Widespread presence of cyanotoxins and taste-and-odor compounds within benthic algae of human-disturbed rivers

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INTRODUCTION

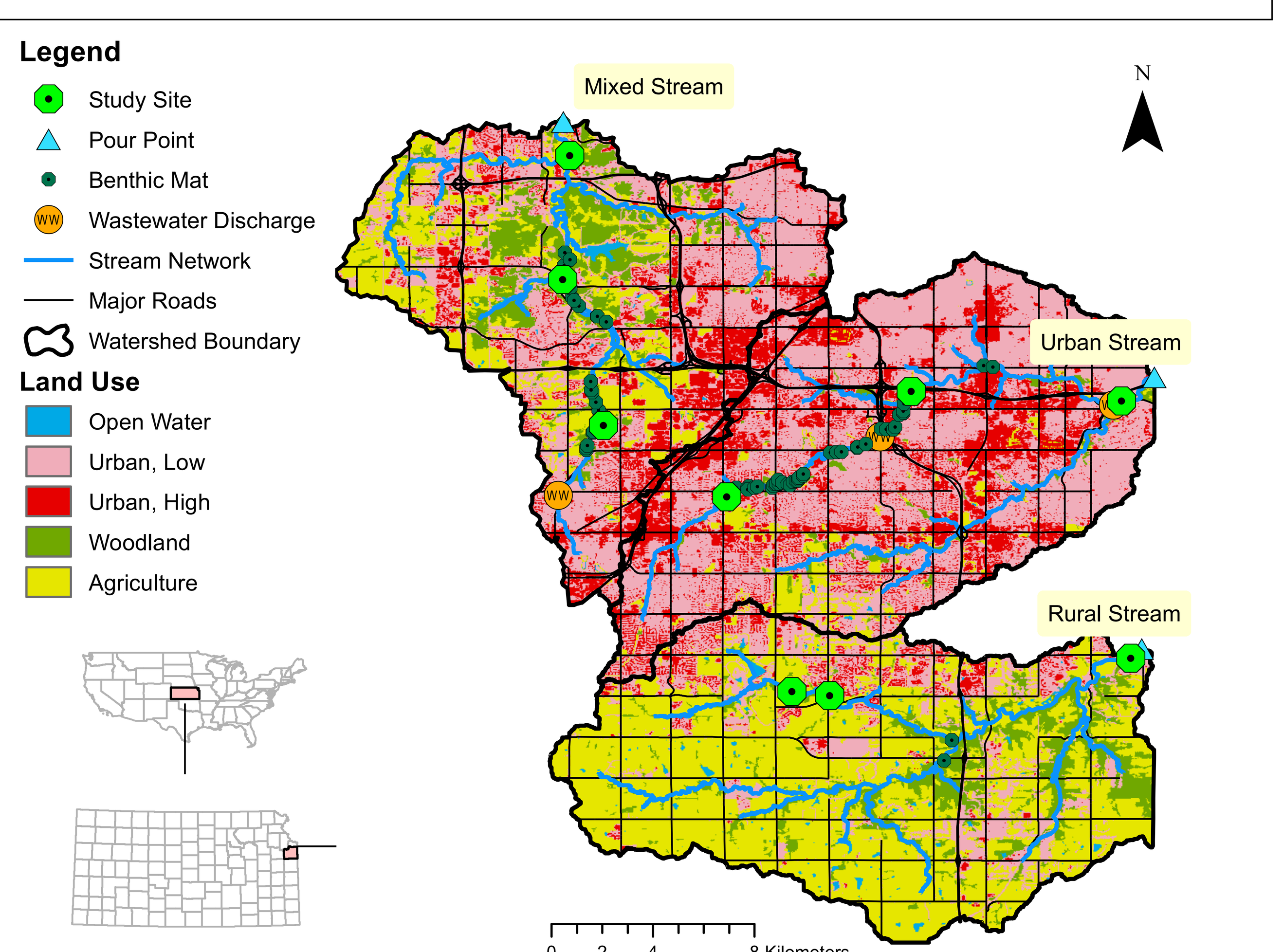
Cyanobacteria have been found to release a variety of metabolites, including nuisance taste-and-odor (T&O) compounds and harmful cyanotoxins. Taste-and-odor compounds make the public skeptical of safe drinking water and are expensive to treat. Cyanotoxins cause liver and nerve damage and have been linked with livestock and pet deaths. Benthic algae are less understood compared to their planktonic counterparts and the variables that promote the production and release of toxins are poorly understood.

