Journal of Research High School

Volume 2022 (2) 79 - 84
ISSN 2688-3651 [online]

Investigation of Impacts of Hurricanes on Water Quality in Savannah River, GA USA

Haelin Lee[1 *]

[1]Gwinnett School of Mathematics, Science, and Technology, Lawrenceville, GA, USA

Received June 21, 2022; Revised August 11, 2022; Accepted, August 19, 2022

Abstract

The purpose of this study was to examine the impacts of hurricanes and storms to the water quality along the Savannah River in three consecutive years. Data was collected from the United States Geological Survey (USGS) on different water quality parameters, including turbidity, dissolved oxygen (DO), conductivity, and salinity. Three surface water stations along the Savannah River were selected to collect data from - each in the upper, middle, and lower parts of the river. The data for the month October in years 2017, 2018, and 2019 were chosen to be collected for each variable as these dates correspond to Hurricane Nate, Hurricane Michael, and Tropical Storm Nestor. Based on the data collected, this study compared the different water quality variables before and after the storm and hurricanes. From the graphs created the trends of a general increase in turbidity, increase in dissolved oxygen as well as decrease in salinity along the river during the periods of the storm and hurricanes. This study also found an increase and decrease of conductivity values, which were more affected by the location. Data analysis found that the storms and hurricanes disturb water quality, which could be characterized by the sampling locations; the station's position on the streams.

Keywords: Hurricane, Water Quality, Savannah River

1. Introduction

Although the most common type of natural disaster in Georgia is severe thunderstorms, Georgia has also been exposed to many hurricanes formed in the Atlantic Ocean and the Gulf of Mexico (Georgia Disaster History, 2021). Since the coast of Georgia aligns with the Atlantic Ocean, which holds a high-pressure system called "Bermuda High," it has been considered that the coast of Georgia has a low chance of impact by landfalling storms (Strother, 2019). As a result, the hurricanes from the tropics end up on the left, curve and head northward, and do not move into the coastal areas of Georgia (Strother, 2019). This may lead one to consider that there is less vulnerability to hurricanes in Georgia; however, as experienced by historic storms, this does not mean that Georgia is not vulnerable to significant damages resulting from natural tragedies. A few examples of historical hurricanes in Georgia include Tropical Storm Alberto, Hurricane Floyd, Hurricane Katrina, and more recently, Hurricane Michael occurred in 1994, 1999, 2005, and 2018, respectively. Tropical Storm Alberto brought twenty-five inches of rain, killing thirty- four people and displacing many homes, and Hurricane Floyd caused the largest evacuation effort in american history as about three million people rushed to evacuate (Georgia Disaster History, 2021). Hurricane Katrina hit western Georgia with heavy rains and winds that destroyed many buildings and took lives; there was a great economic effect as the gas price rose to $6 per gallon

* Corresponding Author
hhaelinlee@gmail.com

Advisor: Dr. Jay Om
jo729@nyu.edu

(Georgia Disaster History, 2021). Hurricane Micheal was a category five storm causing massive destruction with more than $4.5 billion worth of property damage (Reid, 2019). Because of the recency of Hurricane Michael's damages, Hurricane Micheal portrays a great example of the vulnerability of Georgia to Hurricanes. This hurricane became the first major hurricane as a Category 3+ to directly impact Georgia since the 1890s (US Department of Commerce, 2019). Hurricane Michael made landfall in Florida on the afternoon of October 10, 2018 as an extremely dangerous Category five hurricane; Georgia was also affected by Hurricane Michael on the same day, and on the morning of October 11th, the hurricane quickly exited both states as a tropical storm (US Department of Commerce, 2019). As a result of this hurricane, warning areas within Atlanta and Peachtree City County experienced winds that gusted over 70 mph in portions of central Georgia, leading to tree damage, power outages, and severe crop damage (US Department of Commerce, 2019). Because of the substantial destruction caused by the Hurricane, President Donald Trump declared Georgia as in a state of emergency. Despite the fact that the hurricane was not a landfalling hurricane in Georgia, the vulnerability of Hurricanes in Georgia is evident.

