A PRELIMINARY GEOCHEMICAL ANALYSIS OF SPATIAL AND TEMPORAL VARIATIONS IN THE SURFACE WATER CHEMISTRY OF RICE COUNTY, MN

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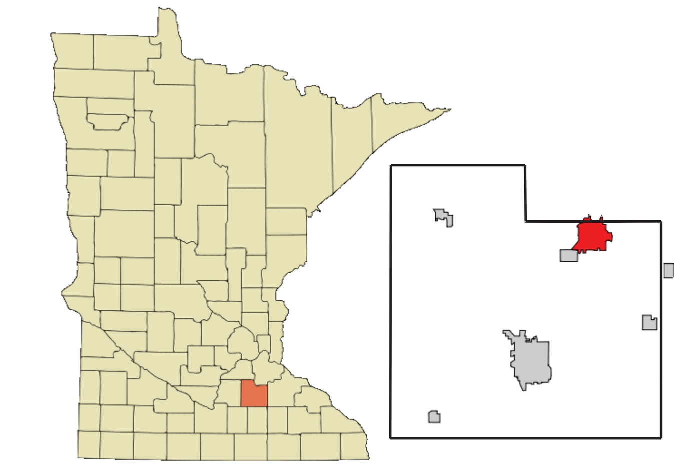

Abstract

Rice County, located in south-east Minnesota, is home to a very complex surface water system. The western portion of the county is largely covered by lakes, while the eastern segment is predominantly farmland cut up by streams and agricultural drainage tiles. This study evaluates the inorganic water quality of the region in order to assess the geological and anthropogenic factors affecting the water system. From summer 2008 to summer 2009, 260 water samples were collected. Using Dionex 600 Ion Chromatography, samples were tested for six cations (Na^+, K^+, Mg^+, $Ca2^+$, Li^+, $NH3^+$) and seven anions (Fl^-, Cl^-, Br^-, NO2, $NO3^-$, $PO43^-$, $SO42^-$). In ArcGIS we sorted and analyzed the sample locations by drainage area. With Kriging interpolation, we created comprehensive chemistry maps of the county to analyze the spatial variance of these ions. The lakes show concentrations in the normal ranges; streams and rivers in the east, however, tend to show high concentrations of $NO3^-$, indicating significant agricultural input. While it is difficult to determine the ecological impact of the dissolved material using the data from this study alone, further research into the ground water system in conjunction with this data will provide the full impact of anthropogenic pollutants on the waters of Rice County.

