A Preliminary Analysis Between Select Water Quality Parameters in Two Urban Rivers in Southeastern Michigan

Zeinab Awada and Haneen Fouani – *Crestwood High School- Dearborn Heights, Michigan*

Abstract

Evaluating the water quality of a stream is essential for determining potential sources of impairment. The Rouge and Ecorse Rivers are two urban streams significantly impacted by the land cover they flow through in Dearborn Heights, a suburban community in Southeastern Michigan. This research sought to discover if any significant correlations exist between conductivity, salinity, and TDS (total dissolved solids). Measurements were taken during a relatively short periods of testing extending from mid to late March. During the testing period, atmospheric weather conditions remained relatively consistent with the expectation of one day of light rain. Vernier conductivity, turbidity, and salinity probes were used to monitor water at each of the two sampling sites. A water sample from each site was taken back to the school lab to determine total solids as this measurement requires both an analytical balance (measuring to the nearest milligram) and a drying oven. Analysis of our data indicates that a strong correlation exists between conductivity, salinity, turbidity, and total solids. The relationship between these variables could potentially make it easier and more efficient to test water quality parameters by using the one to find the other two. This means less time and money to obtain the same data. We recommend that future researchers find additional solutions to the inefficient ways of testing the many water quality parameters.

Background

The management of water quality in Southeastern Michigan is a very important topic. With so many impervious surfaces, there are very few places water can infiltrate into the ground. A great deal of the precipitation we receive (especially from thunderstorms and cold fronts) and quickly melting snow winds up going directly into our rivers as runoff. Because of this, even a little bit of rain can lead to extensive flooding that more often than not damages homes and businesses, closes roads, and even leads to episodes where raw sewage is emptied into rivers because all of the retention basins are filled. The Middle Branch of the Rouge River is especially prone to flooding and the Edward Hines road that parallels the river (and provides a key transportation route to our area) is often closed for many days per year. The Ecorse River (which is really a small stream as it runs through South Dearborn Heights) is especially prone to flooding and what used to be 100-year floods are happening almost yearly. This is a topic that obviously needs to be studied and solutions found. In this research, we tested salinity, water temperature, total solids, turbidity, and conductivity to determine how they might correlate with each other. These parameters, along with others that weren't measured at this time, help to clarify how each river behaves during a storm event. Total solids helps us understand how much dissolved solids, such as inorganic or organic compounds are found inside a body of water. Turbidity is is a measure of water's clarity. Because of the clay that makes up the river beds of both the Ecorse and Rouge River, even just a little increase in the river's volume and velocity typically leads to an increase in turbidity. Salinity is the amount of dissolved salt particles that can contribute to harming plants, animals, and even us humans if found in high enough levels. Salinity is closely related to conductivity, which is a measure of how an electrical current can pass through water. Because inorganic compounds and salt conduct electricity, this parameter has a close relationship with salinity. Salinity has been gradually increasing in the Great Lakes for a variety of reasons but one often cited is the abundant halite (rock salt) we add to our roads each winter as a de-icer. We tested for each of these parameters to determine which of these tests would be essential to monitor on a tight budget and time schedule. .

Research Questions

- In what ways do total solids, salinity, and conductivity correlate?
- How does rainfall effect the amount of total solids?
- If we had limited testing, how could we find the other measurements?
- Can conductivity results be used as a way to inferring total solids and salinity?
- How do water temperature, salinity, and conductivity correlate?

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Null Hypothesis

- There is no way to determine salinity or total dissolved solids using conductivity measurements.
- Rainfall does not effect the amount of total dissolved solids.
- There is no way to find any other measurements with limited testing.
- Conductivity, salinity, and water temperature do not correlate.

