Spatiotemporal Analysis of Water Quality between 2017-2023 for Campus Creek, Manhattan, Kansas

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Introduction

- The function of water ecosystems and the services they provide depends upon a balance of factors in the environment:
  - Temperature
  - pH levels
  - Chemical concentrations
  - Physical conditions
  - Biotic interactions
- Urbanization has a wide range of impacts
  - Increasing pollutants from point and nonpoint sources:
    - Industrial processes
    - Lawn pesticides/fertilizers
    - Petroleum-powered vehicles
  - Increasing runoff due to greater areas of impermeable surfaces
  - Reducing biodiversity
  - Reducing quality of essential ecosystem services.
- K-State's Campus Creek is considered an urban stream that collects stormwater and overland flow surface runoff from the Campus Creek Watershed

- **Research Question:** What is the water quality of Campus Creek and how has it changed?
- **Objectives:**
  - Compare water quality across sampling sites to see if significant differences exist.
  - Determine if there is a significant trend in measures of water quality over time.
  - Derive a Water Pollution Index (aquatic ecology standards) to better quantify and visualize conditions in Campus Creek

Methods

- Sample Collection
  - 2017 – 3 sites and 3 sample periods
  - 2023 – 5 sites and 3 sample periods
- Data Analysis
  - One-Way ANOVA Test (Shapiro and Levene's Tests) followed by Tukey Honestly Significant Differences (HSD) Post-Hoc Test
  - Kruskal-Wallis Test followed by Dunn Post-Hoc Test
- Water Pollution Index (WPI)
  - Standardized WPI for Aquatic Ecology

$$PLi = 1 + \left(\frac{Ci - Si}{Si}\right)$$

    - Parameter Limits (PLi)
    - Observed Concentration of Parameter (Ci)
    - Standard Permissible Limit (Si)

$$WPI = \frac{1}{n}\sum_{i=1}^{n} PLi$$

  - WPI Categories
    - >0.5 Excellent Quality
    - 0.5 to 0.75 Good Quality
    - 0.75 to 1 Moderately Polluted
    - <1 Highly Polluted

Water Quality

- 2023
  - Temperature (°C)
  - Total Suspended Solids (mg/L)
  - Total Dissolved Solids (mg/L)
  - Total Solids (mg/L)
  - Electrical Conductivity (mS/cm)
  - pH
  - Total Nitrogen (ppm)
  - Total Phosphorus (ppm)
  - Total Chlorine (ppm)
  - Total Sulfur (ppm)
- 2017
  - pH
  - Electrical Conductivity (mS/cm)
  - Turbidity
  - Dissolved Oxygen
  - Total Solids (ppm)

Results

Summary Statistics for 2023

- ANOVA results there was a significant difference in nitrogen and sulfur between sites
- Shapiro test revealed residuals were not normal for pH and phosphorus, so Kruskal-Wallis test was used instead of ANOVA with not significant differences found.

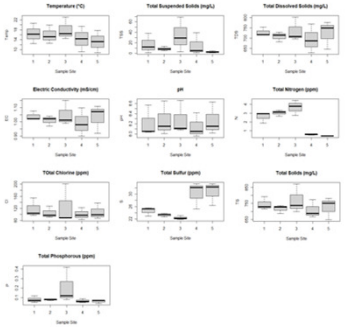

Fig. 1: Boxplots for all data collected in 2017 and 2023 for each pollutant organized by sample site.

			ANOVA Test		Kruskal-Wallis Test	
Pollutant	**Shapiro Test**	**Levene Test**	**F-Value**	**P-Value**	**Chi-Square**	**P-Value**
Temp (°C)	0.06907	0.9944	0.53469	0.7137		
TSS (mg/L)	0.3748	0.3912	1.0606	0.4248		
TDS (mg/L)	0.8962	0.7643	0.29431	0.8751		
TS (mg/L)	0.7484	0.8412	0.47039	0.7567		
EC (mS/cm)	0.8695	0.7812	0.27941	0.8847		
pH	0.001135*	0.9997			1.4886	0.8287
N (ppm)	0.1794	0.3838	26.52	0.000026 42*		
P (ppm)	0.003119*	0.3969			5.9577	0.2001
Cl (ppm)	0.09505	0.8811	0.23273	0.9137		
S (ppm)	0.1345	0.5978	6.5715	0.007348*		

Table 1: Results of Statistical Analysis.

2023 Site Analysis

- Total nitrogen significantly lower at sites 4 and 5 compared to sites 1, 2 and 3
- Total sulfur significantly higher at sites 4 and 5 compared to sites 1, 2 and 3

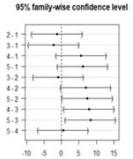

Fig. 2: Differences between sites in Total Sulfur.

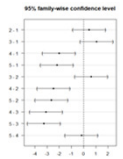

Fig. 3: Differences between sites in Total Nitrogen.

Water Pollution Index

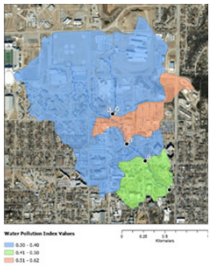

Fig. 5: 2023 WPI Values

- 2017 WPI Mean Value: 0.50195
  - Good Aquatic Ecological Value
- 2023 WPI Mean Value: 0.41092
  - Excellent Aquatic Ecological Value

Exceeded Standard Limits

- Total Suspended Solids
- Total Phosphorus

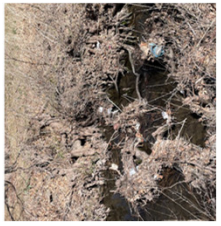

Fig. 6. Litter in Campus Creek near site 3.

2017-2023 Trend Analysis

Significant Changes

- Total solids has *increased significantly* over time.
- pH has shown a slight positive but *insignificant* increase.

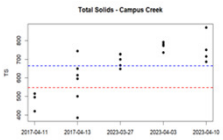

Fig. 4: Total Solids is significantly increasing over time; R^2 = 0.57

Conclusion

- 2023 WPI was 0.410572 (excellent water quality) versus 2017 WPI was 0.50195 (good water quality)
  - WPI for the Campus Creek Watershed has gotten better over time
- We weren't able to properly compare 2023 results with 2017 study because:
  - 2017 WPI was calculated using two variables versus 2023 WPI was calculated using nine variables
  - 2017 water samples were collected during different time periods
  - 2017 trend analysis graph was distorted, making it difficult to get accurate data points to compare with data from 2023

Recommendations

- Investigate further potential factors that are causing change in nitrogen and sulfur levels at sites 4 and 5
- Continue monitoring levels at same sampling areas to improve understanding of baseline conditions
  - Collect water at these locations twice a year, once during wet season in the spring and once during dry season in the fall
- Remove any litter or unwanted debris from the stream and surrounding area to create aesthetic beauty

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