There have been several studies and efforts to increase coastal resilience, focusing on infrastructure. Most research has focused on directly impacted infrastructure, overlooking the substantial consequences of hurricanes, such as water quality and resource management. Water surges cause a drastic rise in contamination levels as hurricanes push toxins and contaminants from the soil directly into water supplies (How Hurricanes Can Impact Water Quality and Safety, 2017). The effects of these contaminated water systems can continue for years and cause health issues making it difficult to reverse and even cause death. Schafer et al. (2020) suggested that water chemistry was temporarily disturbed during hurricane Irma as saline water intruded 15 km into a freshwater river, while runoff of freshwater and dissolved organic matter (DOM) decreased salinity and dissolved oxygen but increased turbidity. There may also be more long-term ecological repercussions from these water quality changes resulting from hurricane events. It should be noted that once the ecological repercussion has occurred, it requires a long environmental recovery period to return to normal water systems.

The Savannah River runs on the border of two states, Georgia and South Carolina, and 1.4 million people in GA rely on it as a drinking water source. Unfortunately, the Savannah River has been known for unhealthy water quality, absorbing a significant amount of untreated wastes annually, threatening the quality of waterways as a recreational and drinking resource (Coleman, 2014). Therefore, monitoring the water quality of the Savannah River and proper data analysis is crucial to maintaining the river as a high-quality drinking water source and developing an appropriate long-term sustainability strategy. This study examined the impacts of heavy rain due to hurricanes and storms on the water quality of the Savannah River.

2. Materials and Methods

Water quality changes with heavy rains due to hurricanes and storms along the Savannah River were studied. Three surface water stations of the United States Geological Survey were carefully selected approximately 15 miles apart representing different environmental conditions. The locations of the selected USGS stations are shown in the figure 1 and the detailed geographical information can be found in the table 1.

The United States Geological Survey data was used to collect data on different water quality variables, including turbidity, dissolved oxygen, conductance, and salinity. This study selected three surface water stations of USGS along the Savannah River. Figure 1 shows the location of several USGS stations along the Savannah River. After each station near the river was checked for its available data, three stations were selected, each in the upper, middle, and lower parts of the river. Station A is a station located in the upper river, and the USGS station number is 02198840, which is pointed out with the red arrow. Station B is located at the mid-river, and the USGS station number is 02198920, which is pointed out with the purple arrow. Station C is a station located in the lower river, and the USGS station number is 021989773, which is pointed out by the green arrow.

