas, therefore monitoring the river may help us protect and preserve biodiversity.

A potential improvement in research methods that could have been utilized would be the addition of both a greater variety of sites and faster lab equipment. The Rouge River is separated into multiple branches, each surrounded by unique surroundings. The upper and middle have greater riparian zones, but the lower branch runs through a more industrial area, with the riparian zone demolished for channelization. If future researchers were to measure the parameter variations through different branches, or compare the parameter measurements to those of neighboring bodies of water, such as the Ecorse Creek, greater variation could be considered and implemented. With faster lab equipment, the research process would be more efficient and take less time. This would allow more time for researchers to more accurately analyze the data and showcase it in a more professional manner. Working with a mentor was of utmost benefit to our group. Our mentor and former A.P. Environmental Science Teacher, Mrs. Diana Johns, provided us with our apparatus, and the knowledge required to conduct this research. She introduced us to the GLOBE program, and greatly assisted us in the scoping out of our sites, helped us with instrument ailments, and continued to motivate us throughout the research period and after.

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Thank you to Mr. David Bydlowski of the GLOBE AREN Project and Dr. Kevin Czajkowski of the University of Toledo Mission Earth for providing Vernier probes and LabQuests for our use. Thank you also to Friends of the Rouge for the protocols we used that were in addition to the GLOBE hydrosphere protocols. Thanks also to Mrs. Johns for her advice and support.

BADGES:

I am a Data Scientist: Over a 4-month period, we tested 3 river sites and collected data of parameters and how they are affected by environmental factors associated with seasonal change. Apart from data collected by our group, we utilized precipitation and water level data from the NOAA. We then analyzed the data gathered with tools, utilizing Excel Spreadsheets, and making graphs to examine relationships among parameters. We found numerous patterns between the factors of temperature and precipitation, and the parameters of salinity, dissolved oxygen, conductivity, pH, total solids, and turbidity. The data collected and analyzed from our own collection and other sources allowed us to effectively draw conclusions and answer our research questions.

I make an Impact: The Rouge River is an important indicator of environmental health, and is a vital source of habitat for many organisms. The current state of it, however, often makes it unpleasant to be around. Along with an increased database, we hope that our analysis of the water parameters will hopefully lead to changes in how the local population may perceive and treat the river. The Rouge River flows through our area's backyards, parks, and roadsides, making it a visible reminder of why we need to treat it more responsibly. Increasing water quality may increase recreation and biodiversity, to so with our findings, we recommend and urge all residents and passers-by to treat the river with respect and consideration to the environment. After all, Rouge River impacts are not limited to the river itself, but the riparian zone around it, its inhabiting species, and the greater waterways it empties into.

I am a STEM Storyteller: Rami Eter, a GLOBE researcher on our team, founded a grassroots local environmental organization, "The Green Project", earlier in 2022. In the time since, Rami created an Instagram account in order to best share local and global environmental news, information, and other content to the community. In order to creatively share what was learned by the group, Rami and the other group members decided to share a post with the community, through an Instagram post on the account. This post highlighted the story of our research, and what was learned, in a creative, well-designed way. The post can be viewed on Instagram on the account @thegreenproject_dh.