Analysis of *E. coli* concentrations along the Ohio River between New Cumberland and Moundsville, WV

Emily Huff[1,2], James Wood[1,3]
[1] Department of Organismal Biology, Ecology and Zoo Science, West Liberty University, 208 University Drive, West Liberty, West Virginia 26074 USA
Emails: [2] ethuff@westliberty.edu, [3] james.wood@westliberty.edu

Introduction

The expansion of urban development has affected stream chemistry and biology in many ways (Lewis et al., 2007) in part due to increased impervious surfaces like roads, driveways, and parking lots which decrease stormwater infiltration (Davies & Bavor, 2000). Stormwater runoff can contain various pollutants (e.g. salts, metals, nutrients)(Arnone & Walling, 2007) but also pathogens such as the *Escherichia coli* bacterium (Scott et al., 2002). In cities with older infrastructure like those in the Ohio River valley, stormwater mixes with sewage in sewer pipes and can be discharged into waterways through combined sewer overflows (CSOs). *Escherichia coli* is commonly present in the intestinal tracts of humans and other warm-blooded animals (Ishii et al., 2006) and is used as an indicator of the presence of other pathogen contamination (Izbicki et al., 2009). The USEPA set a standard for recreational waters for single sample readings of 235 CFU/100ml and a geometric mean of 126 CFU/100ml from five samples over 30 days (USEPA, 1986).

In this study, our goal was to assess *E. coli* concentrations in the upper Ohio River valley in West Virginia between the cities of New Cumberland and Moundsville to assess if E. coli concentrations were safe for recreational waters following EPA limits.

Methods

Seven sites along the Ohio River were sampled between May 8th and June 6th, 2024 (Figure 1). The most upstream sites, OhRv07 was located at a boat launch in New Cumberland WV, OhRv06 was located at the 12th street boat launch in Wellsburg WV, OhRv04 was located at a popular river access location in Warwood WV slightly upstream where an acid mine drainage impacted stream enters the Ohio River, OhRv02 was also located in Warwood behind Warwood Middle School, OhRv01 was located near 5th street in North Wheeling WV, OhRv03 was located in downtown Wheeling WV, just downstream of the confluence of Wheeling Creek and the Ohio River, and the most downstream location, OhRv05, was located at the boat ramp at River Front park in Moundsville, WV (Table 1).

The first sampling event occurred on 8 May and only included OhRv01, OhRv02, and OhRv03. Water samples were collected in triplicate and average. The next sampling events occurred on 23 May, 31 May, and 6 June and included all seven sites (Figure 1) where at each site a single water sample was taken and processed for *E. coli.*

At each site, a water sample was collected from the surface a few feet from the river bank using a sterile 100ml collection bottle. Following IDEXX (n.d.) protocol samples were stored on ice and processed within 6 hours of collection. A field blank of sterile water from the laboratory was also transported and processed as a control with each batch of samples to identify any cross contamination that may have occurred. Samples were diluted with sterile water (10% stream water and 90% sterile water) to ensure *E. coli* concentrations were within the measurable range of the IDEXX system 2,419.6 CFU/100mL at 100% stream water. Next, Colilert growth media was added to each sample, and each sample was sealed in an IDEXX 97 well Quanti-tray. Then the Quanti-trays were sealed and incubated at 37°C for 24 hours, then the results were read.

Water chemistry parameters were measured concurrently with *E. coli* samples when being collected. Water temperature (°C), dissolved oxygen (DO; mg/L), specific conductivity (SPC; µS/cm), chloride (mg/L), and pH were collected in the field using a calibrated YSI Quatro handheld field meter, while turbidity (NTU) was collected using a calibrated Hach 2100Q portable turbidimeter. Mean *E. coli* concentrations were calculated using the geometric mean from all sampling dates.

Results

During this study, the sites upstream of Wheeling WV and Martins Ferry OH were always below the EPA safe limit of 235 CFU/100ml for a single sample reading (Table 1; Figure 2) while the sites below the confluence of Wheeling Creek were always above the EPA threshold. Sites OhRv07, OhRv04, OhRv02, and OhRv01 were below the EPA averaged threshold for geometric mean of 126 CFU/100ml. Mean *E. coli* increased over 7x between the North Wheeling site (OhRv01) and the site in downtown Wheeling (OhRv03) located just below the confluence with Wheeling Creek (Table 1). The highest *E. coli* concentrations were found at the Moundsville sampling location where mean *E. coli* was over 10x the EPA safe limit for recreation. There was low variation in water chemistry between sites (Table 2).

