Comparing the Effects of Precipitation and Select Water Quality Parameters in Two Different Suburban Watersheds

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Abstract

Evaluating the water quality of a stream is essential for determining potential sources of impairment and the effects of flooding. The Rouge River and the Ecorse Creek are two suburban rivers located in North and South Dearborn Heights. This research sought to investigate the correlation between rainfall type and amount and select water parameters. The water parameters measured included dissolved oxygen, turbidity, conductivity, water temperature, and salinity. Measurements were taken throughout a period of 4 months, extending from the beginning of July 2019 to the end of October 2019. During the investigation period, rainfall amounts often varied with heavy precipitation from thunderstorms and steady rain falling from warm front rain as well as dry periods. At each river, Vernier probes were used to determine conductivity, dissolved oxygen, water temperature, and salinity. However, a water sample from both rivers was taken home to measure turbidity using a Vernier turbidity probe. With much of the turbidity, conductivity, and water temperature measurements, there was a direct correlation between precipitation and the levels of those parameters in the water. However, DO had an inverse relationship with rainfall while salinity had a more variable relationship.

Background

Water quality and urban flooding are important and pressing concerns for Southeastern Michigan and the world as well. Urban and suburban areas in Michigan are experiencing more extreme amounts and periods of rain than at any time in past 100 years. Occasional flooding that might have occurred at the 50, 100, or 500-year extreme is now occurring several times a year or every other year. An increase in storms with record precipitation along with more impervious surfaces has led to extreme surface runoff into local rivers. The Middle Branch of the Rouge River is very prone to flooding because the highly developed region surrounding it has few places for water to soak in. Its adjacent roadway is often closed because of flooding for extended periods of time. The Ecorse Creek, a small stream that runs through the south part of Dearborn Heights has seen an increase in yearly floods that are deep enough to swallow cars and good portions of houses. The Middle Branch of the Rouge River and the Ecorse Creek both have hydrographic stations that measure river levels. Little research within these watersheds has specifically looked at the effect of river levels on associated water quality parameters. The flooding issue clearly needs continued research to determine the best course of action to solve a problem that affects hundreds to thousands of individuals and families in our area. This research hopes to fill a missing gap in the public record for how specific rainfall events affect concerns of water quality. Over a 5-month period - we tested salinity, conductivity, dissolved oxygen, turbidity, and temperature as well as the amount of precipitation at each site to determine how the parameters affect each other. We also looked at river water levels in both rivers to see how the water quality parameters fluctuate with the rising and falling levels of the height of the river. Using the data from testing, we hoped to find how each river behaves as a result of a storm or other rainfall event.

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Research Questions

- To what extent can salinity, conductivity, and turbidity measurements be correlated with precipitation totals, stream discharge, and stream velocity?
- How does the type rainfall an area experiences affect the turbidity and conductivity?
- How do water levels of a stream affect turbidity and dissolved oxygen after a rainfall event?

Figure 1. Haneen Fouani and Zeinab Awada testing on Rouge River Site.

Null Hypothesis

- Null Hypothesis 1: Salinity, conductivity, and turbidity measurements cannot be correlated with precipitation totals, stream discharge, and stream velocity.
- Null Hypothesis 2: The type of rainfall in an area does not affect the amount of turbidity or the conductivity.
- Null Hypothesis 3: Water levels of a stream do not affect turbidity or dissolved oxygen after a rainfall event.

Figure 2. Flooding in Southern Dearborn Heights near the Ecorse Creek.

Research Methods

Figure 3 (Left) and Figure 4 (Right): Maps of the Testing Sites. Two sites were chosen for sampling various water quality parameters. Figure 2 shows the Rouge River testing site while Figure 3 shows the Ecorse Creek testing site.

Figure 5 (Left) and Figure 6 (Right) : Equipment Used. Vernier Probes were used in order to test the following parameters: turbidity, dissolved oxygen, conductivity, water temperature, and salinity (Figure 6). While a rain gauge was used to collect rainfall (Figure 5).

Figure 7 (Top) and Figure 8 (Bottom): GLOBE Entry Data. Data was uploaded into the GLOBE Website.

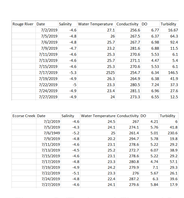

Figure 9 (Top) and Figure 10 (Bottom): Entry into a Spreadsheet. Data was entered into a spreadsheet to begin analyzing it.

Results

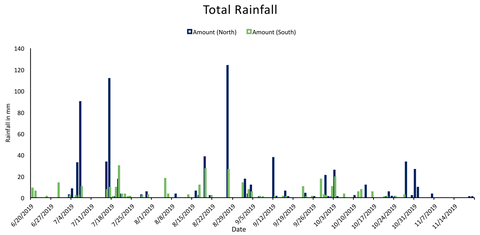

Figure 11: Total Rainfall. This infographic shows the amount of rainfall collected in both Northern and Southern Dearborn Heights. This shows that there was more rain received in the north rather than the south.

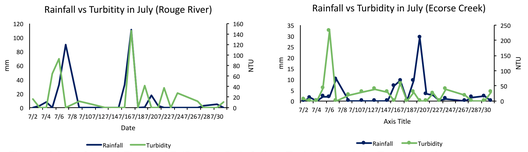

Figure 14 (Left) and Figure 15 (Right): Rainfall vs Turbidity in July. Turbidity showed a direct correlation with Rainfall, meaning immediately after rainfall occurred, both rivers became more turbid.

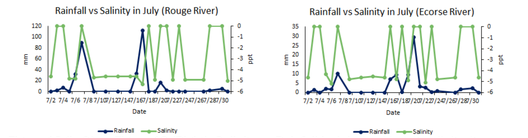

Figure 18 (Left) vs Figure 19 (Right): Salinity vs Rainfall in July. Looking at salinity, it was found that with rainfall, salinity had a direct correlation with it. This means that once rainfall spiked, so did salinity, and once rainfall lowered, so did the number of salt ions.