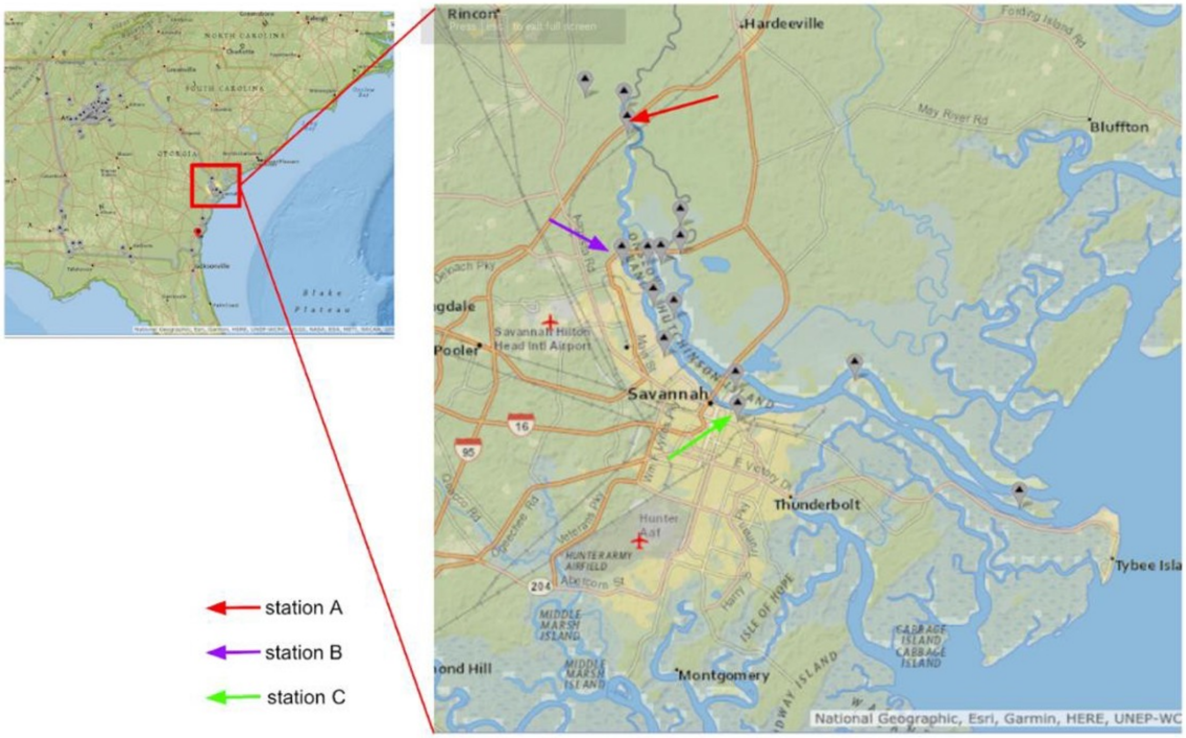

Figure 1. Map of the Stations Located on the Savannah River

Table 1. Geographical Information for the three USGS surface water stations

	Station A	Station B	Station C
USGS station ID	02198840	02198920	021989773
Longitude	-81.09039	-81.15491	-81.08121
Latitude	32.14077	32.16533	32.08105
County	Effingham	Chatham	Chatham

In October, Georgia had impacts due to Hurricane Nate (2017), Hurricane Michael (2018), and Tropical Storm Nestor (2019). On October 7, 2017, Hurricane Nate landed along the central Gulf and brought heavy rain, gusty winds, and coastal flooding. Hurricane Michael landed on October 10, 2018 and brought widespread surge and wind damage (TAE Significant Weather Events). Tropical Storm Nestor occurred around October 17-19 in 2019, and the main impacts were strong winds along coasts and storm surges. This study analyzed data collected in October of 2017, 2018 and 2019 to find the impacts of these series of hurricanes and storms on water quality in Savannah River. Graphs of the different water quality variables before and after hurricanes along the Savannah River were created based on the data collected by USGS. On all of the graphs, each line represents the data of 2017, 2018 and 2019, which are also shown on the legends of each of the graphs. The period of the hurricanes or storms is highlighted and labeled on sections of the graph that show a notable increase or decrease in the water quality variables during the period of the hurricane or storm. Then, using these highlights, the trends of each year is evaluated for each water quality variable. The different stations is also compared to find the differences of effects for the three locations (Stations A, B, and C) of the river.

3. Results and Discussion

This study presented the comparison of different water quality parameters such as turbidity, dissolved oxygen, salinity, and conductivity between pre- and post- hurricanes and storms. Graphs of the different water quality parameters along the Savannah River were created based on the data collected by USGS.

On all of the graphs, the blue lines present data from 2017, the red lines present data from 2018, and the yellow lines present data from 2019. The period of the hurricanes or storms will be highlighted and labeled in sections of the graph that show a notable increase or decrease in the water quality parameters. Then, using these highlights, the trends of each year will be found for each water quality parameter. The different stations will also be compared to find the differences of effects for the three locations (Stations A, B, and C) in the river.