With this study, we investigate how urbanization of freshwater stream ecosystems impacts the concentrations of cyanotoxins (microcystin, anatoxin-a, and saxitoxin) and T&O compounds (geosmin and MIB) and their gene sequence concentrations.

RESEARCH OBJECTIVES

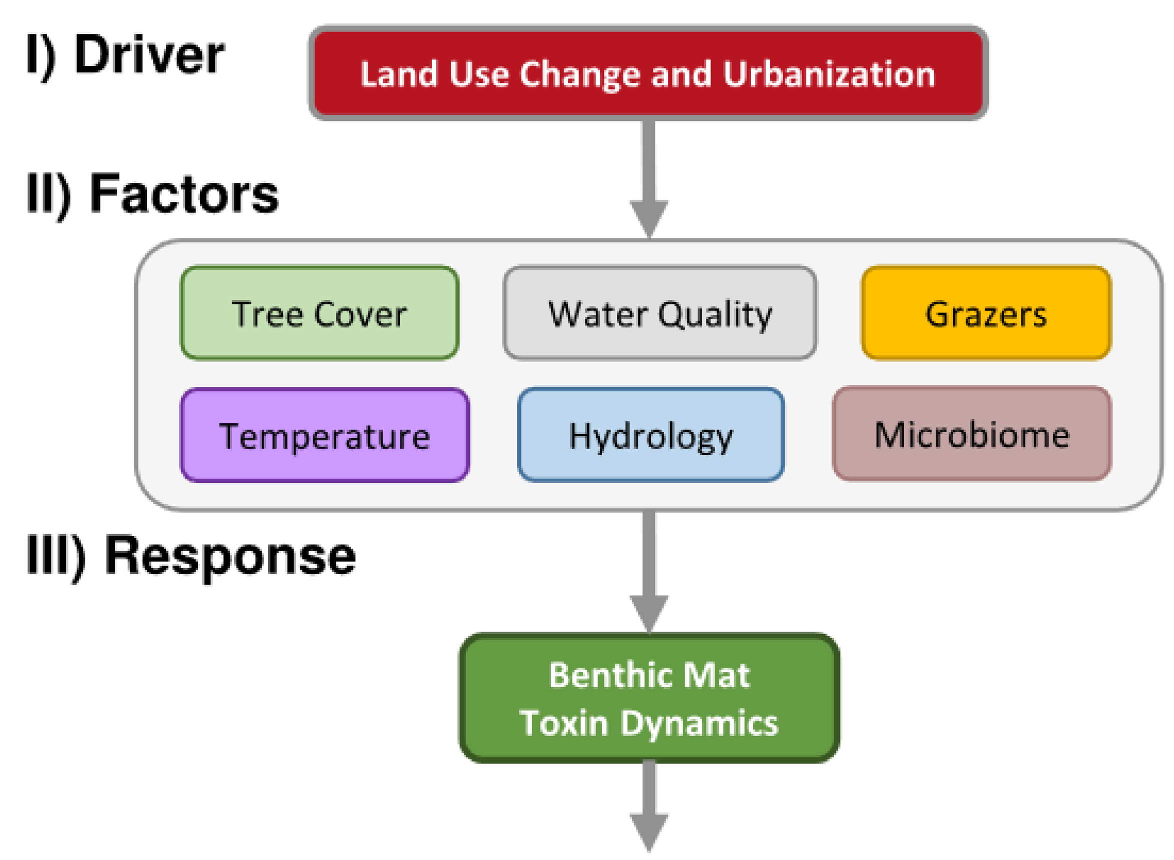
1) To analyze the physicochemical and biological impacts on cyanotoxin and T&O compound concentrations and their respective gene sequence concentrations
2) To relate land-use impacts on water quality and cyanotoxin and T&O concentrations

STUDY SITE



Our study sites are three streams with stark land uses differences in Johnson County, KS: Indian Creek (90% urban), Mill Creek (62%), and Blue River (21%). Apart from land use, the watersheds are similar providing a testbed for assessment of land-use impacts.

