Linking Land Use to Water Quality in Northern Kentucky

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BACKGROUND

•Nutrient enrichment of surface waters associated with nuisance algal growth (Chetelat, *et al.*, 1999; McCormick and O'Dell, 1996; Welch, *et al.*, 1989) that decreases habitat availability and impairs diversity and abundance of aquatic species (Carpenter *et al.*, 1998) is responsible for over 40% of the nations' degraded waters (USEPA 2000a and 2000b).

•USEPA developed nutrient and eutrophic response variable criteria for prevention of nuisance algal growth (USEPA 2000a, 2000b). These criteria are specific to streams with similar geology, topography, land use, and nutrient concentrations (*i.e.* subecoregion), and serve as a starting point for states to delineate their own criteria. For each subecoregion, recommended limits were published for N, P, sestonic and benthic algal biomass (*i.e.* primary eutrophic response variables), DO, and phosphorus storage in benthic algae (*i.e.* secondary response variables) (Table 1).

•Degraded water quality associated with both agricultural and urban land use is well documented, but no data exist that describe the trophic state of Northern Kentucky streams.

OBJECTIVES:

1) Document the trophic status of 12 Mile Creek, Doe Run and Banklick Creeks by sampling bi-weekly for a year and comparing data to U.S. EPA criteria for water quality protection.
2) Assess the relationship between trophic indicators: nitrogen and phosphorus concentrations, sestonic and benthic algal biomass, and phosphorus concentration in benthic algae in the sampled streams.
3) Examine the potential for developing a model of water quality parameters that quantifies land use impacts on Northern Kentucky streams.

METHODS

•Bi-weekly sampling began April 6th 2006.

•Water samples were collected from each site during each sampling event for analysis of nutrients, and primary and secondary eutrophic response variables.

•Water samples were filtered and processed in the laboratory for Total Phosphorus (TP), Soluble Reactive Phosphorus (SRP), Nitrate, Ammonia, and Chlorophyll a (Chl a).

•Rocks were randomly collected until the bottom area (0.059 m^2) of the sampling pan was covered without overlapping rocks. All algae and debris was scrubbed from the rocks and sub-samples of the slurry were collected for determination of periphyton dry weight, Chl a, and phosphorus storage.

•Standard methods were used in all sampling, processing, storage and analysis (APHA, 2005).

ABSTRACT

Linking Land Use to water Quality in Northern Kentucky is a year-long (April 2006 – March 2007) study of nutrients and eutrophic response variables in three Northern Kentucky streams. There are three main objectives: 1) to document the trophic status of 12 Mile, Doe Run and Banklick Creeks by sampling bi-weekly and comparing data to U.S. EPA criteria for water quality protection; 2) to assess the relationship between trophic indicators: pH, dissolved oxygen, conductivity, nitrogen and phosphorus concentrations, sestonic and benthic algal biomass, and phosphorus concentration in benthic algae in the sampled streams; and 3) to examine the potential for developing a model of water quality parameters that quantifies land use impacts on northern Kentucky streams.

Preliminary results presented here indicate that nutrient concentrations, nitrogen and phosphorus, exceed U.S. EPA standards > 70% of the time (one tailed t-test comparison of data to U.S. EPA recommended values, p = 0.05). As would be expected with eutrophic waters (*i.e.* nutrient enriched), sestonic and benthic algal biomass, a primary eutrophic response, exceeded U.S. EPA criteria of 5.37 ug/L chlorophyll a and 150 mg chlorophyll a per m2, respectively. Periphyton phosphorus storage, a secondary response to eutrophication, also exceeded U.S. EPA criteria of 20 mg/m2 nearly 85% of the time (p = 0.05). We conclude that these preliminary results indicate that all three Northern Kentucky streams are eutrophic and that the biological responses to eutrophication detected thus far are a signature of land use impacts on water quality.

Table 1. Recommended summer average nutrient and response variable criteria for streams in level III subecoregion 55 (USEPA, 2000a and b).

Variable	Recommended Summer Mean
Nutrients	
Total Phosphorus (TP) ug/L	70.0
Soluble Reactive Phosphorus (SRP) ug/L	62.5
Total Nitrogen (TN) mg/L	3.5
Primary Eutrophic Response Variables	
Chlorophyll *a* (ug/L)	5.37
*Chlorophyll *a* (mg/m^2)	150
Secondary Eutrophic Response Variables	
Dissolved Oxygen (DO) mg/L	7.9
*Phosphorus (mg/m^2)	20

NOTE: * denotes concentration in benthic algae.