Figure 2 presents comparisons of Turbidity along the Savannah River. Unfortunately, station B did not collect and monitor turbidity data during the period of Tropical Storm Nestor, but based on data collected during the periods of Hurricane Nate and Hurricane Michael, there were 100% to 250% increases in the turbidity values for all stations. In addition, the highest turbidity values were observed at station B with values reaching above 100 TNU. Station B is located at mid-river and is the deepest station, while Station A, which is located in the upper river area saw relatively low initial turbidity level, and Station C, located near the mouth of the river, which is a wide area of the river, saw initial turbidity levels higher than Station A and lower than Station B. The differences in location can explain the initial turbidity levels for the different Stations

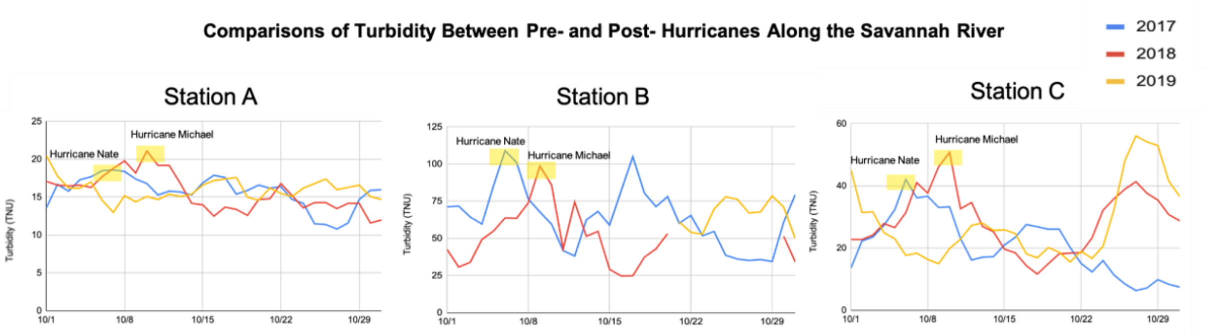

Figure 2. Comparisons of Turbidity

Figure 3 presents the comparisons in dissolved oxygen. There are 25% to 33% increases on DO levels with Tropical Storm Nestor in all stations, while Hurricane Michael only saw increases in stations B and C. It is noted that because of the hydraulic disturbance of the river during the hurricane, there is an increase of surface area contact with the air which will increase the oxygen level in the body of water. In addition, there were generally lower amounts of dissolved oxygen at Station C, which is near the ocean and the lower river, while there was an increasing amount of dissolved oxygen the further the stations were from the ocean. It can be noted that the amount of organic substance originating from the upper parts of the river reduces the DO level of the lower parts of the river. Furthermore, the increased amount of the salinity in the lower parts of the river also decreases the DO level because of the ion-molecule interaction. As shown by the highlighted parts of the graph, there are greater impacts to the DO levels during the storm when compared to the hurricanes.

Figure 4 presents comparisons of salinity along the Savannah River. There is a trend of an increase in overall salinity as the stations get closer to the ocean. In addition, for the graphs of Stations B and C, there is a 25% to 85% decrease in salinity during the periods of both Hurricane Nate and Tropical Storm Nestor, showing an increase in freshwater coming in. In station B, the values of salinity during the period of Tropical Storm Nestor are not visible but could have been similarly affected to station C. Station A had little variance in salinity, and a reason for this is the initial salinity level is too low because the station is located in the upper river.

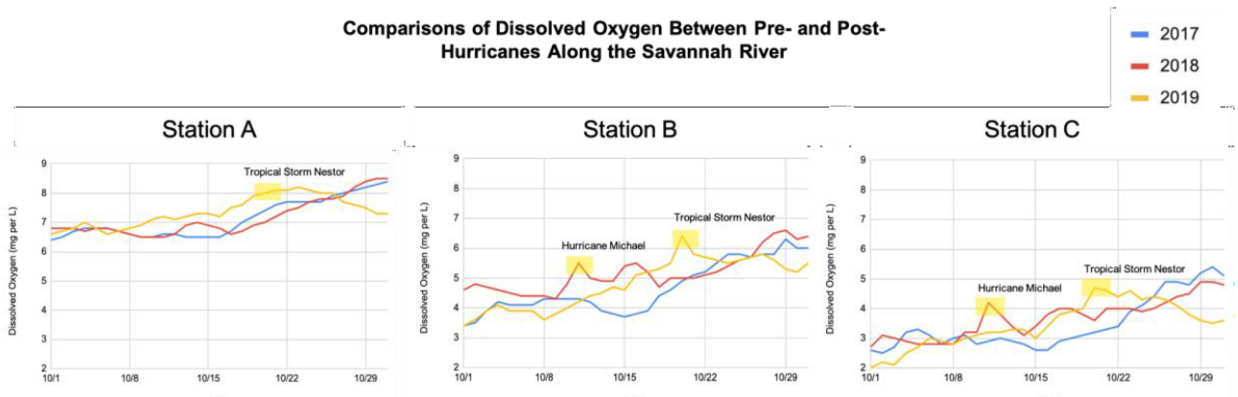

Figure 3. Comparisons in Dissolved Oxygen.

