

# Wet-Weather Conditions' Impact on Bacteria Concentrations in Union County

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## Abstract

**Purpose** - This study aims to investigate the impact of wet-weather conditions on bacteria concentrations in Union County waterways, taking into account the local geographical area. The research aims to assess water quality concerns and potential health risks for recreational activities.

**Motive** - Inspired by previous findings of bacterial contamination in Lewisburg's waterways, I sought to explore how the rural setting of Union County might influence the relationship between rainfall and bacteria levels in local water bodies.

**Design and Approach** - This study employs both a quantitative and exploratory approach, utilizing tools such as ArcGIS, statistical analysis, interviews with residents, and data visualization. The data itself was collected from fifteen sites during wet and dry conditions, and analyzed for various water quality parameters.

**Findings** - The results revealed that all monitored sites consistently showed bacteria concentrations above accepted levels, with a strong positive correlation between rainfall and increased *E. coli*, total coliform, turbidity, and flow rate during wet conditions. These findings provide evidence that the water bodies in Union County continue to stay polluted, impairing their recreational or general use.

**Value** - This research offers a novel perspective on the issue of water quality, providing insight through data analysis and graphical representation. These findings, in collaboration with the Buffalo Creek Watershed Alliance, contribute to the call for restoration efforts throughout Union County's waterways, highlighting the importance of a healthy water system.

## 1 Introduction

This project investigates the water quality in Union County and aims to understand if the waterways are impaired, through bacterial contamination, runoff pollution, and or nutrient concentrations. Using DEP sampling methods, laboratory tests, microbial source tracking (MST), and exploratory data analysis (EDA), we aim to identify and characterize pollution sources and types. This study builds upon previous years' research, collaboration with the Buffalo Creek Watershed Alliance (BWCA) to increase public awareness of the issue of water quality in Union County and drive change. This year's iteration introduces qPCR techniques, advancing from the gel-based PCR approaches used previously, allowing real-time data collection and analysis. The findings from this study could affect local environmental policies and conservation efforts, leading to a net improvement in the water quality in UC.

## 2 Background

Central Pennsylvania's landscape, rich in rural farmland, poses a potential public risk for recreational water-based activities. Past research shows that farm runoff can affect local water bodies, especially with the leakage of nutrients and farm effluents (Hooda *et al.*, 2000). Even so, the

impact of wet-weather events on nutrient concentrations—like nitrogen and phosphorus from fertilizers—and bacteria such as *E. coli* and Coliform remains unclear. With rainfall and outdoor activities peaking during the summer months (May - Sept.) in Central PA, there is a concern about the risk for those engaging in water recreation after wet-weather events.

Post-rainfall events often lead to increased total Coliform and *E. coli* counts (Hernandez *et al.*, 2020) (Ackerman and Weisberg, 2003), although this rise can dissipate within 24 hours due to natural water currents and the first flush effect (Kleinheinz *et al.*, 2009). It seems though that bacteria in water bodies are increasingly developing antibiotic resistance, which is critical for determining treatment options for polluted waterways. For instance, studies at California beaches found that 50% of isolated bacterial samples, both wet and dry, were resistant to ampicillin (Hernandez *et al.*, 2020).

## 3 Method

### 3.1 Field Sampling

When sampling, our taken samples adhered to the Pennsylvanian Department of Environment Protection (DEP) standards. A DEP representative assisted onsite for the initial sampling to showcase proper techniques, which was applied for subsequent sampling. One additional parameter was introduced for this year: flow rate, measured using a Hach FH950 handheld flow meter with a depth attachment. The device produced velocity and depth measurements, allowing us to calculate the estimated flow rates for the sites, which was later calculated in Excel.

Initially there were fourteen sites but added a fifteenth – Saint Mary’s Park – to address a specific research question. The list of sampling locations is shown below (Figure 1). The sites were chosen to capture a representative picture of the water quality across the Lewisburg area; Locations were added upstream and downstream of potential pollution sources, as well as sites in varying land use areas (agricultural, residential, etc) to capture a range of influences on water quality.