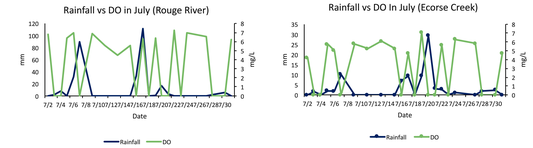

Figure 12 (Left) and Figure 13 (Right): Rainfall vs Dissolved Oxygen in July. Dissolved oxygen varies greatly with temperature and rainfall. So, looking at this in the summer, dissolved oxygen levels were lower when it rained due to an increase of temperature in the water. As temperature levels increase, dissolved oxygen levels decrease due to the water's inability to hold oxygen.

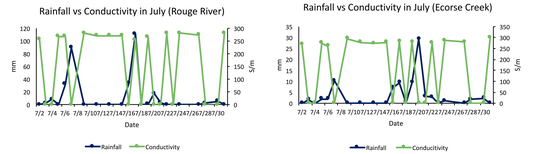

Figure 16 (Left) and Figure 17 (Right): Rainfall vs Conductivity in July. Rainfall and Conductivity in both the Rouge River and the Ecorse Creek showed almost identical patterns. In this case, conductivity was used as a substitution for total solids as in our previous research there was found to be a correlation between the two. These infographics show that with increased rainfall, there was an increase in conductivity immediately afterwards.

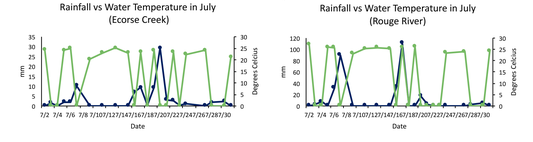

Figure 20 (Left) and Figure 21 (Right): Rainfall vs Water Temperature in July. Water temperature and Rainfall have an inverse correlation between the two. This means that as it rains more and more, the water temperature decreases and as it rains less, water temperature increases.

Conclusion

During our four-month study period, rainfall appears to have a correlation with the water quality parameters that we have tested. These water quality parameters include dissolved oxygen, water temperature, turbidity, conductivity, and salinity. Of these parameters, dissolved oxygen and conductivity have an inverse relationship while turbidity, water temperature, and salinity have a direct correlation to rainfall. Along with these parameters, we also looked at the differentiating height of the two rivers compared to rainfall. We primarily focused on the correlations between water temperature, conductivity, turbidity, dissolved oxygen, and rainfall. We found that these selected parameters have a tight correlation between them. Between water temperature and dissolved oxygen, as temperature increases dissolved oxygen decreases due to the water's inability to hold oxygen. The rivers became more turbid due to run off, which darkened the river. Once the rivers darken, more heat is absorbed due to albedo, which increases the water temperature.

Research Implications

In the heavily developed regions of Michigan where a high percentage of impervious surfaces are present, the amount and type of rainfall can have significant implications for the people living there. The two rivers and watersheds in Dearborn Heights, MI drain runoff from the homes and businesses of nearly 60,000 people. These streams also carry the runoff of nearby communities of similar population and development density. Without a plan to properly manage the infiltration and runoff of storm events, houses and businesses in the floodplains near the rivers will experience flooding during these predicted and likely extreme precipitation events with subsequent high personal and economic losses. This is a very important issue for citizens living in Dearborn Heights because they are directly impacted by flooding in both the northern and southern portions of our city. In North Dearborn Heights citizens are inconvenienced by important transportation corridors during flood events and people living in South Dearborn Heights have to contend with damage and losses related to the flooding of their homes and vehicles. Currently very little longitudinal water quality monitoring is taking place in our city. Creating a database of information useful to city and regional planners can help provide much needed information to take future action to help alleviate the ecological, economic, and personal effects of frequent flooding. Researching correlations between the different water quality parameters and precipitation events in our watersheds will make it possible to have evidence to show to state and federal agencies with possible funding to help find solutions to the flooding parts of our city has been experiencing. Right now the city is looking into a multimillion way to channelize the River in the South Dearborn Heights. The research completed here points the way to a possible cheaper, more ecological sound, and more effective way to manage runoff might be to reduce impermeable surfaces by buying back a few homes in the region and building in places where small wetlands can be developed to allow the runoff to soak in rather than runoff.

Discussion

Unfortunately, there were some testing conditions that we didn't have control over during our research period. Ideally it would have been better to test every day at the same time. However, transportation and other responsibilities made this not possible. In addition, it would have been better to have a larger dataset of additional water quality parameters to test. Testing of additional parameters such as nitrates, phosphates, coliform bacteria, etc. was not possible this past summer as our school lab was not available to us because of construction. Luckily, a USGS (United States Geological Survey) stream gauge located adjacent to the South Dearborn Heights study site provided us with accurate stream height and discharge data. Even so, there was no comparably close USGS stream gauge on the study site in the north part of Dearborn Heights. Flooding at this location made it hazardous to study at times. It would have been best to test the water at both sites simultaneously but because of equipment limitations and the lag time present when travelling from one site to another, this was simply not possible. We also tried to compare our data to other schools, but not many were testing during the same time period we were. One such school was located in Thailand. Sadly, their school was out so we couldn't contact them when we needed to as well as the fact that there was a drought there and there wouldn't have been enough data regarding precipitation to compare. Vernier instruments were utilized in this research and although they provide accurate data, it is not as precise as what more advanced instrumentation would provide. Although not as precise, the values we obtained do show trends that can be used to predict outcomes. We learned that when rainfall spiked, river levels raised.

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