LAND USE DRIVERS OF NITRATE LEVELS IN CROW CREEK WATERSHED TRIBUTARY OF THE MISSISSIPPI RIVER

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INTRODUCTION

While only 21% of Iowa's water runs into the Mississippi river, the state contributes 45% of the river's nitrate load (Jones, 2021). This load included 280,000 tons of nitrogen, which represents a 72% increase since 2003 (Jones, 2021). This is both an environmental and drinking water issue. Many people get their drinking water from underground aquifers replenished by tributaries of the Mississippi and therefore cleaning this water becomes a financial hardship for a town or city. This study aimed to identify the source of two nitrate-N hotspots in Iowa's Crow Creek watershed by analyzing the land use surrounding the tributary.

The two largest anthropogenic factors that cause nitrogen flux in streams are agricultural runoff and urbanization. An acre of corn loses approximately 100-140 lbs of nitrogen to the surrounding environment due to excessive fertilizer application and timing, and poor soil management practices (Fuchs, 2021). Urban systems typically add nitrogen runoff due to impervious surfaces or leaky infrastructure such as: pipe lines, sewage systems, and sealed drains.

Crow Creek is a moderate sized watershed, approximately 4843.278 Ha area, that extends from Eldridge Iowa in the North through the communities of Davenport and Bettendorf Iowa, eventually emptying into the Mississippi. Hot spots were defined using data collected at established Upper Mississippi sampling sites in 2018-2019. The first hot spot identified was found at a pair of sites between Panorama Park and Middle Road, Bettendorf Iowa, in an urban or mixed urban/agricultural area, and had seasonal mean Nitrate-N of 4.21 mg/L and mean 4.76 mg/L. The second hot spot was a pair of sites between 53rd Avenue across from Crow Creek Park to Utica Ridge Road across from the Crow Valley golf course, also in Bettendorf Iowa. This hot spot contained one agricultural site and several urban and mixed sites with seasonal mean Nitrate-N of 5.89 mg/L and 5.39 mg/L. The overall purpose of this study was to sample a series of sites upstream of these hot spots in order to provide the city with information on the likely sources of Nitrate-N, as well as to provide guidance about the process of water quality improvement.

METHODOLOGY

- Local hot spots for Nitrate-N were identified by examining mean values from established sample sites in the Upper Mississippi 2018-2019 dataset. Google Earth was used to identify previously unsampled tributaries and local land use upstream of the established sites.
- Sites were selected for sampling based on accessibility, presence of flow, and their potential relevance in explaining downstream nitrate-N New sites.
- Sampling occurred on October 17th, 2020 (twenty four new sample sites and zero repeat sites) and November 7th, 2020 (five new sample sites and four repeat sites).
- Samples were collected from sites with visible flow in acid washed Nalgene sample containers and stored on ice in a dark cooler.
- Samples were analyzed for Nitrate-N approximately three to four hours after collection on an AQ300 Discrete autoanalyzer using a colorimetric cadmium reduction method (EPA-126-D).
- Analysis was based on a seven point calibration, no samples were above the highest standard (5 mg/L). However, some samples ran close to or below the detection limit 0.1 mg/L.

RESULTS

Nitrate-N concentrations in tributaries that fed the hot spots depended strongly on surrounding land use (ANOVA, 2df, F= 6.628, p<0.005) (Fig.1). The mean NO3-N concentration of streams surrounded by agriculture was higher than the mean NO3-N concentration of streams surrounded by urban or mixed land use. Two outliers were identified: an agricultural stream with 0 mg/L NO_3-N and one urban stream with 3.2 mg/L NO_3-N. One possible alternate explanation for this pattern would be if first order streams in this watershed were primarily agricultural, so that the land use pattern was confounded with stream order and measured N was a function of dilution. However, the NO_3-N concentration of first, second and third order streams did not differ significantly from one another (ANOVA, 2df, F=1.200, p < 0.317) therefore, the results can not represent simple dilution (fig 2). A map of Crow Creek watershed clearly shows the gradient of high to low nitrate concentrations (see Fig. 3). Streams with less than 1.0 mg/ L are seen mostly in the urban sampling site areas of Bettendorf. However, in the more agricultural area of Eldridge, the nitrate concentration is far higher ranging between 2 mg/L and 4 mg/L NO_3-N concentrations.