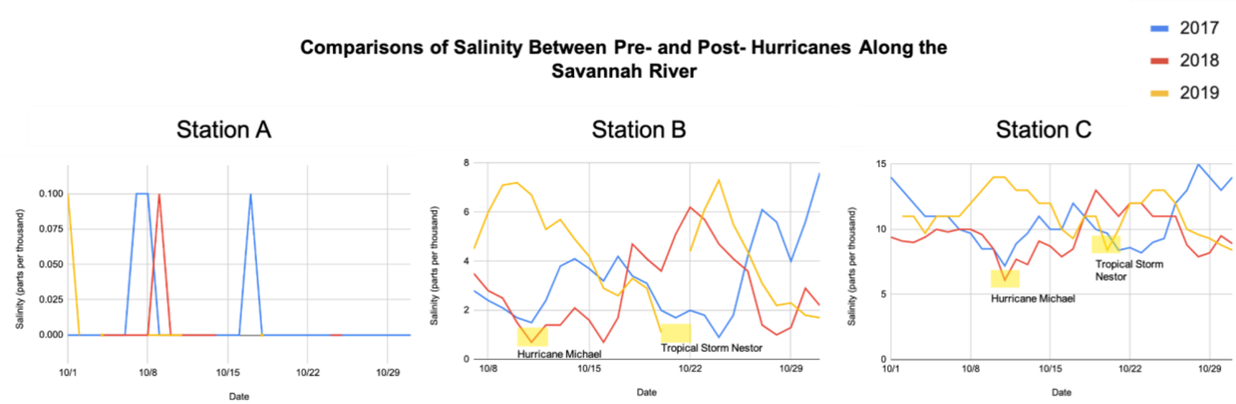

Figure 4. Comparisons in Salinity.

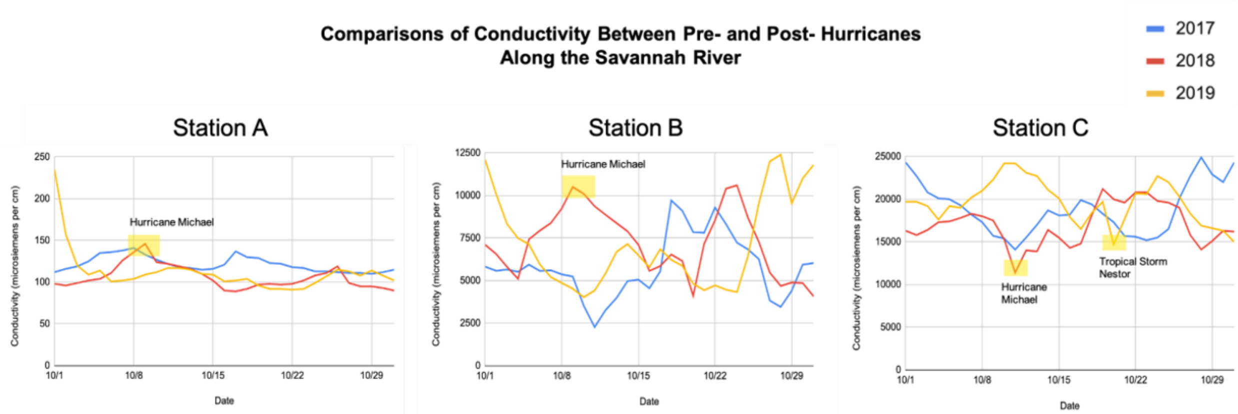

Figure 5. Comparisons in Conductivity.

