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Q-275 Comparison of Microbial Water Quality Parameters of Four Geographically Similar Creeks in Northeast Tennessee

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ABSTRACT

Four creeks within the Watauga River watershed in Northeast Tennessee are routinely monitored for water quality assessments. To identify sources and monitor remediation, Sinking Creek, Cash Hollow Creek, Buffalo Creek and Boones Creek are monitored for chemical and microbial parameters. These parameters include phosphates, nitrates, BOD and fecal coliforms. Sinking Creek is a tributary of the Watauga River with 10 miles of impaired water. Cash Hollow Creek enters the Watauga River at river mile 11.4 with 3.4 miles of impaired water. Boones Creek contains 18.6 impaired miles while the status of water quality in Buffalo Creek is not yet determined. Agricultural input is a major source of pollution for Sinking and Boones Creek. Cash Hollow Creek is impacted by a combination of sources of which urban runoff is the largest due to storm sewers and land development. Boones, Cash Hollow and Sinking Creeks are considered impaired and are on the state's 303(d) list due to pathogen loading but only Sinking and Cash Hollow Creek have TMDLs. The seasonal and spatial patterns are more obvious for microbial than for chemical parameters. From 2002 - 2005, 14 stations on Sinking Creek were sampled quarterly. Fecal coliforms were elevated and always greater than 200 CFU/100ml for stations 1 – 5. Due to agricultural land use adjacent to stations 1 – 4, this would be expected. There was also a seasonal trend with higher concentrations found in the fall and spring. Cash Hollow Creek's 9 stations were sampled monthly from 2002 - 2005. Although very high fecal coliforms concentrations were found, there were no obvious patterns. The 12 stations on Buffalo Creek were sampled quarterly from June 2004 to June 2005. Fecal coliform concentrations were high at station 8, which is adjacent to agricultural land. Boones Creek was sampled monthly from March 2005 to present and no obvious trends have been noted. The objective of this research is to compare patterns in these geographically similar creeks to identify any common patterns associated with various pollution sources. We will discuss the preliminary results and conclusions about the usefulness of these data to accomplish this objective.

INTRODUCTION

The Tri-Cities (Bristol, Johnson City, Kingsport) area within Northeast Tennessee is experiencing rapid growth primarily in the form of new residential developments. The terrain and land use patterns have forced much of this development to occur in close proximity to headwater streams in the Watauga River watershed. There is great concern about protecting these resources. To better understand the current water quality and predict water quality changes as development occurs we initiated a water monitoring program to address these issues.

Four creeks within the Watauga River watershed are routinely monitored to identify pollution sources and monitor remediation. Sinking Creek is a tributary of the Watauga River with 10 miles of impaired water. Cash Hollow Creek enters the Watauga River at river mile 11.4 with 3.4 miles of impaired water. Boones Creek is undergoing a rapid transition from agricultural to mixed land use with the construction of many housing developments. Boones Creek contains 18.6 impaired miles while the status of water quality in Buffalo Creek is not yet determined. Agricultural input is a major source of pollution for Sinking Creek and Boones Creek. Cash Hollow Creek is impacted by a combination of sources of which urban runoff is the largest due to storm sewers and land development. Boones, Cash Hollow and Sinking Creeks are considered impaired and are on the state's 303(d) list due to pathogen loading but only Sinking and Cash Hollow Creeks have TMDLs.

Chemical and microbial parameters measured for these creeks include biochemical oxygen demand (BOD), nitrates, phosphates and fecal coliforms. A measure of the oxygen consumed by microorganisms during the breakdown of organic material, BOD varies seasonally and temporally and is affected by temperature and altitude (USEPA 2006). BOD may be altered by anthropogenic means, including feedlot runoff, failing septic systems and industrial effluent. Introduction of waste increases available nutrients and biomass, resulting in increased oxygen demand and less available dissolved oxygen. Decaying biomass is the primary natural source of phosphates and nitrates, but phosphates may also be introduced through mineral weathering. Anthropogenic introduction may occur through sewage release, fertilizer runoff, industrial effluents and detergents (USEPA 2006). Excessive nitrates and phosphates can lead to eutrophication and decreased dissolved oxygen, impacting aquatic ecosystems.

Fecal coliforms are routinely monitored in surface waters and indicate fecal pollution. Although they usually do not pose a health risk, their presence indicates that pathogenic microorganisms may be present. Fecal coliform concentrations above action levels indicate that contact or ingestion of the contaminated water may pose a health risk. Due to their association with human and animal feces, the USEPA requires that drinking water be completely void of any fecal coliforms (USEPA 2006).

The initial focus of the program was on streams already known to be impacted. The main objective of these studies is to learn more about the response of these streams to anthropogenic stressors, to identify methods that help identify sources of impairment and to identify Best Management Practices (BMPs) that will prevent and remediate the effects of this rapid urbanization. The specific objectives of the study are aimed at understanding the variability in spatial and temporal responses in headwater streams in the watershed.