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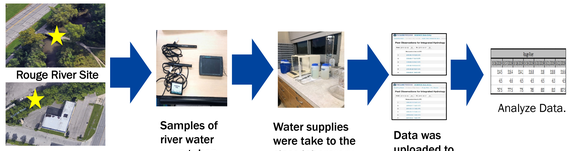
Methods



Measurement Limitations

There were some testing conditions that were beyond our control during this investigation. For example, because we were testing two different rivers, there was a time lag between when each was tested. In addition, although we tried to be consistent with what times we monitored each day, these times varied because of school and family observations. Another limitation was that the test period was only 7 days (1 week). In the future it would be good to have longer test period within each of the four seasons we have in Dearborn Heights, Michigan. We were somewhat inexperienced with the sampling equipment we used and it also took longer to get water samples some days because of the weather. In addition, the GLOBE website does not currently accept data entry from Vernier or Pasco data acquisition devices even though they have been approved by the GLOBE Program for this purpose. To overcome this issue we entered some of the data we recorded under comments in the appropriate spot under general hydrology data entry.

Results

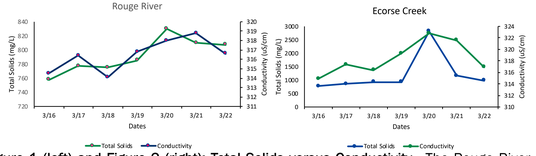


Figure 1 (left) and Figure 2 (right): Total Solids versus Conductivity. The Rouge River had a random relationship between total solids and conductivity. The first two points were directly linear; but as the days went on, as conductivity decreased, total solids increased. The Ecorse River had a totally different relationship. Total solids had a limited variation. That being said, the only day that total solids increased was on the day where it rained approximately 4 mm. This may be because the Ecorse River has a smaller width than the Rouge and has more impermeable surfaces.

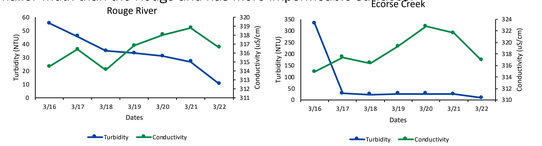


Figure 5 (left) and Figure 6 (right): Turbidity versus Conductivity. In the Rouge, conductivity and turbidity are perpendicular to each other, meaning that in the beginning, when turbidity levels were high, conductivity levels were low. As the days gradually went on, the data shifted, making the conductivity levels high but the turbidity levels low. But in the Ecorse, the difference is a little greater. Turbidity stayed almost constant with only the first day very high; while conductivity had a variation. Correlations between conductivity and total solids always linear. The ratio that they create does not only contribute to salinity, isn't but also material counts.

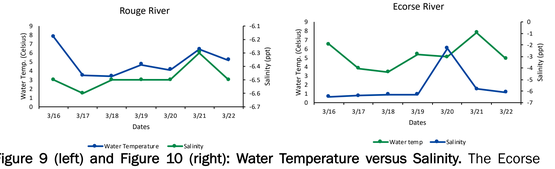


Figure 9 (left) and Figure 10 (right): Water Temperature versus Salinity. The Ecorse River had significantly lower amounts of salinity than the Rouge River even though water temperatures at both sites were very similar. Water temperature and salinity have an inverse relationship, meaning that the higher the temperature the lower the salinity in both river systems.

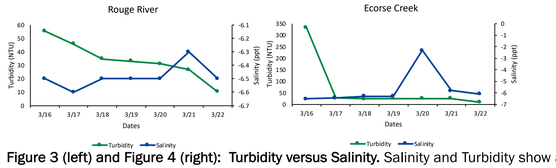


Figure 3 (left) and Figure 4 (right): Turbidity versus Salinity. Salinity and Turbidity show a similar pattern in the Rouge River but the Ecorse River shows a much large difference between them. This may be due to the different land types surrounding them. The Ecorse Creek has such a smaller width and is also surrounded by numerous amounts of impermeable surfaces with no or little permeable surfaces. The Rouge River, however, had relatively permeable surfaces surrounding it most places. This contributes to the point that amounts of all measurements will be different.