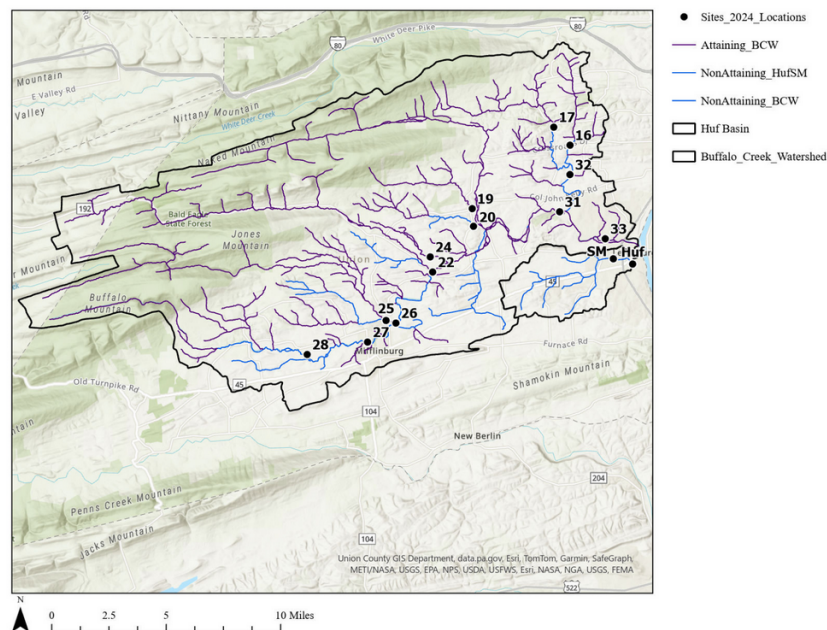


Figure 1: ArcGIS map of the fifteen chosen sites.

### 3.2 Labwork

A range of tests were performed on the fifteen collected samples within six hours of the collection, with the exception of bacteria extraction, which was done within 24 hours. Our analysis covered primarily water quality indicators: turbidity, total suspended solids (TSS), nitrate, nitrite, ammonia, and bacterial content (coliforms & *E. coli*). My primary goal was to assess how wet-weather events (rainfall greater than 0.25” on the previous or sampling day) affected bacterial concentrations.

For bacterial analysis, we used EC compact dry plates to test for *E. coli* and coliforms, applying dilution factors of 2, 5, and 10 as needed. We plated a 1 mL aliquot of the diluted sample, incubated it at 37°C for 24 hours, and calculated the CFU per 100 mL for each sampling location (Gamboa, 2023). These tests provided a thorough evaluation of water quality and its parameters, aiding our research question.

### 3.3 Analysis

Data and parameters collected in the field, such as pH, DO, conductivity, and temperature, were entered into an Excel spreadsheet for analysis. Lab experiment results were also added, with their calculated means and standard deviations as needed. We tracked discrete values, such as water volume filtered for DNA extraction, aiming for 0.9-1L (900-1000mL). Out of 111 samples, 69 (62.16%) met the target volume for DNA extraction.

My lab mates used GIS mapping tools, such as ArcGIS, to create maps to showcase catchment areas for all sampling sites and to identify land use patterns. They were able to integrate parcel identification data to highlight manure application, and to pinpoint nutrient (nitrogen, phosphorus, etc) hot spots. This visual application assisted in connecting land use practices with water quality, and determine the effect of geography to water quality

## 4 Results

### 4.1 Water Parameters

The data showcases a clear consensus: that all fifteen monitored sites continue to show bacteria concentrations above accepted levels. The box and whiskers plot (Figure 2) reveals that both mean and median *E. coli* concentrations surpass the Pennsylvania Department of Environmental Protection's limit of 200 CFU/100mL. This finding follows previous years' work and reinforces the water quality concerns in the Lewisburg area.