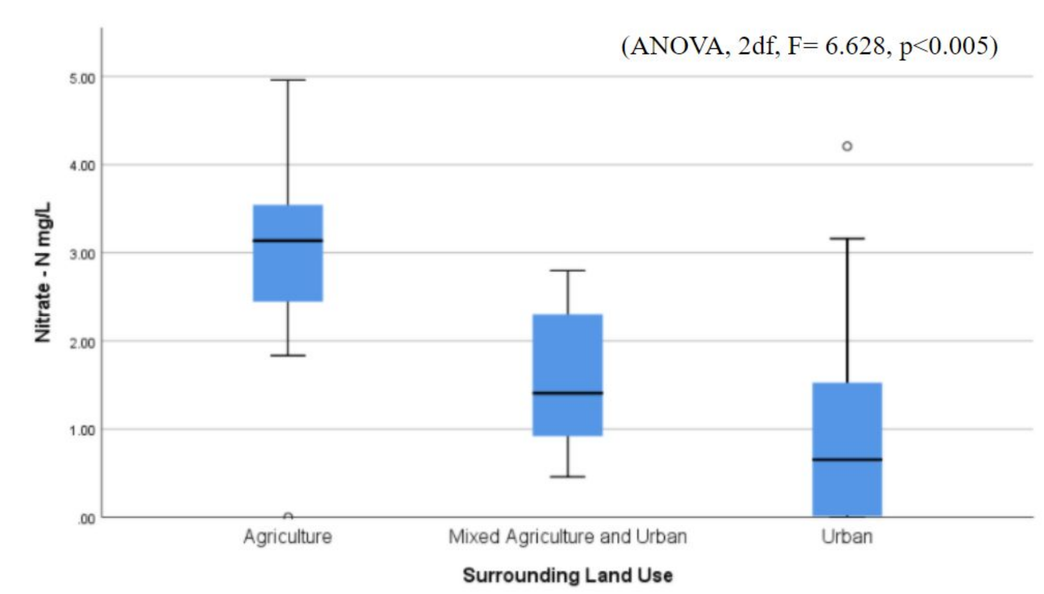

Figure 1: Box plot representing nitrate concentration - N mg/L compared to surrounding land use found higher nitrate concentrations in agricultural streams.

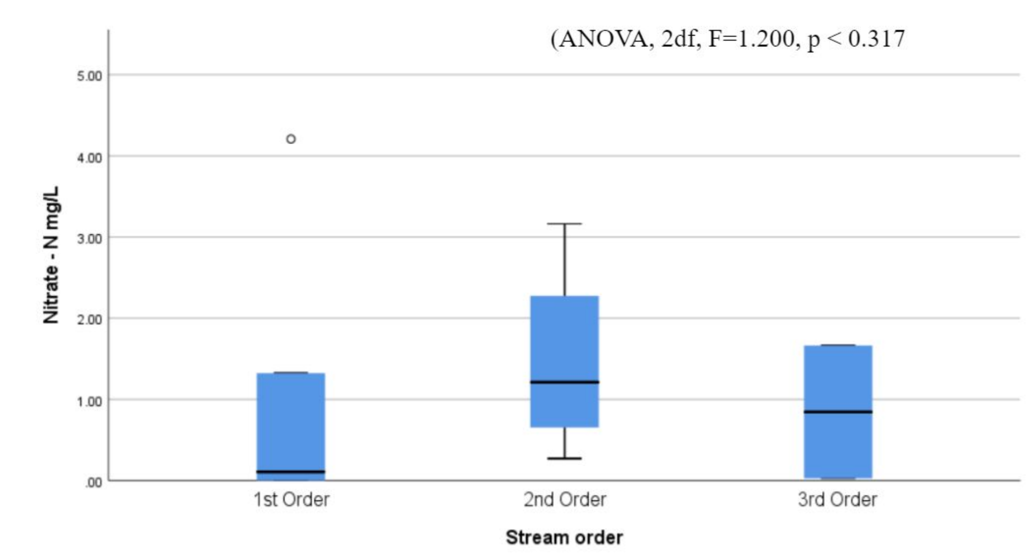

Figure 2: Box plot representing nitrate concentration - N mg/L compared nitrate concentration between first, second, and third order of streams. No significant difference was found.