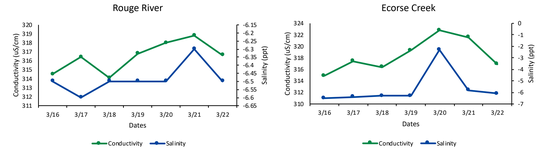


Figure 7 (left) and Figure 8 (right): Conductivity versus Salinity. In the Rouge, both parameters increased after the 20th when it rained (we had 4 mm of rain); but in the Ecorse, it increased the day of. This could be due to the fact that both rivers were unable to be measured simultaneously. Everyday, we went to the Rouge River around 18:30 (6:30 pm). After that, we would then go to the Ecorse River Creek which was about 10-15 minutes away from the first site.

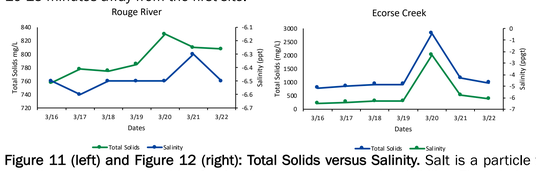


Figure 11 (left) and Figure 12 (right): Total Solids versus Salinity. Salt is a particle that contributes to the total solids of a river because it reduces the visibility. The relationship shown above says that in the Ecorse river, it's a direct relationship while in the Rouge, it varies

Conclusion

- During our one week study period, rainfall appears to increase the amount of total solids measured in a water sample. This is most likely due to the increased addition of both sediments and dissolved minerals as runoff enters the stream and the velocity of the river increases due to an increased volume of water. Increased groundwater entering the stream during these times also adds dissolved minerals.
- The testing period of this research was too limited to make any definitive conclusions. In order to truly understand how each of the tested parameters affect each of these rivers, a longer longitudinal study must be conducted.
- Conductivity, water temperature, and salinity all closely correlate with one another. Our monitoring indicates that with increasing water temperature, conductivity increases as well due perhaps to the increased fluidity of water at higher temperatures. Salinity is also changed because the temperature determines how easily dissolved the salt ions are. The salt ions, which are more soluble in warm water, also contribute to conductivity because they break down into cations and anions.
- Turbidity has a relationship with both salinity and conductivity. Salinity contributes to turbidity because the salt particles in the water reduce visibility.
- Although other researchers have developed an equation that allows one to way to derive salinity and total dissolved solids using conductivity measurements, we found our data lacking sufficient data points to work with this mathematical relationship. For the present, until a larger sampling effort is mounted at both rivers, we suggest that water quality monitoring efforts continue to report the parameters.
- One of the goals of this research was to find a close enough correlation between total solids, conductivity, and salinity so that only one parameter could be measured and the others inferred mathematically. We also suggest that additional replicate testing be done for each parameter in case some of the data is an outlier.

Research Implications

Improving water quality research and making monitoring more efficient and meaningful is an ongoing concern for both professional and citizen scientists. Streamlining what parameters need to be tested can make monitoring both more time efficient and targeted to the concerns of each river system. If some water quality parameters differ very little or have less overall significance to the quality of a stream then instead of testing for everything, only the most important tests would be completed. This could potentially save a lot of money and personnel resources and also encourage citizen scientists to participate if they have limited time. This research was only conducted during one week as winter transitioned into spring in Southeastern Michigan. Increased longitudinal water quality testing would necessary to implement before real recommendations could be made. With increased testing over longer time periods, it is hoped that student derived algorithms and mathematical relationships could be developed that would allow for the prediction of what happens when one parameter increases or decreases and what effect that has on water quality tests. One of the most pressing concerns for both the Ecorse and Rouge River is flooding. Evidence of how this impacts water quality will be essential in helping to motivate both city officials, residents, and other stakeholders take action to solve this pressing issue.

Work Cited

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