Discussion

Our data broadly suggests the Ohio River is safe for recreation above 5th street in North Wheeling, but our data also indicates concerns about water quality below 5th street. While out data does not identify specific sources of *E. coli*, several CSOs are located on Wheeling Island and at 5th St. near the I-70 bridge and upstream of the confluence of Wheeling Creek; all which could be responsible for considerable increases in E. *coli* in the Ohio River between our 5th street sampling location (OhRv01) and below the confluence (OhRv03).

Wheeling Creek may be contributing substantially to the Ohio River's *E. coli* concentrations as multiple CSOs are located along the creek and previous studies have indicated high *E. coli* loads in Wheeling Creek, possibly from CSO, leaking infrastructure, or illicit discharges (Huff & Wood, 2023; O'Connor & Wood, 2021). The sources of the extremely high *E. coli* concentrations at OhRv05 in Moundsville are unknown. Sources of *E. coli* likely come from both Ohio and West Virginia. Additionally, large flocks of Canada geese have been observed along the banks of the river in all area's samples and may contribute considerable quantities of *E. coli*.

Monitoring *E. coli* along the Upper Ohio River provides valuable insight into water quality in the region and can support recreation and economic development in the region's communities. While additional investigation is needed to identify and mitigate sources of *E. coli* near the cities of Wheeling and Moundsville WV and Bridgeport and Martins Ferry OH, the findings of low *E. coli* between New Cumberland and 5th street in North Wheeling suggest that portions of the Ohio River are generally safe for recreation (as assessed by *E. coli* loading at these selected access points) and represent considerable improvements in water quality in the Ohio River over the last 50 years

Literature Cited

Arnone, R. D., & Walling, J. P. (2007). Waterborne pathogens in urban watersheds. *Journal of Water and Health*, *5*(1), 149–162. https://doi.org/10.2166/wh.2006.001

Davies, C. M., & Bavor, H. J. (2000). The fate of stormwater-associated bacteria in constructed wetland and water pollution control pond systems. *Journal of Applied Microbiology*, *89*, 349–360.

Huff, E., & Wood, J. (2023). Analysis of Fecal Bacteria in the Wheeling Creek Watershed. In *West Liberty University*. West Liberty University.

IDEXX. (n.d.). *Colilert - IDEXX US*. Retrieved April 26, 2023, from https://www.idexx.com/en/water/water-products-services/colilert/

Ishii, S., Ksoll, W. B., Hicks, R. E., & Sadowsky, M. J. (2006). Presence and growth of naturalized Escherichia coli in temperate soils from Lake Superior watersheds. *Applied and Environmental Microbiology*, *72*(1), 612–621. https://doi.org/10.1128/AEM.72.1.612-621.2006

Izbicki, J. A., Swarzenski, P. W., Reich, C. D., Rollins, C., & Holden, P. A. (2009). Sources of Fecal Indicator Bacteria in Urban Streams and Ocean Beaches, Santa Barbara, California. *Annals of Environmental Science*, *3*, 139–178. www.aes.northeastern.edu,

Lewis, G. P., Mitchell, J. D., Andersen, C. B., Haney, D. C., Liao, M. K., & Sargent, K. A. (2007). Urban influences on stream chemistry and biology in the Big Brushy Creek watershed, South Carolina. *Water, Air, and Soil Pollution*, *182*(1–4), 303–323. https://doi.org/10.1007/s11270-007-9340-1

O'Connor, A., & Wood, J. (2021). *E. coli trends and identification of bacteria in stream water along a rural to urban gradient*.

Scott, T. M., Rose, J. B., Jenkins, T. M., Farrah, S. R., & Lukasik, J. (2002). Microbial source tracking: Current methodology and future directions. *Applied and Environmental Microbiology*, *68*(12), 5796–5803. https://doi.org/10.1128/AEM.68.12.5796-5803.2002

USEPA, U. S. E. P. A. (1986). *Ambient Water Quality Criteria for Bacteria*.

