EFFECTS OF VARIABLE STREAM DISCHARGE ON TEMPORAL COMPARISON OF WATER QUALITY DATA DUE TO LAND USE

2019 Summer Research Report on Water Quality Issues for the Hudson Valley Farm Hub

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Abstract

Like all streams passing through transitions of changing land management practices, water quality in the lower Esopus Creek, located in Hurley, New York, is often at risk of contamination. Analyses of stream water chemistry parameters were performed over a span of three growing seasons to evaluate water quality evolution in a selected reach of the drainage basin, with the intention of determining the effectiveness of environmentally friendly growing practices implemented by the Hudson Valley Farm Hub (HVFH), in Hurley NY. However, the comparison of water quality changes over time gets complicated because the stream flow may not remain the same while water samples get collected at different times. If the land use does not change, the dissolved load of constituents should remain the same. In this circumstance, samples collected during high flow conditions should show a lower concentration compared to samples collected when the stream discharge is lower.

Water samples were collected from the lower Esopus Creek and its tributaries flowing through the HVFH area at 18 locations. Stream discharge was measured in five selected sample locations using a current flow meter. These samples were analyzed for common cations (Ca, Mg, Na, P, and NH_4) and anions (NO_3, PO_4, Cl, and SO_4). The temperature, pH, dissolved oxygen, and total dissolved solids (TDS) of water samples were measured in the field. The water chemistry data was compared with the stream discharge data.

The result shows that water quality gradually improved over time. The variation in stream discharge affects concentrations but no significant relationship was observed. For example, during early summer, the TDS showed a strong negative correlation with stream discharge, while nitrate concentration did not show any significant relationship with discharge. However, when the TDS and nitrate concentrations were compared using June-October data, no relationship was observed with discharge, but nitrate showed a better relationship with discharge than TDS in this case. This could be attributed to the fact that during low flow condition the baseflow is the dominant contributor of stream discharge and the water quality parameters of baseflow remain relatively constant. Additional temporal data needs to be collected to figure out this complex relationship for better comparison.

Introduction

Throughout the months of June - October various hydrologic data was collected from the Hudson Valley Farm Hub (HVFH) with the goal of measuring the impacts of environmentally friendly growing practices had on the surrounding watershed. The Esopus Creek is in direct contact with the HVFH's property in multiple locations which made this area perfect for the qualitative and quantitative testing of the water chemistry data to further understand the sought-after relationships. The data collected from the HVFH was also compared to water chemistry data collected from different locations within the Esopus Creek outside of the HVFH. This relationship allowed for the comparison of the data provided by the HVFH's environmentally friendly growing practices to that of standard water chemistry data not backed by such growing practices.

Methods

There are two different types of data that was collected in order to make this research possible. The first type of data that needed to be collected was the stream discharge data which was used in conjunction with the water chemistry data. The hardware used to collect the discharge data was a FP111 global flow probe current meter, shown below.

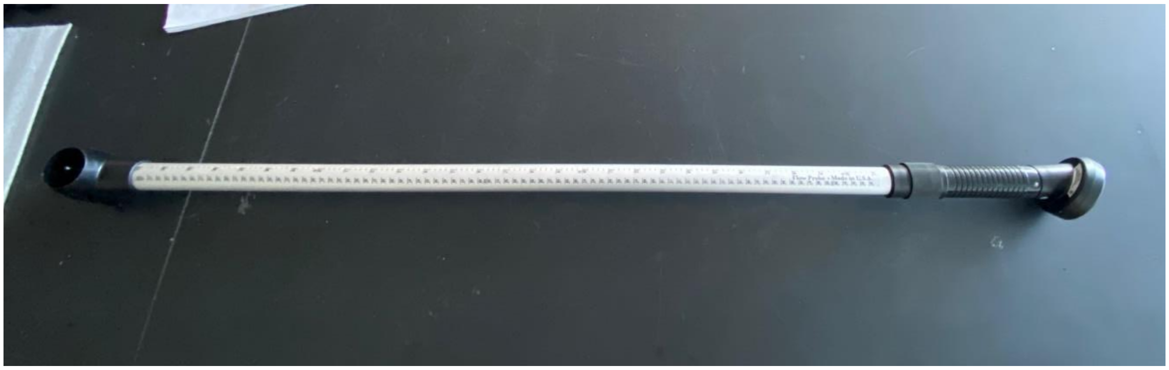


Figure 1: FP111 Global Flow Probe

The methodology used during the actual collection of this data is standard practice in hydrology. First, a section of stream was chosen to collect the discharge data. Many different types of sections were chosen in order to get a well-represented data set for quantification. Measures were taken to insure to include a range of stream sections that varied in width and in total discharge. When a given section of stream was chosen, it was broken up into 2 feet intervals. The purpose of this is to get the most accurate depiction of the discharge that is occurring across the entire stream section. Once the stream was broken up into equal parts the current meter was then used to measure the discharge in ft/second (f/s). The meter was placed in the middle of the two-foot section and then placed at approximately 0.6x the depth of the given segment (figure 2).

