Abstract

A comparative study of the 2011/2013 water quality assessments in the Pasquotank Watershed in Northeastern North Carolina

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I. Introduction

A. Overview

A watershed describes a range of land that includes a common set of streams and rivers that all drain into a single larger body of water, such as a superior river, lake, or ocean. [1]. Watersheds can come in all shapes and sizes. They divide counties, states, and national boundaries [2]. "In the continental US there are 2,110 watersheds; including Hawaii Alaska, and Puerto Rico, there are 2,267 watersheds." [2] All streams, tributaries, and rivers are associated to a watershed. In most cases, small watersheds gather together to become larger watersheds. Watershed activity that affects the water quality, quantity, or flow at any location, can also alter the features of the watershed at downstream locations. A watershed has four important functions, collecting water from rainfalls, storing water, releasing water, and providing a home for fauna and flora. [3] Watersheds support life, in more than one way. According to the Environmental Protection Agency, "more than $450 billion in foods, fiber, manufactured goods and tourism depend on clean, healthy watersheds." The Earth consists of 70% of water and out of that, 40-50% of our land's waters are impaired or endangered. This could lead to insufficient water, meaning that the water will be inhabitable leaving no drinking water or produce. "Watershed protection is a means of protecting a lake, river, or stream by managing the entire watershed that drains into it." To ensure a healthy watershed the community must get informed on how humans can impact a body of water. [4]

In the 2013 project the following factors were evaluated: dissolved oxygen (DO), clarity, turbidity, pH, total dissolved solids (TDS), salinity, and conductivity. All of these parameters can affect the overall quality of a watershed.

B. Dissolved Oxygen

Dissolved oxygen in water is a necessity for aquatic life. [5] Water temperature, clarity, turbidity, TDS, and salinity all affect DO [6]. Other factors that contribute to the rise or fall of DO levels are the volume and velocity of a water source [6].

C. Turbidity

Turbidity is the measurement of the scattering effect of the dispersed and suspended solids on light. These solids can promote the growth of harmful microorganisms and can block light from reaching aquatic vegetation. This can affect the DO levels in stream, rivers, and lakes. [13]

D. Clarity

Clarity is a measurement of how clear the water is. While this does take into account the suspended solids in the water, it mainly focuses on colored particles in the water that absorb light. Color is created by the material in the water such as iron and manganese, but is also a product of the organic material in the water including tannins, which provide a dark brown color to the water. [14]

E. Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) are the total amount of traveling charged ions, which includes minerals, salts or metals [8]. TDS correlates with the purity of water. A higher concentration of TDS indicates improved conductivity however it can also cause a reduction in dissolved oxygen [9].

F. Salinity

Salinity is the measurement of salt that is dissolved into the water. The amount of salt in the water can determine what lives and grows in different zones. Salinity is a large factor in testing water quality as the higher the amount of salt, the lower the amount of dissolved oxygen the water can hold. Salinity is measure in parts per million (ppm). [15]

G. Conductivity

Conductivity is the measurement of the water's ability to conduct electricity. The measurement is affected by the amount of dissolved solids, for example nitrate, which carries a negative charge, and sodium, which carries a positive charge). The area in which the water flows can also be a determining factor of the measurement. It is measured in micromhos per centimeter (µmhos/cm) or microsiemens per centimeter (µs/cm). [16]

H. pH

The pH is a measurement of how acidic or basic something is. The pH is measured on a scale form 0-14 where 0-6.9 is acidic, 7 is neutral and 7.1-14 is basic. Water with a particularly high or low pH is lethal. Water with a fairly low pH can deplete the amount of hatching fish eggs and can affect fish and macroinvertebrates. [10] Amphibians are predominantly defenseless, mostly because of their delicate skin. [10] Some scientists concluded that the current decline in amphibian numbers globally is due to acid rain, which can cause the pH levels to decrease. [10] A pH level between 6.5 and 8.2 is considered standard for bodies of water [11].

The land that surrounds the watershed can influence many different factors in positive and negative ways. Pollution, agricultural, and development are some of the biggest factors [7].

II. Analysis

A. WQI 2011/2013

The overall change between the Water Quality Indices of 2011/2013 was slight. The data illustrates that the Pasquotank River had a higher water quality than the other tributaries in 2011, while in 2013 Newbegun Creek had the highest. The change in which waterway had the top water quality was possibly due to the amount of wind that was encountered on the first day of sampling at Newbegun Creek. During this trip, the wind levels were high causing a great amount of churning of the water. This had a large affect on the dissolved oxygen levels, which impacted the water quality of Newbegun Creek. Other than the change in which waterway had the top water quality, the other water quality indices all remained consistent with each other.

TABLE I. Comparative data for 2011/2013 parameters.

2011 Water Source	pH	DO mg/L	Turbidity (in)		TDS (ppm)	Salinity (ppm)	Conductivity (mS/cm)
Newbegun Creek	5	4	17		3006	2146	4
Mill Dam Creek	5	4	32		3203	2285	5
Areneuse Creek	4	4	19		2460	1758	4
Pasquotank River	6	5	14		761	541	1
Sawyers Creek	7	4	19		856	607	1
Knobbs Creek	5	5	23		1847	1325	3