OBJECTIVES

1, Compare microbial and chemical parameters across these geographically similar creeks to identify any common patterns associated with various pollution sources.

2. Understand how seasonal and spatial patterns affect water quality within the Watauga River watershed.

MATERIALS AND METHODS

Sample Collection: Water samples for fecal coliform analysis were collected in triplicate in 100ml sterile whirl-pack bags. Water samples for nitrate, phosphate and BOD_5 analysis were collected in triplicate in 2 L plastic Nalgene™ bottles. Sinking Creek was sampled quarterly since 2002 and Cash Hollow Creek was sampled monthly since 2002. Buffalo Creek was sampled quarterly since 2004 and Boones Creek was sampled monthly from March 2005.

Fecal Coliform Analysis: Fecal coliform analysis was conducted according to Standard Methods for Examination of Water and Wastewater (APHA 1992). Samples were processed in triplicate and the sample volume was selected to produce 30-300 colonies. Samples were filtered through a 47mm Millipore MF (Millipore, Bedford, MA) type mixed cellulose filter with a 45μm pore size.

Nitrate/Phosphate Analysis: Nitrate and phosphate analyses were performed in triplicate using colorimetric HACH™ methods. NitraVer® 5 and PhosVer® Reagent Powder Pillows (HACH Company, Loveland, CO) were used for nitrates and phosphates respectively.

Five-Day BOD Analysis: BOD_5 analysis was conducted according to Standard Methods for Examination of Water and Wastewater (APHA 1992). Samples were analyzed in triplicate and dissolved oxygen was measured using the YSI Model 5000 (YSI Inc., Yellow Springs, OH).

Figure 1. Map of Boones, Buffalo, Cash Hollow and Sinking Creeks showing sampling locations and surrounding region.

Figure 2. Typical from the agricultural region (2 and 4), the urban region (6) and the forest region (14)

Figure 3. Typical agricultural (4) and developed sites (6) on Boones Creek.

Figure 4. Typical urban (5&6) and agricultural (9) sites on Cash Hollow Creek.

Figure 5. Typical urban (5) and agricultural (8) sites on Buffalo Creek

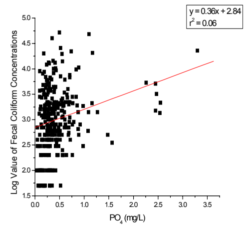

Figure 6. Linear regression of fecal coliform concentrations as a function of phosphate concentrations in Boones Creek.

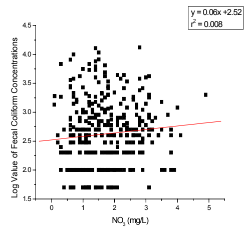

Figure 7. Linear regression of fecal coliform concentrations as a function of nitrate concentrations in all creeks during the spring months.

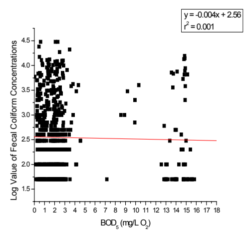

Figure 8. Linear regression of fecal coliform concentrations as a function of BOD_5 in Sinking Creek.

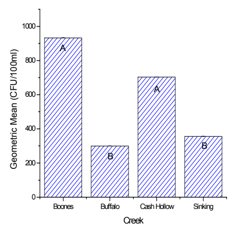

Figure 9. Comparison of fecal coliform concentrations across creeks.

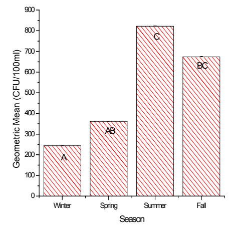

Figure 10. Comparison of fecal coliform concentrations across seasons.

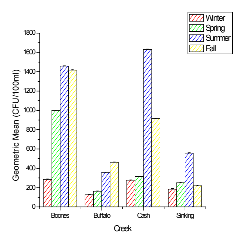

Figure 11. Comparison of fecal coliform concentrations by creek and season.

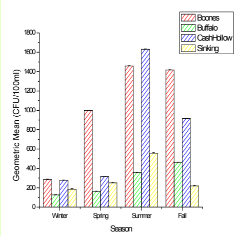

Figure 12. Comparison of fecal coliform concentrations by season and creek.

RESULTS

1. No strong correlation between chemical parameters and fecal coliform concentrations across season and creek.
2. No significant differences in fecal coliform concentrations between Boones and Cash Hollow Creeks.
3. No significant differences in fecal coliform concentrations between Buffalo and Sinking Creeks.
4. No significant differences in fecal coliform concentrations between summer/fall, winter/spring or spring/fall seasons.

CONCLUSIONS

The conclusions of this study are:

1. Buffalo and Sinking Creeks have similar patterns in fecal coliform concentrations, but only Sinking Creek has a TMDL. This suggests that TMDL development may require multi-year data at multiple sampling sites instead of the limited 30-day geometric mean.
2. In these streams, elevated chemical parameters do not correlate with elevated fecal coliform concentrations. This suggests that chemical water quality parameters do not provide additional information to identify sources of fecal contamination.

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