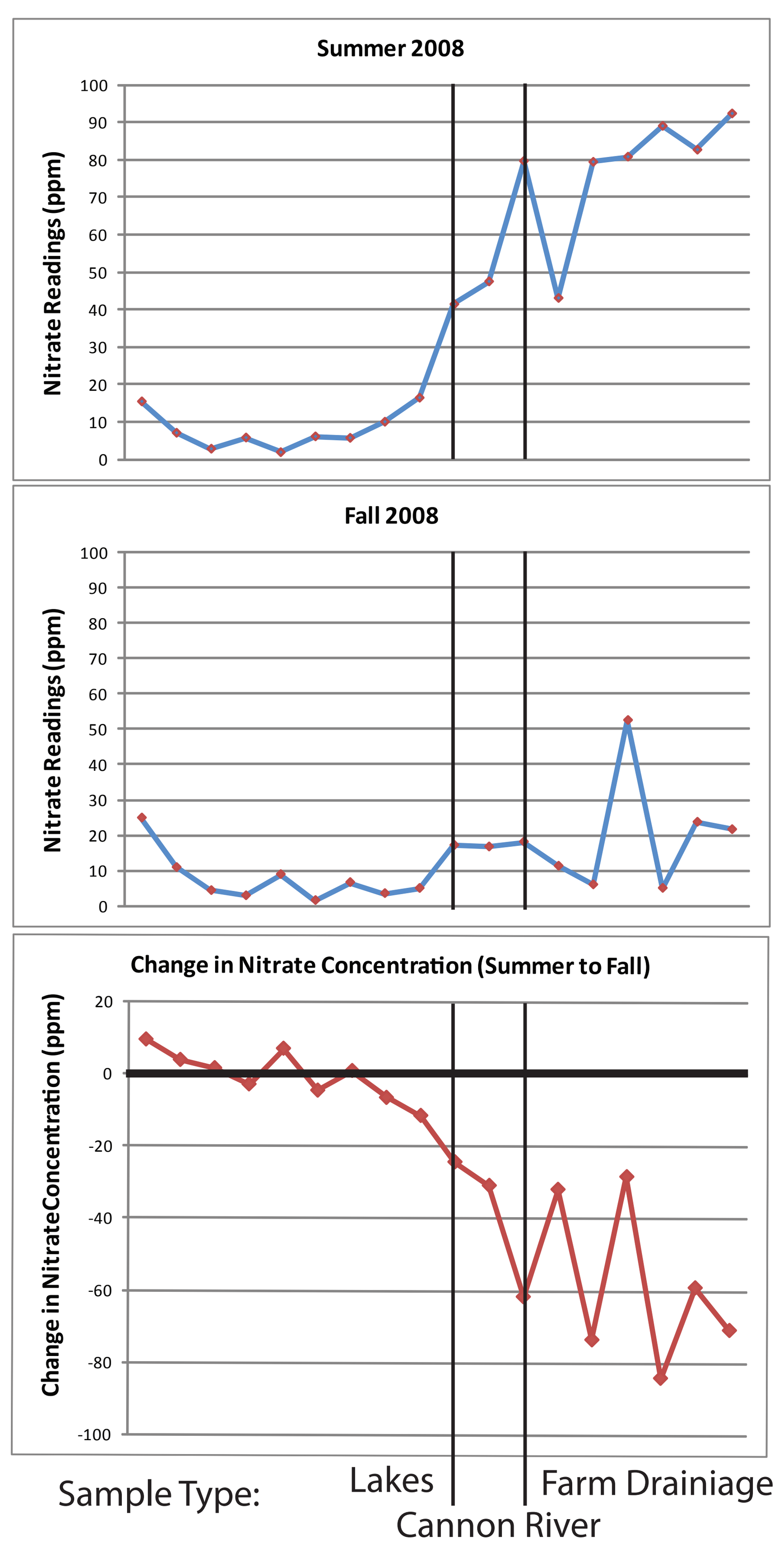

Figure 1. Nitrate values from the Northwest to the Southeast of Rice County. The x axis represents distance along this transect. Note the relatively consistent lake chemistry, while farm drainiage has significant changes between seasons.