Tables and Figures

Table 1. Geometric mean at each site, reported in the most probable number of colony forming units (CFU), latitude, longitude and site description of where each site was located

Site	Geometric Mean	Latitude	Longitude	Site Description
OhRv07	108	40.4997	-80.6124	New Cumberland, boat launch
OhRv06	148	40.27523	-80.61369	Wellsburg, crocked dock boat launch
OhRv04	32	40.12413	-80.70467	Warwood, upstream of confluence with Glenn's Run (off Heritage Trail)
OhRv02	87	40.113013	-80.702668	Warwood, near Warwood Middle School
OhRv01	126	40.07797	-80.727592	North Wheeling, off 5th street
OhRv03	892	40.062042	-80.726023	Downtown Wheeling, below confluence of Wheeling Creek and the Ohio River
OhRv05	1261	39.91274	-80.75234	Moundsville, Riverfront Park boat launch

Table 2. Summary data of water chemistry values for each site. Each value represents the geometric mean. SPC = specific conductivity (µS/cm), Temp = temperature (°C), NTU = turbidity, DO = dissolved oxygen (mg/L), Cl = chloride (mg/L).

Site	SPC	Temp	pH	NTU	DO	Cl
OhRv07	359	21.9	7.47	9.21	8.64	17.3
OhRv06	359	22.0	7.61	11.9	8.44	17.9
OhRv04	356	22.4	7.55	11.6	8.53	21.5
OhRv02	353	21.5	7.64	14.4	8.52	16.8
OhRv01	352	21.4	7.62	23.5	8.39	15.9
OhRv03	429	21.5	7.90	21.1	7.69	15.5
OhRv05	375	22.8	7.65	21.3	8.27	18.1

