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Session 3A: Karst and Groundwater

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Session 3A: Karst and Groundwater

Examining the Utility of Tryptophan-Like Fluorescence As a Proxy for Fecal Contamination in Karst Basins, Inner Bluegrass Region, Kentucky*

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In karst terrain, the integration of surface and subsurface drainage along solution-enhanced flow paths facilitates the movement of microbes between surface water and groundwater. Fecal pathogens from leaking or overflowing sanitary sewers, failing septic systems, wastewater discharge, and agricultural and urban runoff can contaminate water resources. Simple fecal indicators such as *E. coli* bacteria are commonly used to assess water quality with respect to enteric pathogens. However, the need for culturing and incubation prior to enumeration limits the utility of these indicators. Dissolved organic matter (DOM), notably tryptophan-like fluorescence (TLF), has been positively correlated with *E. coli* and other thermotolerant coliforms (Sorensen et al., 2015, 2018; Ward et al. 2020, 2021) and can be monitored with real-time sensors. TLF describes the portion of DOM that is excited at ~280 nm and emits at ~350 nm. Other DOM components (such as humic-like and tyrosine-like fluorescence) can also be used for assessing water quality, but several studies have suggested that, in freshwater environments impacted by sewage, TLF most commonly comes from protein molecules sourced from microbes. Consequently, TLF is likely a good proxy for microbial activity, but few studies of TLF have been conducted in karst systems or in the USA.

We are examining the utility of TLF monitoring for two karst basins in central Kentucky. The Cane Run/Royal Spring basin in Fayette and Scott counties encompasses both urban and agricultural land uses, whereas the Camden Creek basin in Woodford County is agricultural. Royal Spring, which supplies water to the City of Georgetown, and Camden Creek were collected via grab samples for *E. coli* and DOM analysis weekly from June 9, 2021, to June 22, 2022. TLF was monitored at 15-minute intervals with submerged fluorometers at Royal Spring from August 4 to December 22, 2021, and from March 11 to June 22, 2022. Storm monitoring was also conducted at Royal Spring from May 5 to 7, 2022, when water samples were collected hourly during a 26-hour period and tested for *E. coli*. Preliminary results show similar *E. coli* ranges at both sites (<1 to 4839 MPN/100 mL at Royal Spring; <1 to 3255 MPN/100 mL at Camden Creek). TLF concentrations ranged from 1 ppb to 1460 ppb at Royal Spring. During storm monitoring at Royal Spring, *E. coli* values ranged from 138.2 to 2092 MPN/100 mL and TLF values ranged from 28.9 ppb to 40.9 ppb. Both *E. coli* and TLF concentrations peaked over periods of hours following storms. At Royal Spring, TLF is correlated to *E. coli* for samples in the August–December dataset ($r^2 = 0.73$, Spearman's $\rho = 0.63$, $n = 21$) but not in the March–June dataset ($r^2 = 0.19$, Spearman's $\rho = 0.34$, $n = 41$). When TLF values are adjusted to account for differences between sensors and calibration standards and the combined datasets are plotted together, a linear trend is evident ($r^2 = 0.71$) for *E. coli* counts >500 MPN/100 mL (Figure 1). Therefore, TLF may be useful as a preliminary, real-time surrogate for *E. coli* at elevated concentrations.

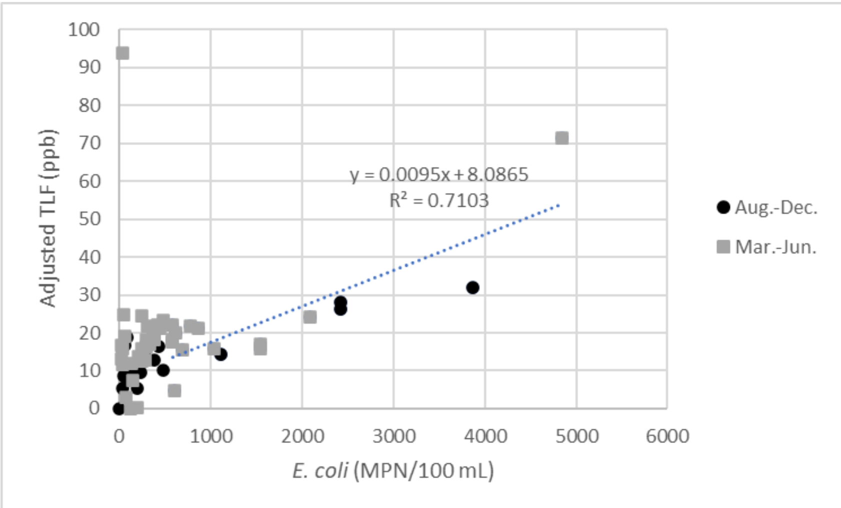

Figure 1. TLF concentrations adjusted for differences in calibration ranges plotted against *E. coli* concentrations. Dashed line represents linear regression for combined data sets with *E. coli* values >500 MPN/100 mL.

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A Predictive Flood Model for Urban Karst Environments

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Urban karst environments are often plagued by groundwater flooding, a type of flooding where water rises from the subsurface to the surface through the underlying caves and karst features. The heterogeneity and duality of karst systems make them very unpredictable, especially during intense storm events; urbanization exacerbates the problem with the addition of many impervious surfaces. Residents in such areas are frequently disturbed and financially burdened by the effects of karst groundwater flooding. The Federal Emergency Management Agency (FEMA) offers limited protection to citizens living near flood-prone karst areas, as they primarily focus support on the areas near surface streams and water bodies. The City of Bowling Green, Kentucky is one of the largest cities in the United States built entirely upon karst and experiences frequent, unpredictable groundwater flooding making it the ideal study area for this project. This research will attempt to aid the flooding problem in Bowling Green, with the creation of a predictive flood model for the Lost River Basin – a 150km^2 groundwater basin that contains most of the city. The model will be created primarily by analyzing relationships between precipitation, antecedent conditions, and the fluctuation of the potentiometric surface. High-resolution data monitoring will be employed to ensure accuracy of the model. As a result, this study will allow residents to better prepare for rain events, offer additional information on the storage and response times of an urban karst aquifer, and create a strong methodology for other flood-prone, urban karst areas to utilize for flood prediction.

Improving Best Management Practices for the Siting, Maintenance, and Design of Urban Karst Groundwater Injection Wells*

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Class V injection wells in urban karst areas generally lack effective regulation and guidance to prevent sediment and pollutants from entering surface and groundwater supplies. Bowling Green, Kentucky, is home to over 1,500 mapped Class V wells; pollutants can flow unimpeded through these wells, impairing water quality and causing well obstruction. Of the documented wells within Bowling Green, hundreds are partially or fully obstructed, leading to chronic flooding throughout the city. The objective of this study is to determine proper management practices for drilling, maintaining, and closing injection wells by monitoring injection well performance in the City of Bowling Green. Historic data on well obstruction, well drainage, and geographic variables (landuse, flood zones, impervious surface area, etc.) will also be mapped and analyzed within ArcPro. Relationships between Class V well obstruction and said variables will then be used to implement intentional, practical recommendations on the design; siting; and maintenance of wells, particularly structural BMPs designed to improve long-term well performance. These data should lead to science-based policy recommendations on Class V injection well implementation and maintenance, which could result in improvements in flood control and stormwater runoff quality.

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