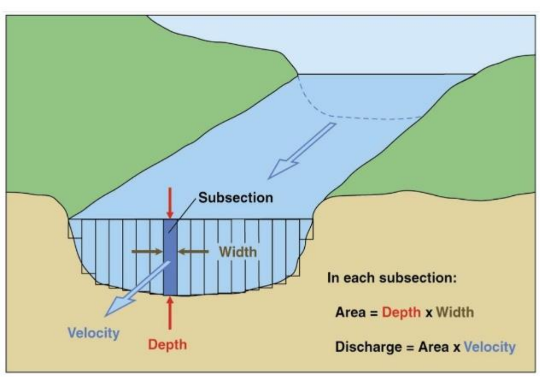


Figure 2: Schematic diagram of the procedure followed for the discharge calculation

The purpose for doing this is to try and get the most accurate average of the discharge in each section of the stream. For analysis, the total stream length was recorded, total depth of each 2-foot segment, and the velocity measured for each section by the current flow meter. All the collected filed data was utilized to calculate the total discharge for the stream segment. This was done by multiplying the total depth of the segment, width of the segment, and velocity in (f/s). Once all these values were multiplied together, the discharge of each segment was determined. These values were then calculated for the entirety of the stream section and added together to get the total discharge value in cubic feet per second (cfs).

Figure 3: HACH Water Chemistry Meter

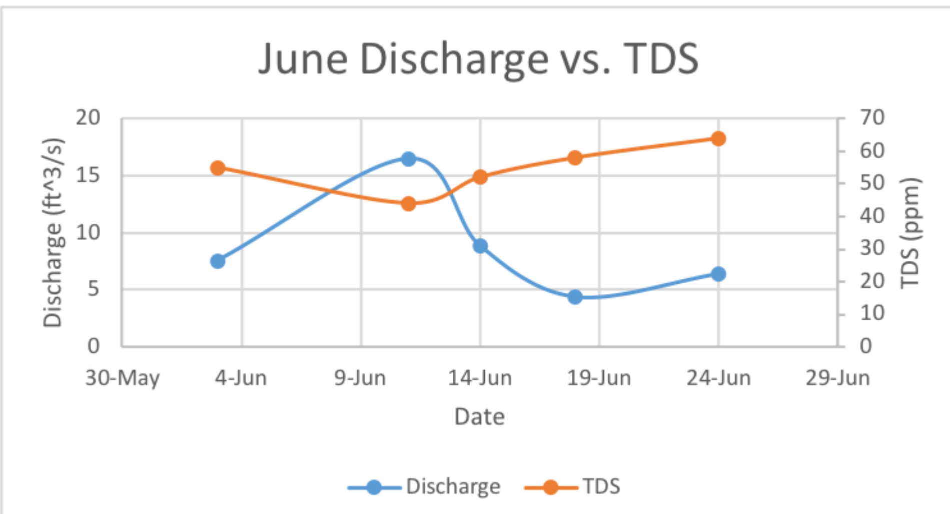
The second type of data that was collected was the water chemistry data. This information helped us to determine what was going on in the water and what nutrients were being introduced as a result of the farming practices on and off the HVFH land. There were several anions and cations that were measured within the water. The main bunch that we were testing for were nitrate, nitrite, phosphate and ammonia. Others included calcium, magnesium, sodium, potassium, and chloride. All of these different nutrients, anions and cations were calculated using a HACH and Ion Chromatography back at the lab. This was done by first collecting a sample while we were on site collecting discharge data and then placing this sample into a cooler to preserve the concentrations as close to natural levels as possible. Once the samples were back at the lab the HACH water chemistry meter was used for determining levels of nitrate, nitrite, phosphate, and ammonia. Ion Chromatography was used for all other anions and cations using the same collected samples mentioned above. In conjunction with the water chemistry data, water quality data was also collected to help further analyze the water. This data paired with the discharge helped paint an overall picture in which we were able to see everything that was happening within the water. The water quality parameters collected included temperature, pH, dissolved oxygen, and total dissolved solids (TDS). These parameters were collected in the field in order to ensure the values were as accurate as possible. For instance, parameters such as DO needs to be measured in the field because it can change with temperature. If we were to have measured these parameters in the lab with the collected samples the obtained numbers would not have been accurate and led to false data/conclusions. For temperature, pH and TDS a HANNA water chemistry probe was used and for DO a YSI 550A dissolved oxygen probe was used.