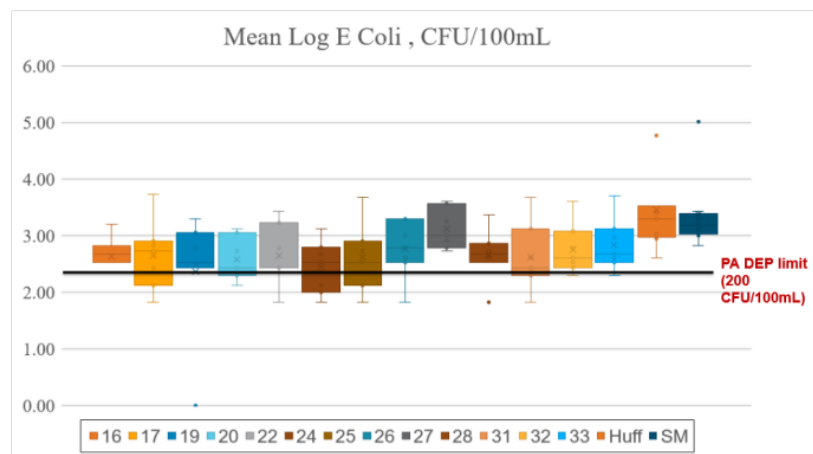


Figure 2: Box and whiskers plot of *E. coli* concentrations.

### 4.2 Correlation Matrix

The spearman correlation (Figure 3).analysis of the parameters obtained at the Huff and SM sites, during both wet and dry conditions, reveals a series of relationships. A positive correlation ( $r_s = 0.5$ ) was found between the following: total nitrogen (TN) and conductivity, rainfall and turbidity, rainfall and *E. coli*, *E. coli* and total coliform (TC), *E. coli* and turbidity, and turbidity and TSS. A negative correlation ( $r_s = 0$ ) was found between the following: Dissolved oxygen (DO) and TC, DO and *E. coli*, DO and temperature.

A spearman correlation done only on wet samples ( $n = 22$ ) collected from May 23 to July 11 (Figure 4).showcased other interesting relationships. The heatmap highlighted a positive and strong correlation between rainfall and several parameters: flow rate, turbidity, *E. coli*, and TC concentrations. This analysis showcases that wet conditions have a direct correlation with the decrease of water quality and increase of bacterial growth.



Figure 3: Correlation heat map of all major water quality parameters observed at the fifteen sites..

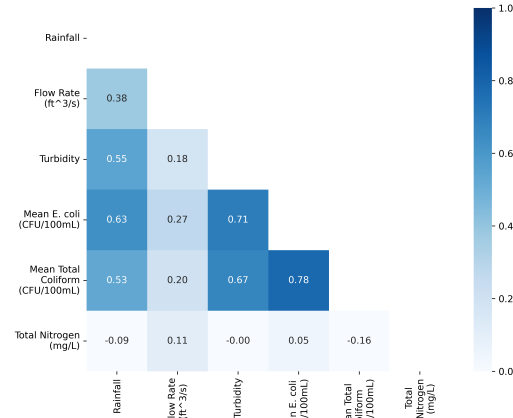


Figure 4: Correlation heat map of specific water quality parameters observed at the Huff and SM sites.

## 5 Conclusion

### 5.1 Impact

This research seeks to facilitate environmental improvement, with the objective of elevating Union County's waterways to meet the DEP's health standards for recreational use. By assessing critical water quality data, this study empowers Lewisburg and adjacent community residents to make evidence-based decisions regarding the safety of local water sources. In collaboration with the Buffalo Creek Watershed Alliance (BCWA), this research aims to enhance water management strategies and advocate for enhanced safety protocols, thereby fostering community awareness and promoting the long-term sustainability of regional ecosystems.

### 5.2 Future Work

Performing a t-test to find a statistical significance between the two sampling sites (Huff and SM) and seeing if they are statistically significant. I would also like to continue working on my personal project, which aimed to automate the bacteria counting process using Python and the OpenCV2 library.

## References

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