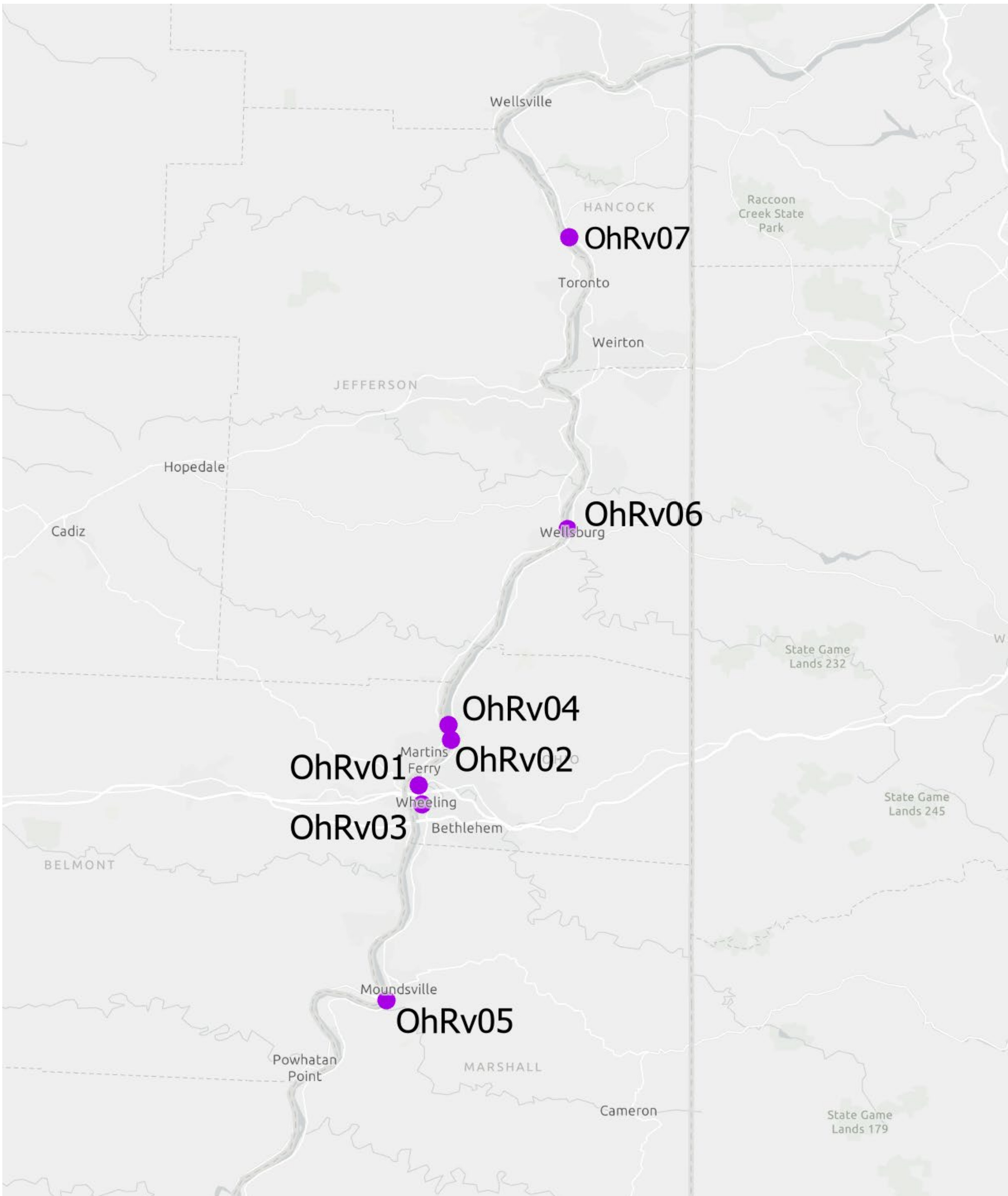

Figure 1. Map of sampling locations along the Ohio River

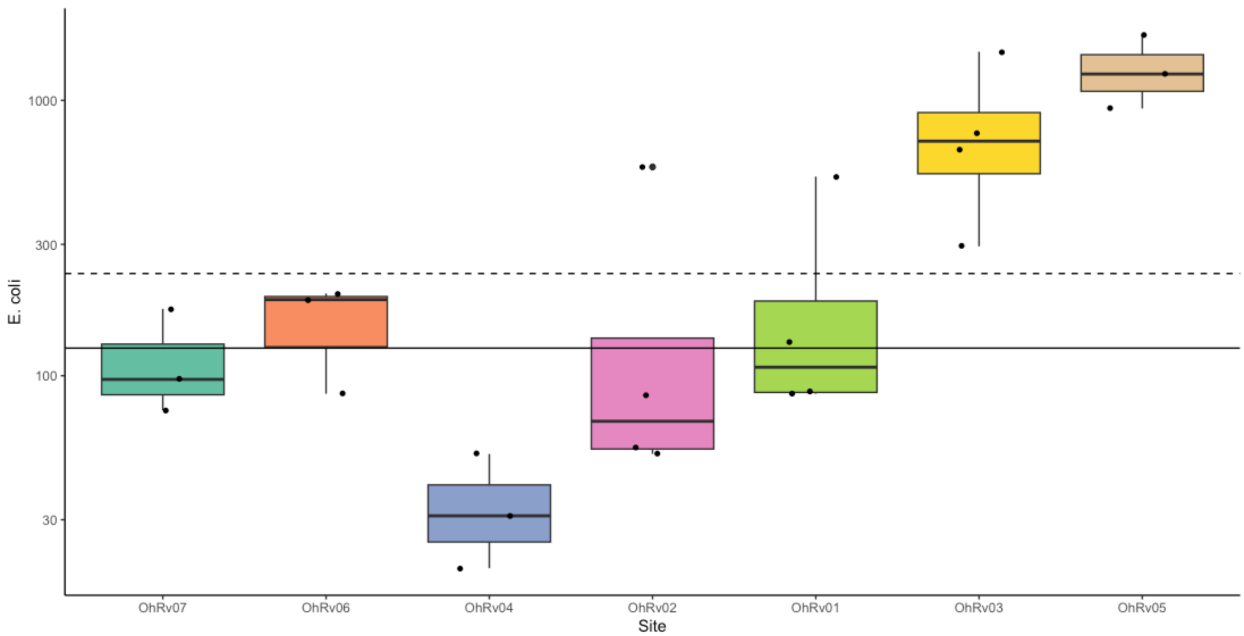

Figure 2. Boxplot of sampling on the Ohio River arranged from upstream (left) to downstream (right). The dashed line indicates the 235 CFU/100ml single sample safe limit and the solid line indicates the 126 CFU/100ml geometric mean safe limit.

OhRv02, downstream in Warwood, WV, 2/17/23


OhRv01, downstream in North Wheeling, WV, 10/20/20


OhRv03, upstream in Wheeling, WV, 5/23/24

OhRv02, downstream in Warwood, WV, 10/18/21

OhRv01, upstream in North Wheeling, WV, 10/20/20


OhRv01, downstream in North Wheeling, WV 9/30/20

OhRv02, upstream in Warwood, WV, 4/19/22

OhRv02, downstream in Warwood, WV, 9/6/19


OhRv02, upstream in Warwood, WV, 6/27/22