2013 Water Source	pH	DO mg/L	Clarity (in)	Turbidity (in)	TDS (ppm)	Salinity (ppm)	Conductivity (mS/cm)
Newbegun Creek	7.4	5.0	18.0	9.5	3242.0	2272.5	4.89
Mill Dam Creek	7.0	2.5	24.0	10.5	3263.5	2331.5	4.39
Areneuse Creek	7.4	2.0	22.0	11.0	2455.0	1751.5	3.77
Pasquotank River	6.1	3.0	13.0	5.5	815.5	582.5	1.07
Sawyers Creek	7.5	3.5	17.5	9.5	856.0	611.0	1.09
Knobbs Creek	7.1	3.0	25.5	13.0	1314.5	910.0	2.03

B. Dissolved Oxygen

The stream measurements for 2013 roughly paralleled the measurements for the 2011 project. Dissolved oxygen, the largest factor in stream health, varied from low levels at the head of each waterway to much higher levels at the intersection of the waterway with the Pasquotank River. The Pasquotank River readings also replicated this pattern from the intersection of the Dismal Swamp Canal to the town of Elizabeth City. Factors influencing this include wind, water depth, and width of the waterway. Newbegun Creek came in at the top of the Water Quality Index mainly due to the high dissolved oxygen readings. These high readings may have been shaped by persistent northerly winds entering the mouth of the river creating greater wave action.

C. TDS, Salinity, and Conductivity

TDS, salinity, and conductivity readings remained high as in 2011 in Mill Dam Creek, Areneuse Creek, and Newbegun Creek. These waterways are well below Elizabeth City where the Pasquotank River narrows greatly, increasing the influence of the brackish water brought in during the summer months. The testing points for the Pasquotank River start at the city and work north towards Knobbs Creek and Sawyers Creek yielding less of an influence by the brackish water in the lower Pasquotank River. From this it can be derived that salt is the main solid in these waterways. Another check of these waters during the cooler months could possibly prove or disprove this conjecture.

D. pH

The pH readings for this year's sampling were higher than the 2011 tests. The almost neutral state of this year's readings was unexpected due to historic records of very low pH. Factors that may have caused this were a dry period without much runoff from the area swamps and a period of extreme heat during the sampling period. The comparison between the two years may also have been influenced by a change in testing methods. The 2011 team utilized test strips with which the color must be interpreted and the 2013 team put into use a digital pH meter that could be calibrated to basic, neutral, and acidic.

E. Clarity/Turbidity

At the recommendation of Mr. Jeff Schloss of the University of New Hampshire, a separate test for turbidity was initiated. Using this black side of the Secchi disk, the team was able to compare the color of the water (clarity) to the suspended particles in the water (turbidity). The readings paralleled each other with clarity having approximately a ten inch greater reading at each test point. The Secchi disk is a very subjective test, greatly affected by the user's perception and other factors such as water reflection and the amount of sunlight during a test.

III. Conclusion

A. Overall

In this project, the data show that the overall health of the Pasquotank Watershed, as determined by the Water Quality Index Calculator, has remained consistent compared to the previous 2011project.

B. Variations

Though minor variations were found in the WQI, the overall health of the Pasquotank and its tributaries remain around the medium range. The most noticeable difference involved the dissolved oxygen of Newbegun Creek and Areneuse Creek. The position of Newbegun and the Pasquotank River switched because in 2011 Pasquotank had the highest WQI in 2013 it is Newbegun.

C. Land Associations

As in the 2011 project very little association was made between the landforms surrounding these waterways and the test results. This may have been as a result of a low rain period during the testing.

D. Areneuse; Mill Dam; and Newbegun Creek

One of the major correlations discovered was the relationship between Areneuse Creek, Mill Dam Creek, and Newbegun Creek. These creeks are well downstream of the other waterways tested (Pasquotank River, Knobbs Creek, and Sawyers Creek) and were found to have much higher concentrations of salt. This affected both the conductivity and the TDS tests. These results were also noted when the 2011 project data were analyzed. The team did not sample at the mouth of the Pasquotank and if that location was tested it could have shown some insight on the high concentrations of salt.

E. Data Sampling

Better equipment and drawing on the experience of the 2011 team allowed this year's project to make two samplings of each waterway doubling the amount of data acquired. Increased documentation with each project should establish a firm base from which to gather increased data and increase the type of tests performed for a more accurate assessment of the watershed's well being.

F. Data Presentation

The team used an online visual database of points created in 2011 and tested in 2013. The code was originally written to present one trip of data and expanded during this project to display two trips. The code utilizes JavaScript code to incorporate the Google Maps interface. An extra point was added to the Newbegun section of the trip.

IV. Future Work

A. Meter Capability

For future testing of water samples it is suggested that a more advanced meter be acquired that would be able to perform multiple tests. The YSI Professional Plus Multi-Parameter Meter, which is manufactured by YSI, is capable of measuring dissolved oxygen, conductivity, salinity, total dissolved solids, pH, and temperature. The acquisition of a small, flat-bottomed, boat with a small engine would decrease the amount of time needed to cover each waterway. This boat should be light enough to carry into locations that do not have launching ramps and have a secondary source of power such as a trolling motor. It is also suggested that the addition of nitrogen, nitrate, and fecal coliform tests be studied. These are just a few of the many tests that the Environmental Protection Agency calls for, but are major factors in determining the health of the water being tested. While these tests are essential parts of water quality tests they may be beyond this program's abilities to test at this level of research. There is a large gap in the testing area of the Pasquotank River starting at Elizabeth City and ending at the mouth of the Pasquotank River. It is suggested that this area be added to the test sites currently being monitored. Test points could be at a greater interval due to the larger body of water begin tested. An online database should be implemented that would allow one online page to access any set of data from any project year. The current online paradigm requires that each page be hard-coded to a particular set of data. Development of a PHP interface with the data would allow greater access to multiple sets of data for better comparison.

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