Figure 4: YSI 550A DO Probe & HANNA Probe

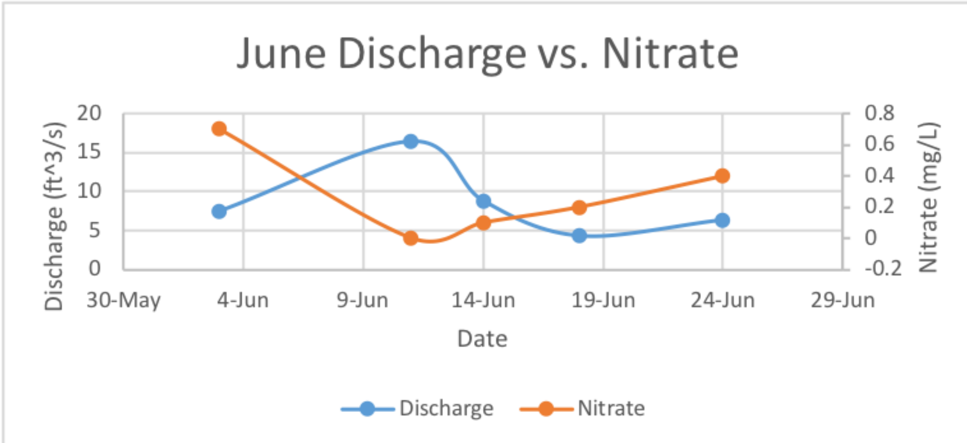
Once all this data was collected, graphs were created analyzing discharge vs. nutrient or water chemistry parameters to identify any correlations that were present. These graphs/correlations were then used to identify if there was in fact any difference to the water quality or chemistry as a result of the changes in streamflow.

Results

Using all of the data collected over a 5-month period, graphs were made in order to see if any correlations existed. When this data was first being collected (June) there was a strong negative correlation for parameters such as discharge vs. TDS, whereas the same correlation could not be said about parameters such as discharge vs. nitrate.

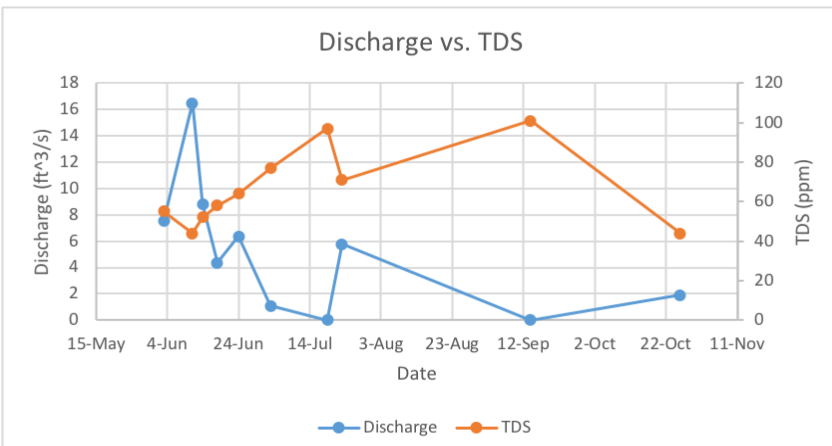


Graph 1: Early Summer Discharge vs. TDS

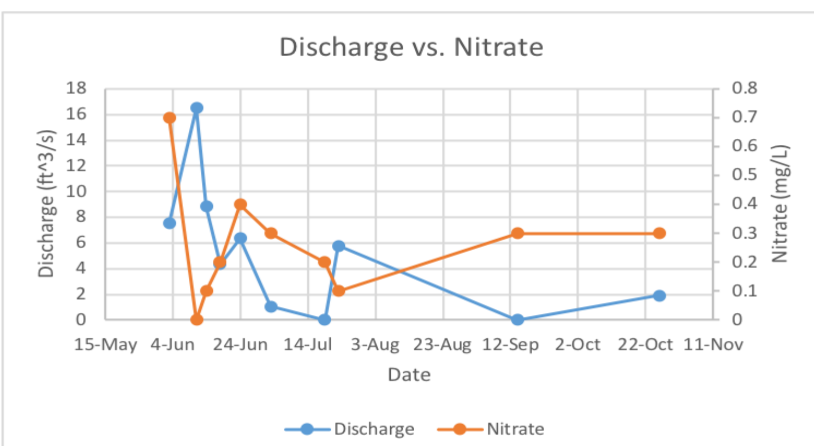


Graph 2: Early Summer Discharge vs. Nitrate

Data collected during the first month showed an inverse relationship with TDS indicating that the TDS load stayed the same so any increases or decreases to the discharge resulted in models with the lower or higher TDS concentrations respectively.



