Water Research 219 (2022) 118526

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Connecting microbial, nutrient, physiochemical, and land use variables for the evaluation of water quality within mixed use watersheds

Matthew T. Flood [a,*], J. Sebastian Hernandez-Suarez [b], A. Pouyan Nejadhashemi [b], Sherry L. Martin [c], David Hyndman [d], Joan B. Rose [a]

[a] Department of Fisheries and Wildlife, Michigan State University, East Lansing MI 48824, USA
[b] Department of Biosystems and Agricultural Engineering, Michigan State University, East Lansing MI 48824, USA
[c] Department of Earth and Environmental Sciences, Michigan State University, East Lansing MI
[d] Department of Geosciences, School of Natural Sciences and Mathematics, University of Texas at Dallas, Richardson TX, 75080, USA

ARTICLE INFO

Keywords:
Microbial source tracking
Watershed
Land use
Nutrients
Fecal pollution
Streamflow

ABSTRACT

As non-point sources of pollution begin to overtake point sources in watersheds, source identification and complicating variables such as rainfall are growing in importance. Microbial source tracking (MST) allows for identification of fecal contamination sources in watersheds; when combined with data on land use and co-occuring variables (e.g., nutrients, sediment runoff) MST can provide a basis for understanding how to effectively remediate water quality. To determine spatial and temporal trends in microbial contamination and correlations between MST and nutrients, water samples ($n = 136$) were collected between April 2017 and May of 2018 during eight sampling events from 17 sites in 5 mixed-use watersheds. These samples were analyzed for three MST markers (human – B. theta; bovine – CowM2; porcine – Pig2Bac) along with *E. coli*, nutrients (nitrogen and phosphorus species), and physiochemical paramaters. These water quality variables were then paired with data on land use, streamflow, precipitation and management practices (e.g., tile drainage, septic tank density, tillage practices) to determine if any significant relationships existed between the observed microbial contamination and these variables. The porcine marker was the only marker that was highly correlated (p value <0.05) with nitrogen and phosphorus species in multiple clustering schemes. Significant relationships were also identified between MST markers and variables that demonstrated temporal trends driven by precipitation and spatial trends driven by septic tanks and management practices (tillage and drainage) when spatial clustering was employed.

1. Introduction

Non-point sources of pollution have significant impacts on water quality and create health risks through a variety of hazards, including the spread of pathogens, eutrophication, harmful algal blooms, and increased sedimentation (Bullerjahn et al., 2016; Smith et al., 2015; Vermeulen et al., 2015; Sharpley et al., 2015; Wen et al., 2017; Mateo-Sagasta et al., 2018; Zandaryaa and Mateo-Sagasta, 2018). Overland agricultural runoff is being recognized around the world as having increased impacts on water quality, overtaking known urban and industrial sources as the most prominent contributors to eutrophication of coastal and inland waters particularly in some high-income nations (OECD, 2012; USEPA, 2012; Bonsch et al., 2015; OECD, 2017; Mateo-Sagasta et al., 2018). For example, agricultural runoff has been found to contribute up to 44 and 58% of the phosphorus and nitrogen, respectively entering the Laurentian Great Lakes (United States of America) (Robertson and Saad, 2011). Understanding these impacts on water quality is important in areas such as the state of Michigan, which has three times more agricultural than urban land cover, and has seen an increase in manure application, irrigated land, and the use of organic fertilizers (Michigan Land Use Leadership Council, 2003; USDA, 2019). This increasing trend in organic agricultural practices and their corresponding increase in economic importance for states and local farmers, along with their known impacts on water quality, represent a growing area of uncertainty (USDA, 2019).

Several key agricultural water pollution research needs and knowledge gaps have been identified, including: the need for pollution source identification, identification and testing of locally appropriate markers,

* Corresponding author.
E-mail address: floodmat@msu.edu (M.T. Flood).

https://doi.org/10.1016/j.watres.2022.118526
Received 12 January 2022; Received in revised form 15 April 2022; Accepted 26 April 2022
Available online 29 April 2022
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