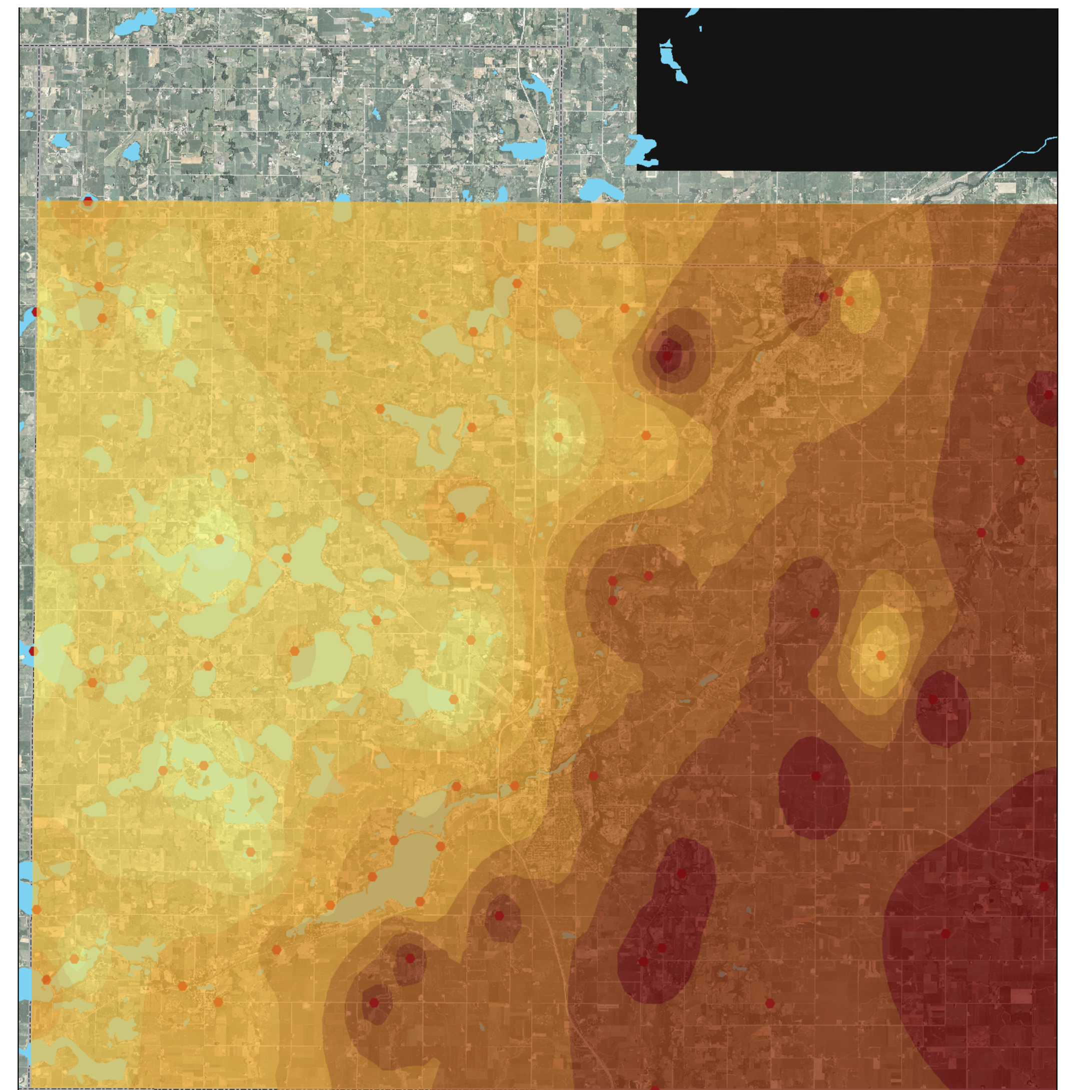

Figure 2. Summer 2008 interpolated nitrate map of Rice County, MN. (Layer data courtesy of the MN DNR).