Graph 3: Full Summer Discharge vs. TDS



Graph 4: Full Summer Discharge vs. Nitrate

The graph above (Graph 4) have included the full set of data for the entire 5 months. No distinguishable correlation for the discharge vs. TDS were observed. However, discharge vs. nitrate now shows relatively better correlation compared to early summer when there were no observable correlations present.

Discussion

The basis behind this research was to try and find any correlations between discharge data and other water chemistry parameters so that future comparison of water quality parameters can be performed for different time periods with confidence. The main variables that we were expecting to see the most correlations between were discharge vs. TDS and nitrate. This was because of the nature in which these parameters would enter the hydrologic cycle. In the case of TDS, if the watershed is matured and developed in the area where you are sampling you would expect that the TDS has reached an equilibrium with the surrounding area. This would mean that we can assume the TDS contaminant load will be the same regardless of discharge under normal climatic conditions. The relationships you would expect to see under these specified equilibrium conditions in relation to TDS and discharge would be inverse in nature. For example, if you had a day where there was an elevated discharge in a given sampling area you would expect to see a decreased amount of TDS. The opposite approach would also hold true, if the discharge was at a lower magnitude than a predisposed average the TDS concentration would appear to be higher. Looking at graph 1, you can see that during the first couple of visits this relationship of discharge vs. TDS holds true. Over the course of the next couple of months we collected data and plotted the same relationship, shown in graph 3. This data seems to show the same trend, however, if you look at the magnitude of TDS in mid-June and compare it to the values found in late October, they are about the same. This progression over the course of 5 months shows that this inverse relationship no longer existed for some reason. These findings are just a snapshot into the complex nature of this hydrogeologic relationship. One hypothesis for this data would be to assume that during low flow conditions the main contributor of this TDS data would be baseflow. Base flow is defined as the hydrologic flow sustained between precipitation events in a stream which is the groundwater component that is feeding the stream. Since base flow does not vary significantly over time, this source of TDS which primarily derived from the rock-water interaction do not vary as well.

The second main parameter that we were testing for was nitrate. The same technique was used where discharge was graphed against nitrate concentrations to see if any correlations could be found. When these parameters were compared using June data there was little correlation early in the month and then the two began to both show signs of increasing values. This could be attributed to an increase in nitrate within the waterway which would disrupt the expected relationship. The most common sources of nitrate, especially in this area would be nitrogen bearing fertilizers that get flushed off the crops and into the water. However, it is important to note that the HVFH has implemented environmentally friendly growing practices which include the use of non-harmful fertilizers. The Lower Esopus is the main waterway that passes through the many different locations on the HVFH, however, the surrounding area is also heavy in other agricultural practices. Since the HVFH is located downstream from these other agricultural sites the possibility of nitrate being found within the water came from these locations. A fertilization event outside of the HVFH could be the source of this outside nitrate, causing the increasing trend and lack of negative correlation between discharge and nitrate during this time period. At the end of our 5-month time frame for sampling on site, the new results were then graphed to identify any correlations or changes in previously identified trends. It was found that over the next four months the expected negative correlation between discharge and nitrate became more pronounced at our sampling locations. This can be seen in graph 4 where after the early summer months, where fertilization would be expected to occur, the expected correlations began to take shape.

Conclusion

Over the course of 5 months, spanning from June 2019 - October 2019, temporal streamflow and water chemistry data was measured at selected sites in and around the HVFH. The main goal of this data collection was to investigate the potential relationships between variable stream discharge and water chemistry parameters. The reason behind choosing the HVFH was because they have implemented environmentally friendly growing practices that allowed for a unique baseline to be set with regards to water chemistry data. The findings showed a gradual increase in water quality over time due to said practices. However, the discharge events this year did not vary significantly over time which hindered us from collecting a wide range of data to fully measure and analyze this complex relationship. More data will be collected over the next couple of growing seasons to fully understand this relationship.

Sources Used:

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