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Middle Creek Water Assessment Using Water Quality Index (WQI)

Matt Beren & Ahmed Lachhab - Earth and Environmental Sciences, Susquehanna University

Susquehanna UNIVERSITY

Introduction

Middle Creek (Figure 1) is located in Snyder County, Pennsylvania and is surrounded by a large farmland area. The headwaters of this small stream starts at two separate branches, which merge and flow into Penns Creek, which discharges into the Susquehanna River. Water quality analyses were performed along Middle Creek by monitoring the chemical and physical properties. It is believed that high levels of pollution in the Susquehanna River and the Chesapeake Bay are caused by runoff from smaller upstream tributaries such as Middle Creek.

This study focuses on the analysis of water quality using individual measured parameters and Water Quality Index(WQI) in 11 sites along Middle Creek. The sites were labeled A, B, C, D, E, F, G, H, I, Walker Lake(WL) and Faylor Lake(FL). Middle Creek was split into three sections; Faylor Lake extension (G, FL, F), Walker Lake extension (I, WL, H) and sites A through E. This allowed us to depict trends in the data and show where exactly higher levels of measured parameters are located. The sites were sampled three times the first week, twice the second week and once a week for the last three weeks of monitoring. Temperature, pH, conductivity, TDS, DO and ORP were measured in the field using a YSI 556 MPS multimeter. Samples were tested to determine nutrient and ion levels. Four major nutrients (PO_4^{3-}, NO_2^-, NH_3 and NO_3^-) were measured using a DR2800 spectrophotometer while a Dionex ICS-2000 was used to measure anion & Cations concentrations. Values of C_i and P_i were determined for each parameter based off table 1. These values were plugged into the WQI in order to determine the water quality at each site along MC (Figure 2).

Table 1: Values for P_i and C_i pertaining to the parameters used to determine the WQI of Middle Creek.

	P_i	100	90	80	70	60	50	40	30	20	10	0
	C_i											
pH	1	7	7.0 - 8.0	7.0 - 8.5	7.0 - 9.0	6.5 - 7.0	6.0 - 9.5	5.0 - 10	4.0 - 11	3.0 - 12	2.0 - 13	1.0 - 14
K_E	2	< 0.75	< 1.00	< 1.25	< 1.50	< 2.00	< 2.50	< 3.00	< 5.00	< 8.00	< 12.00	> 12.00
TSS	4	< 20	< 40	< 60	< 80	< 100	< 120	< 160	< 240	< 320	< 400	> 400
NO_2^-	2	< 0.005	< 0.01	< 0.03	< 0.05	< 0.10	< 0.15	< 0.20	< 0.25	< 0.50	< 1.00	> 1.00
NO_3^-	2	< 0.5	< 2.0	< 4.0	< 6.0	< 8.0	< 10.0	< 15.0	< 20.0	< 50.0	< 100.0	> 100.0
NH_4	3	< 0.01	<.05	< 0.10	< 0.20	< 0.30	< 0.40	< 0.50	< 0.75	< 1.00	< 1.25	> 1.25
P	1	< 0.2	< 1.6	< 3.2	< 6.4	< 9.6	< 16.0	< 32.0	< 64.0	< 96.0	< 160.0	> 160.0
COD	3	< 5	< 10	< 20	< 30	< 40	< 50	< 60	< 80	< 100	< 150	> 150
BOD_5	3	< 0.5	< 2.0	< 3	< 4	< 5	< 6	< 8	< 10	< 12	< 15	> 15
DO	4	≥ 7.5	> 7.0	> 6.5	> 6.0	> 5.0	> 4.0	> 3.5	> 3.0	> 2.0	> 1.0	< 1.0
T (°C)	1	21/16	22/15	24/14	26/12	28/10	30/5	32/0	36/-2	40/-4	45/ -6	> 45/< -6

(J. Vicente et al., 2009)

Table 2: WQI Quality Scale

Water Quality Index	Quality Scale
91-100	Excellent water quality
71-90	Good water quality
51-70	Average water quality
26-50	Fair water quality
0-25	Poor water quality

(Yiu Ming et al., 2008)

$$WQI = \frac{(\sum_i P_i C_i)}{(\sum_i P_i)}$$

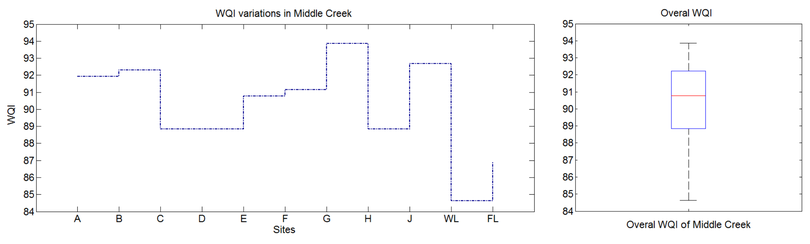

Figure 2: Average Water Quality Index value for all sites and overall WQI for MC.

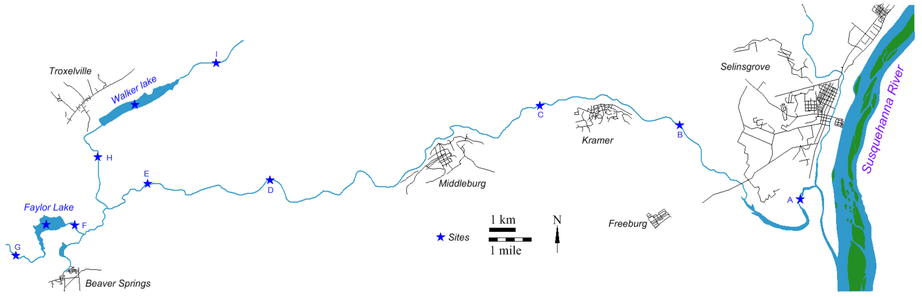

Figure 1: Middle Creek and the eleven sample sites marked as A, B, C, D, E, G, H, I, WL & FL.