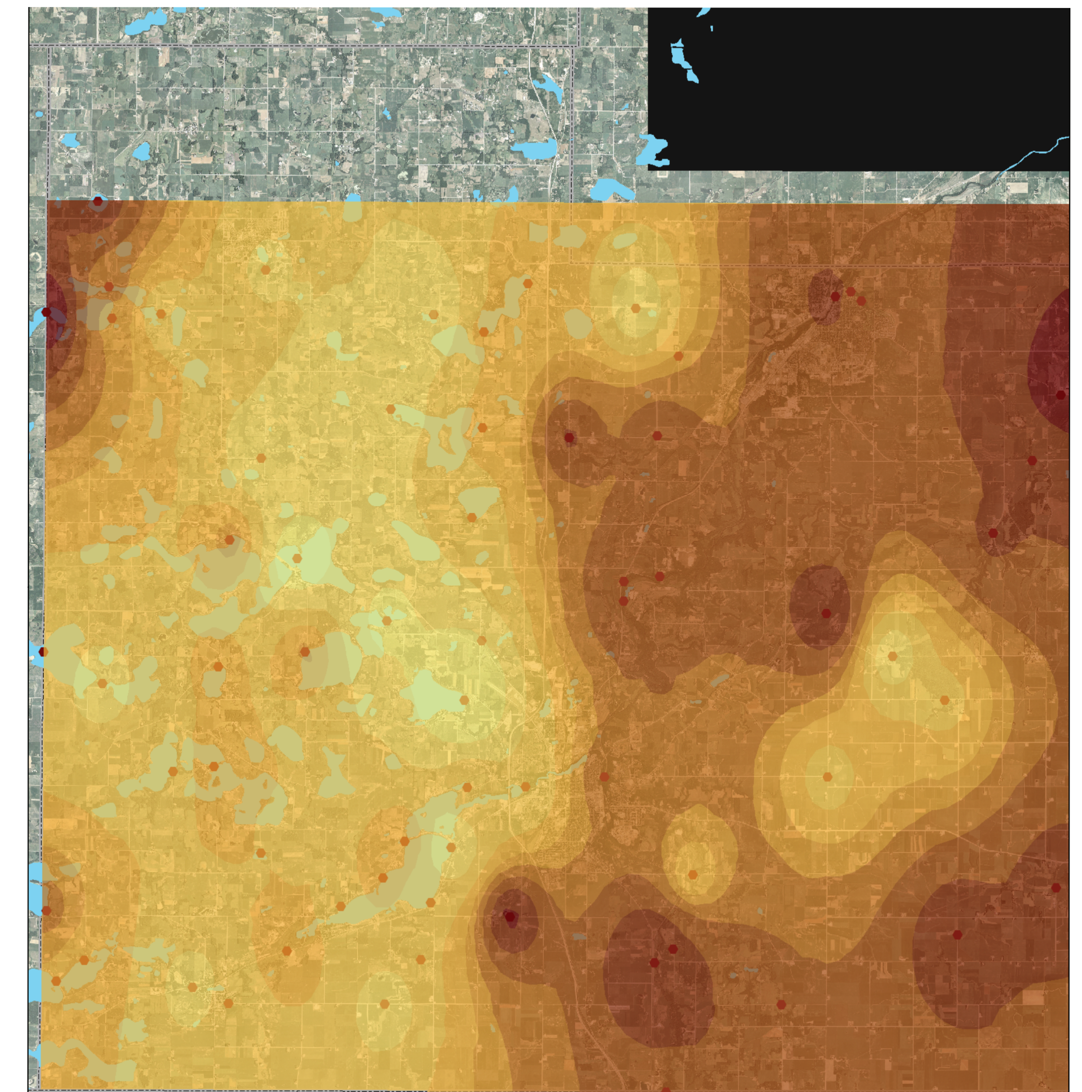

Figure 3. Fall 2008 interpolated nitrate map of Rice County, MN. (Layer data courtesy of the MN DNR)

Introduction

Water resource management has become a growing concern in the United States over the last decade. While Minnesota may not be facing the droughts experienced in other areas of the country, it faces a different set of challenges when it comes to preserving it's water resources. Rice County, MN, presents an interesting surface water environment. In the west, the county is dominated by lakes, formed as a result of the glaciation throughout Minnesota's history. The east is dominated by farmland, which is drained by tributaries of the Cannon River. The Cannon River then carries water from both the East and West portions of the county into the Mississippi, where it eventually travels to the Gulf of Mexico. Agricultural land use, comprising about 58% of the Mississippi River Basin (Goolsby and Battaglin, 2000), is a major source of nutrients for both the Gulf waters and inland watersheds. The majority (49-67%) of nitrate flux to the Gulf of Mexico comes from soil mineralization and fertilizers; the latter of which has risen dramatically during the past half-century to over six times its 1950s levels (Goolsby and Battaglin, 2000). In this study, we set out to investigate the surface water chemistry across both space and time, in an effort to isolate point or broad sources of nitrate pollution affecting this surface water system.

Methods

We sampled over four discreet time periods, Summer 2008, Fall 2008, Spring 2009, and Summer 2009. This study focuses on the first farming season (Summer and Fall 2008). Water samples were analyzed both *in situ* for Nitrate, as well as analyzed in the lab using an Atomic Absorption Spectrometer and a Dionex 600 Ion Chromatograph. ArcGIS was then used for spatial analysis of the chemistry data.