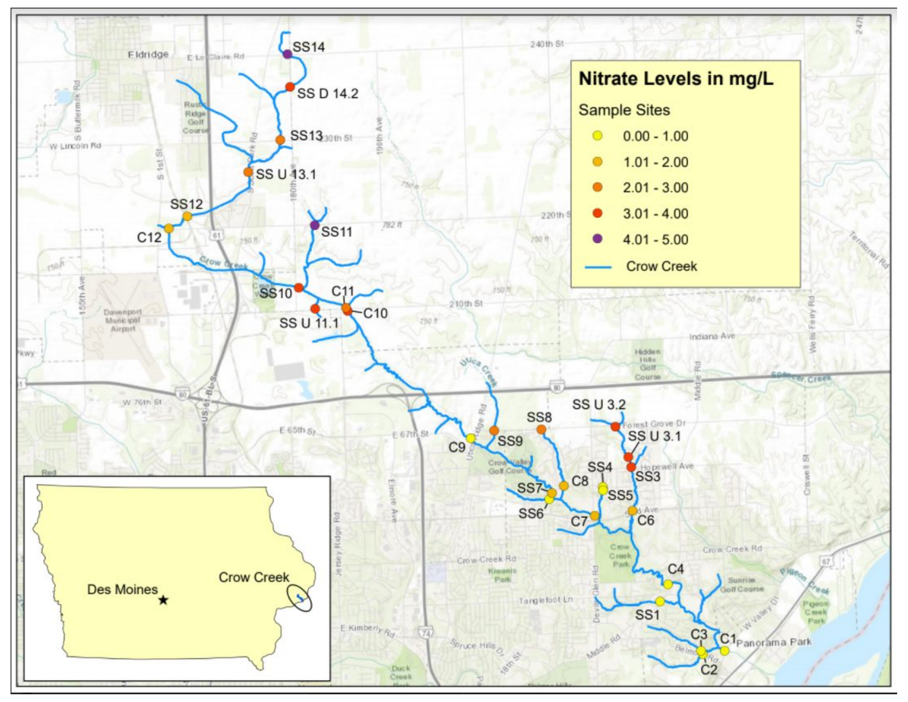

Figure 3: Map of entire Crow Creek watershed with each sample site labeled and colored to distinguish nitrate concentration observed at the site.

DISCUSSION

Nitrate-N hot spots in Crow Creek were associated with upstream agricultural sites with elevated NO_3-N (fig 1, fig 3) this suggests that these hot spots are more likely due to agricultural runoff than leaky urban infrastructure. Two outliers did not follow this trend. One of these sites was an urban site with an unusually high nitrate concentration labeled as site 3. However, this site is less than a mile directly downstream of significant amounts of agricultural land (fig 3). Further, two agricultural sites measured directly upstream from site 3 had similarly elevated levels of nitrate to this outlier. This not only explains the outlier but demonstrates the effect agricultural runoff has further downstream. The second outlier was an agricultural stream site with 0 mg/L of nitrates found. It is unclear why this site had such a low measured NO_3-N concentration. This may have been due to the protection of a large natural riparian buffer but this is not supported by a trend in data of other sites with buffers. We also found no statistically significant difference between the concentrations of NO_3-N at different stream orders in the watershed, indicating that our results were not skewed by a simple dilution effect in the streams (fig. 2).

Limitations to this study included an inability to collect repeated data for each site, lack of access to some tributaries that fell on private property, and our limited familiarity with underground city infrastructure. Regardless, there is still a strong and consistent trend throughout the dataset depicting agriculture as a primary contributor to NO_3-N in Crow Creek, a conclusion that matches the literature implicating agriculture as a primary contributor to nitrogen loading in streams (Jones, 2021).

In order to improve the water quality of the hot spots identified in the Crow Creek watershed, various modifications to agricultural practices and land use are necessary. Significant factors include a reduction of fertilizer application, changes in timing of the application, cover crop usage and a reduction of tillage. Besides changes made to agricultural practices, riparian buffer systems around streams can help reduce N load. Buffers have been shown to increase in effectiveness as width increases. 50%, 75%, and 90% of nitrogen removal efficiencies in surface flow occurred in buffers approximately 27m, 81m, and 131m wide, respectively (Mayer, 2007). It is also important to consider soil type, hydrology, subsurface biogeochemistry, and especially type of vegetation. Herbaceous and forest plants such as coniferous and deciduous trees, are found to be the most effective at reducing the amount of nitrogen loading into streams (Mayer, 2007).

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