Title: **Groundwater Pollutant Transfer and Export from a Northern Mississippi Valley Loess Hills Watershed**

Project I.D.: DNR Project # 181

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Background/Need: Non-point source pollutant inputs are the most widespread and vexing contributors to ground and surface water, affecting the drinking water resources and the biotic integrity of many of the nation's water bodies. The relation between agriculture and nonpoint pollution is well established, and the contribution of pollutants from agricultural lands is significant. The increase in agricultural chemical use combined with the long residence time of groundwater suggests that groundwater transport of pollutants may not yet be in equilibrium with the current landscape; the consequences of which could mean that despite all of our current efforts to improve water quality pollutant export will continue to increase until equilibrium is reached.

Objectives: This study assesses the role of groundwater in the export of nutrients and pesticides from the Fever River Watershed; an agriculturally dominated watershed in the Northern Mississippi Valley Loess Hills region. More than 100 water bodies in the NMVLH are listed as impaired on state 303(d) lists, and half of the land area is in impaired watersheds. About two-fifths of the area is in cropland and another fifth in permanent pasture. Streamflow is baseflow dominated with groundwater discharge occurring through well defined riparian springs, ill-defined riparian seeps, and streambed discharge.

Methods: In this study, we estimated the groundwater pollutant transfer to a receiving stream, compared groundwater transfer and export with that from runoff, and determined whether groundwater transfer and export were likely at a steady-state or increasing. We used the following approach:

1. Groundwater pollutant transfer to the receiving stream was determined through repetitive sampling of stream water quality and discharge during the study period.
2. Comparisons with runoff transfer and export were made at a gauging and sampling station which measured water quality and discharge during runoff events.
3. Questions about steady-state vs. increase were inferred by sampling water quality and groundwater age-date at groundwater discharge features, such as riparian springs.

This study was conducted in the upper Fever River watershed, an area representative of the agriculturally-intensive portion of the NMLVH region. We report here information gathered during calendar years 2003 and 2004.

Results and Discussion: Groundwater age-dates ranged from 1969 – 1989. Nitrate-N ranged from 4.7 to 23.5 mg L^{-1} while dissolved reactive P ranged from 0.003 to 0.052 mg L^{-1}; both showed a positive relationship to groundwater age-date. Denitrified N ranged from 0 to 4.5 mg L^{-1} and was negatively correlated to groundwater age-date. Metolachlor ESA was the most pervasive pesticide residue detected in groundwater samples, followed by de-ethylatrazine, alachlor ESA, atrazine, and de-isopropylatrazine, the summed concentration of pesticides ranged from 2.1 to 9.1 µg L^{-1}.

Baseflow accounted for approximately 86% of the total streamflow in the Fever River. Nitrate accounted for the largest nutrient loss; groundwater NO_3 export (23.4 kg ha^{-1} yr^{-1}) accounted for 80% of the total annual N loss. Even though runoff represented only a small portion of the annual streamflow, 85% of total P was transported during runoff events. Pesticide concentrations were generally highest during spring runoff events, however; pesticide residues were present in baseflow year round and show that the amounts transported by groundwater can be significant.

Conclusions/Implications/Recommendations: The land-use practices, geology and hydrological settings in the Fever River watershed are representative of much of southwest Wisconsin. We conclude that the watershed is not yet in equilibrium with current land-use and denitrification within the aquifer is not capable of sufficiently denitrifying current NO_3 loading rates to groundwater. As a result, concentrations of NO_3 in the surface waters of these systems will likely increase before finally stabilizing because of the time it takes for groundwater to penetrate the aquifer and reach discharge locations. Understanding groundwater surface water relationships are critical for interpreting stream water quality data and understanding past and future impacts of land management decisions.

Related Publications: None to date

Key Words: nitrate, phosphorus, pesticides, groundwater age-date denitrification

Funding: DNR

Final Report: A final report containing more detailed information on this project is available for loan from Wisconsin's Water Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069.