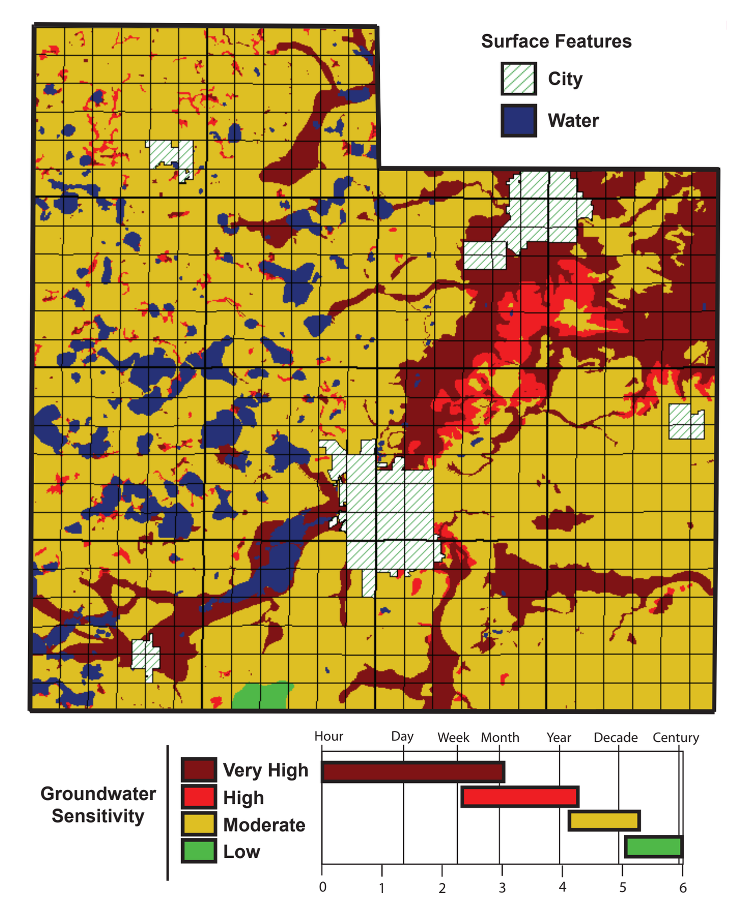

Figure 4. Rice County Groundwater penetration map. Note the higher penetration rate in and around Northfield (in the northeast). This illustrates that pollutants in this region will have a greater effect on groundwater chemistry.