RESULTS AND DISCUSSION

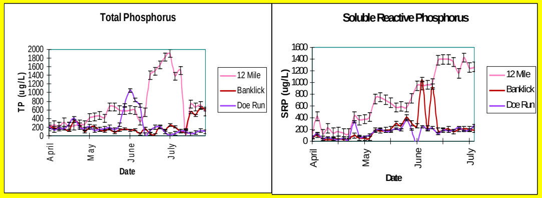

Figure 1. Consistent with previous findings (USEPA 2000a and 2000b), both forms of phosphorus increased in concentration over the summer at all sites. The USEPA recommended limit for TP is 70 ug/L and 62.5 ug/L for SRP (Table 1). After mid-May all sites exceeded the recommended TP and SRP concentrations. Of particular interest is the fact that TP and SRP concentrations in 12 Mile creek were consistently higher than in Doe Run and Bancklick creeks. 12 Mile creek is the least urbanized of the three watersheds and these results raise two questions: 1. Is the phosphorus input actually from agriculture? Or, 2. Are there illicit discharges of home sewage from inadequate septic systems? The increase in SRP and TP in Doe Run and Banklick throughout the dryer months is consistent with urban streams receiving phosphorus input in the form of sewage, especially given that the TP is nearly all in the soluble reactive form (Carpenter, et al., 1998; Correll, 1998).

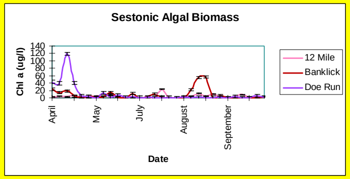

Figure 2. Sestonic chlorophyll a concentrations periodically exceeded the recommended limit of 5.37 ug/L in all 3 streams. Extremely high algal growth occurred in Doe Run with higher flows that carried run off through the reservoir during the spring months. In Banklick creek, the highest algal biomass occurred during summer low flows, a common trend in sewage impacted streams (Carpenter, et al., 1998; Correll, 1998).

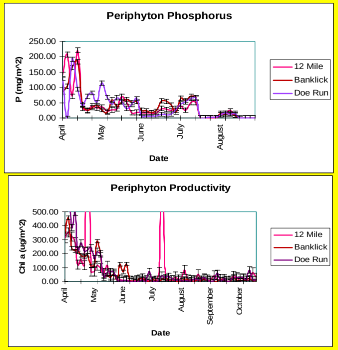

Figure 3. Consistent with the aqueous TP and SRP trend, periphyton productivity and phosphorus storage exceeded USEPA recommended criteria, 150 ug chl a/m^2 and 20 mg/m^2, respectively, in 12 Mile creek throughout most of the sampling period. The fact that periphyton phosphorus storage exceeded recommended criteria in Banklick and Doe Run creeks may explain the lower concentrations of aqueous phosphorus at these sites (Chetalat, et al., 1999; McCormick and O'Dell, 1996).

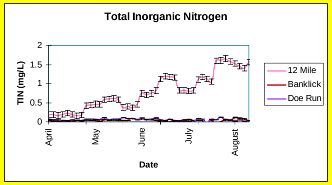

Figure 4. Total Inorganic Nitrogen (TIN) was calculated by adding N measured as Ammonia and as Nitrate. This portion of the total aqueous nitrogen is the most important for biological productivity and toxicity. This method assumes that TIN is an adequate surrogate for total nitrogen. TIN did not exceed USEPA criteria (3.5 mg/L) from April through August. However, TIN progressively increased during the sampling period in the most agricultural stream, 12 Mile Creek. These results, unlike previous studies, indicate that agricultural land use is a significant source of nitrogen (Chetalat, et al., 1999; McCormick and O'Dell, 1996). Completion of the year long study is necessary to fully discern the pattern of nitrogen fluxuation in all 3 streams.

CONCLUSIONS:

This is an ongoing study and includes many variables not presented here. However, based on these preliminary results of some of the most critical trophic indicators we can conclude that Northern Kentucky streams are eutrophic through at least part of the year. A complete annual analysis is important for understanding the seasonal variation in trophic conditions and responses.

ACKNOWLEDGEMENT:

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