Results

Physical Properties

- Conductivity (K_E) and Total Dissolved Solids (TDS) generally increased downstream.
- Dissolved oxygen (DO) varied along sites. Walker Lake and Faylor Lake had the highest dissolved oxygen concentrations. Sites D and E also showed very high concentrations. Site F (downstream Faylor) and site H (downstream Walker) both had the lowest concentrations of dissolved oxygen.
- pH varied among all sites but remained within the range of 8 and 10. Walker Lake and Faylor Lake had the highest pH of all sites
- Sites A-E showed similar temperatures. Walker Lake, Faylor Lake and site F had the warmest temperatures. Sites G and I had the coldest temperatures.

Chemical Properties

- Biochemical Oxygen Demand (BOD_5) varied among sites but remained fairly similar for all sites except for the lakes. The Lakes showed BOD_5 readings of 2.0 to 5.0. While the remaining sites showed readings of 0.5 to 2.0.
- Chemical Oxygen Demand (COD) varied among sites. Walker lake and Faylor lake had the highest measurements on average.
- Nitrite (NO_2^-) and phosphate (PO_4^{3-}) varied among sites. Very small concentrations were found at all sites.
- Very small concentrations of ammonia (NH_3) were found at each site. All sites had similar concentrations.
- Nitrate (NO_3^-), Chloride (Cl^-) and sulfate (SO_2^{-4}) concentrations were found to increase downstream.
- All sites had alkalinity values between 15 and 30 ppm.

WQI

- WQI allows for many parameters to be represented by one single number.
- WQI at each site varies due to differences in parameter values.
- Sites G and J had the highest WQI, while WL and FL had the lowest.
- The average WQI of MC was found to be 91. Based off table 2, MC has excellent water quality.
- Temperature, BOD_5 and pH are responsible for the low WQI values for WL and FL.
- Although WL and FL had the lowest WQI values of 85 and 87 respectively, table 2 indicates that the water is still of good quality.
- Site G is the headwater explaining the high WQI values.

Future Work

This is an ongoing Project. Anion concentrations will be measured using Ion Chromatography. Samples need to be collected on a weekly basis over an extended period of time in order to determine the effects of farmland on Middle Creek and its overall effect on Susquehanna River and eventually the Chesapeake bay.

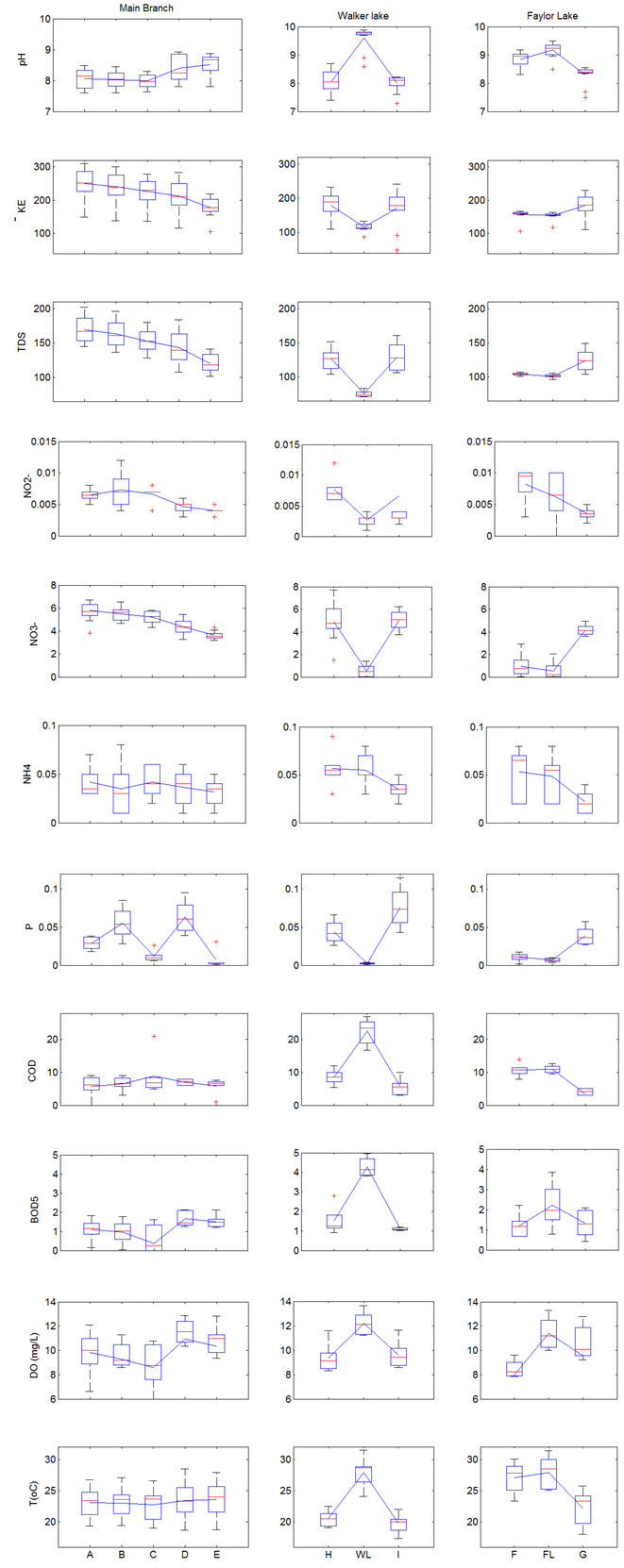

Figure 4: Parameters used for WQI

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