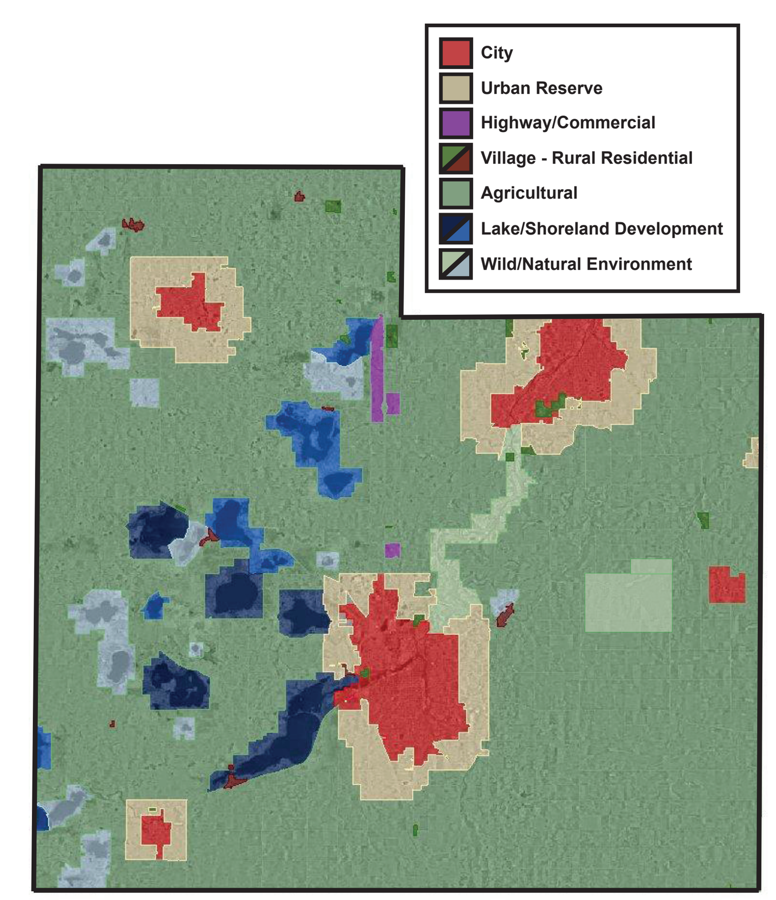

Figure 5. Rice County land use map. While it is primarily agricultural, the locations of the two largest cities (Northfield in the northeast and Fairibault in south central Rice County) and the lakes in the west.

Results

Nitrate values duing the summer ranged from 1.86 ppm to 98.57 ppm. The range of values during the fall was 0.58 ppm to 54.82 ppm. On average, nitrate levels in lakes tended to be much lower (<30 ppm) than the rest of the sample locations (Figure 1). Figures 2 and 3 illustrate the spatial trends in the nitrate levels. The spatial trends illustrated by these maps appear obvious, as the western, lake-dominated portion of the county is in stark contrast to the nitrate rich eastern portion. Conductivity was also measured at each sample location, which ranged from 213 μS to ~1000 μS. These readings also followed the general trend of increasing from west to east. There were a number of locations that had anomolously high nitrate levels, one in the north central portion of the county (which can be seen clearly in Figure 2), and one in the south central portion of the county (which can be seen clearly in Figure 3). These two samples are located near drainage tiles from surrounding farms, and thus indicate key point pollution sources.

Discussion and Conclusions

There is a clear spatial trend in the nitrate values as displayed by Figures 2 and 3. Nitrate concentrations tend to be higher in the east. When comparing this result with the map in Figure 5, it is clear that the higher nitrate values correlate directly with the agriculturally dominated region of the county. During the fall, there are a group of relatively low nitrate values recorded in the east central portion of the county, which correlate well with the natural preserve located in that area. Spatial trends were not the only focus of this study, however. Figure 1 is a comparison between the nitrate values taken along a transect from the northwest corner of the county to the southeast. This figure shows that while the nitrate concentrations in the lakes stay relatively constant from season to season, there is a stark dropoff in nitrate values in the fall season for the farm dominated southeast. This is a clear indicator that fertilization is the primary contributor to nitrate pollution in the surface water system. Figure 4 shows the groundwater penetration rate, an important thing to consider when determining the impact of pollution on the entire water system of Rice County (Fenelon and Moore, 1998). While this study did provide us with a basic idea of the dynamics of this water system, its primary function is to set up the field for future research. We were unable to collect groudwater data in this particular sample set, however using the data we already collected and the methods we developed we have set up a study to determine a) the degree to which surface pollutants get into the Jordan and St. Peter aquifers of Rice County and b) the residence time of these pollutants in the system.

Acknowledgements

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References

DNR Data Deli. [Online]. <http://deli.dnr.state.mn.us> (Modified June 25, 2008) Minnesota Department of Nautral Resources.

Fenelon, J.M., and R.C. Moore. "Transport of agrichemicals to ground and surface water in a small central Indiana watershed." J. Environ. Qual. 27:884-894.

Goolsby, D.A., W.A. Battaglin, G.B. Lawrence, R.S. Artz, B.T. Aulenbach, R.P. Hooper, D.R. Keeney, and G.J. Stensland. "Flux and sources of nutrients in the Mississippi-Atchafalaya River Basin: Topic 3 report for the integrated assessment on hypoxia in the Gulf of Mexico." NOAA Coastal Ocean Program Decision Analysis Series No. 17. (2006)