CONCEPTUAL MODEL



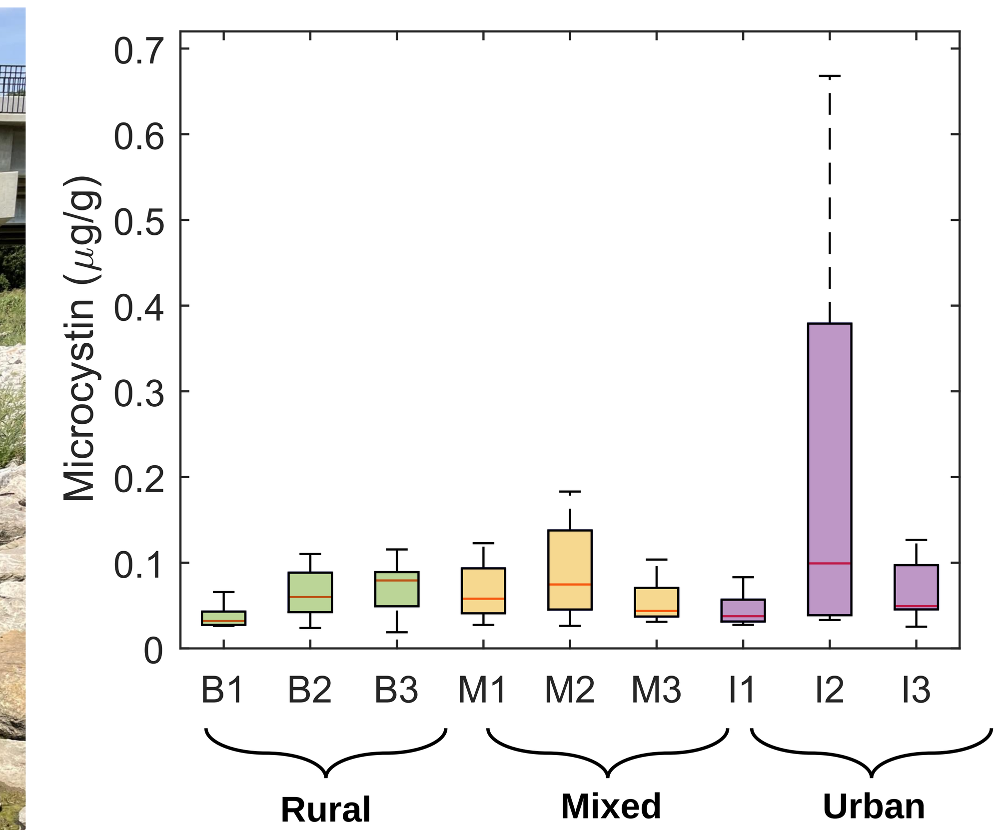
Sites	Substrates	Sensor Readings	Physical Readings	Data Points	Lab Tests
Indian Creek (90% urban) (3 sites) Mill Creek (62% urban) (3 sites) Blue River (21% urban) (3 sites)	Water column	Horiba In situ water quality	4 water samples 2 filtered with 0.45-micron filter	From Horiba: temperature pH conductivity turbidity DO	From Biogeochemistry: TSS, TOC N & P
	Benthic Algae	BenthoTorch In situ benthic algae biomass	15 cobbles gathered 2 algae scrapes per cobble	From BenthoTorch: algae biomass From ruler: mat thickness	From algae: Isotopes Taxonomy From toxins: qPCR, ELISA GC/MS

SAMPLE COLLECTION & TOXIN ANALYSIS

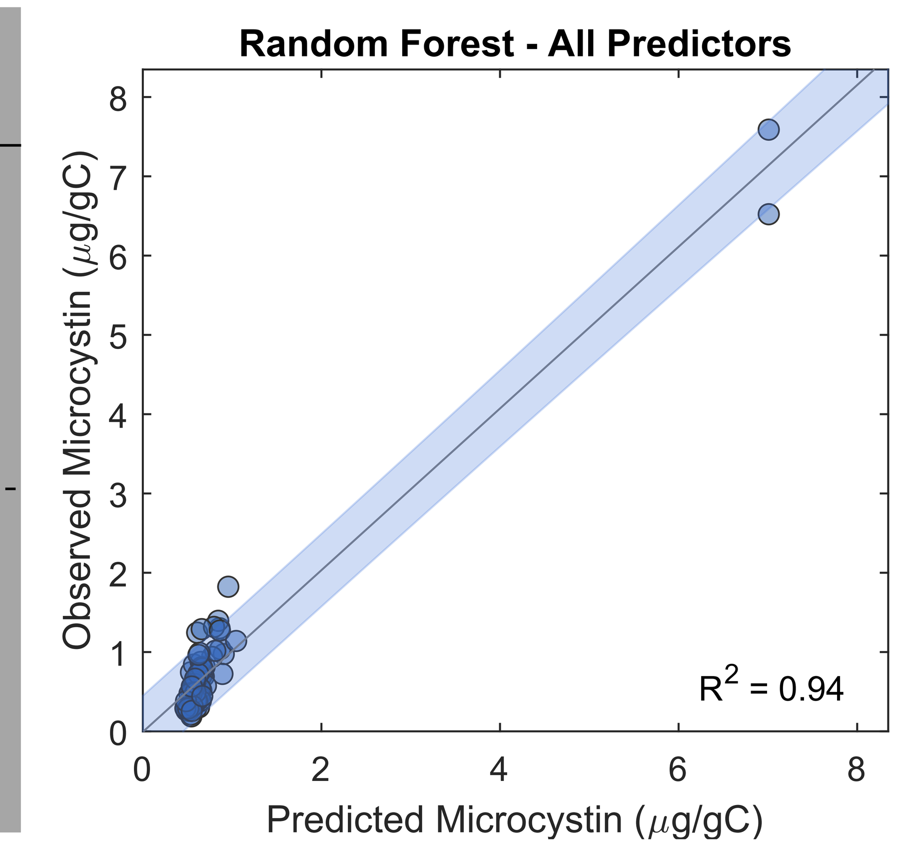
Sample Collection: 9 sample runs performed from August into November of 2021. Sediment, nutrients, and dissolved organic carbon samples sampled from water. Benthic algae samples are scraped from 15 cobble from each site in an aggregate sample. Two field sensors are utilized: Horiba U-52 for water and chemical parameters and the BBE Moldaenke BenthoTorch for algae community composition.