Figure 5 shows the comparisons in conductivity. There seems to be a general increase in conductivity as the stations were closer to the ocean. The conductivity near the lower river stations have initial levels reaching almost 25000 μS/cm while the conductivity of the upper river station have initial values of about 150 μS/cm. These initial values are affected in different ways from the hurricanes and storms. For stations A and B, there is an increase in the conductivity of the water during Hurricane Michael. This can be explained by the hurricanes disturbing the sediment of the river, which will increase the amount of inorganic substance in the body of water. On the other hand, there are decreasing spikes in conductivity values for Hurricane Michael and Tropical Storm Nestor in station C. This could be because during the storms, more fresh water entered the areas of station C which will reduce the conductivity of the water body.

4. Conclusions

This study found that extreme weather events such as storms and hurricanes disturb the water quality of the Savannah River region. This study observed a general increase in turbidity and dissolved oxygen as well as a decrease in salinity along the river. However, this study found both an increase and decrease of conductivity values, which were more affected by other factors such as the strength and duration of the hurricanes or storms. Therefore, this study concludes that an increased amount of freshwater inflow and wind effects during hurricanes and storms alter water quality along the river in a coastal area. Furthermore, these disturbances could be characterized depending on the location along the river.

References

Barker, J. (2018). Hurricane Michael in GA: girl dies, $2B crop loss, 224K in dark. *Douglasville, GA Patch*. https://patch.com/georgia/douglasville/hurricane-michael-hits-georgia-power-outages-curfews-more.

Coleman, D. (2014). Savannah river nation's third most toxic, study shows. *The Florida Times-Union*. https://www.jacksonville.com/article/20140627/NEWS/801253299.

DRF Water Heating Solutions. (2017). How hurricanes can impact water quality and safety. *How Hurricanes Can Impact Water Quality and Safety - DRF Water Heating & Plumbing.* https://www.drftps.com/how-hurricanes-can-impact-water-quality-and-safety/.

Fondriest Environmental, Inc. (2013). Dissolved oxygen. *Fundamentals of Environmental Measurements.* https://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/.

Fondriest Environmental, Inc. (2014). Conductivity, salinity and total dissolved solids. *Fundamentals of Environmental Measurements.* https://www.fondriest.com/environmental-measurements/parameters/water-quality/conductivity-salinity-tds/.

Fondriest Environmental, Inc. (2014). Turbidity, total suspended solids and water clarity. *Fundamentals of Environmental Measurements.* https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

Georgia Disaster History. Georgia emergency management and homeland security agency. (2021). https://gema.georgia.gov/georgia-disaster-history.

Heil, J. (2021). 10 U.S. states where hurricanes hit most often. *Universal Property & Casualty Insurance Company.* https://universalproperty.com/united-states-where-hurricanes-hit-most.

National Hurricane Center and Central Pacific Hurricane Center. (2021). Saffir-Simpson hurricane wind scale. https://www.nhc.noaa.gov/aboutsshws.php.

National Weather Service. (2021). TAE significant weather events. *National Oceanic and Atmospheric Administration.* https://www.weather.gov/tae/events.

Reid, K. (2019). 2018 hurricane Michael: facts, FAQs, and how to help. *World Vision*. https://www.worldvision.org/disaster-relief-news-stories/2018-hurricane-michael-facts.

Schafer, T., Ward, N., Julian, P., Reddy, K. R., & Osborne, T. Z. (2020). Impacts of hurricane disturbance on water quality across the aquatic continuum of a blackwater river to estuary complex. *Journal of Marine Science and Engineering*, 8(6), 412. http://dx.doi.org/10.3390/jmse8060412.

Strother, J. (2019). Hurricanes in Georgia: what you need to know from UGA's dr. marshall shepherd. *UGA Alumni*. https://alumni.uga.edu/2019/08/30/hurricanes-in-georgia-what-you-need-to-know-from-dr-marshall-shepherd/.

US Department of Commerce, N. O. A. A. (2019). Hurricane Michael hits Georgia. *National Weather Service.* https://www.weather.gov/ffc/2018_hurricane_michael