Toxin Analysis: Intracellular toxins and compounds are extracted from the algae by lysing the cells in freeze-thaw cycles. The extracted solution is analyzed for toxin concentration (microcystin, anatoxin-a, and saxitoxin) via ELISA kits, T&O compounds (geosmin and MIB) on an GC-MS, and toxin-producing gene abundance analysis via qPCR.

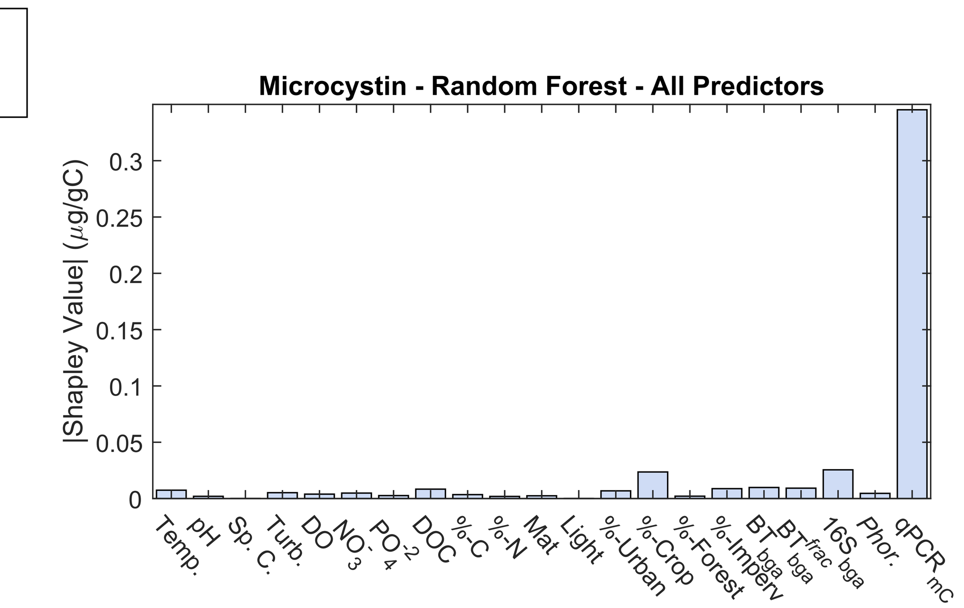
RESULTS



Microcystin and geosmin were detected in all benthic algae samples, whereas anatoxin-a, saxitoxin, and MIB were found in 65%, 26%, and 84% of samples, respectively.



Predictive models utilized data from physicochemical and biological data points from the water and algae scrape samples. Random forest models showed stronger R^2 than comparative linear regression models.



Shapley values that show for microcystin production, mycE gene abundance, cyanobacteria gene counts, temperature, and Sp. Cond. are dominant predictors.

CONCLUSIONS

Cyanotoxins and T&O compounds were prevalent in many algae samples. While urbanization did not show any strong correlations to cyanotoxin or T&O concentrations, our results do suggest that any human-derived environmental impact, whether urbanization or ruralization, can lead to the occurrence of cyanotoxins and T&O compounds within freshwater benthic mats.

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