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Assessing Vulnerability Mapping of Nitrate Contamination Among the Private Well Owners of Black Hawk County, IA

Junu Shrestha
University of Northern Iowa

Sushil Tuladhar
University of Northern Iowa

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ABSTRACT
Nitrate fertilizers have been extensively used in agricultural practices providing farmers an inexpensive way of applying nutrients to plants. These fertilizers applied in agricultural fields make their way to ground water and surface water systems by leaching and runoff. The safe limit for nitrate as nitrogen (NO₃-N) recommended by EPA is 10 mg/L in drinking water. The main objective of this study was to find potential sites that are vulnerable to nitrate contamination in the ground water of Black Hawk County through a weighted overlay analysis using ArcGIS 10.2.2 Software. Well locations (N=911) with nitrate concentration measurements from 2003 to 2014 were retrieved from the "Grants to County" database provided by the Iowa Department of Natural Resources (IDNR). The nitrate concentrations ranged from 0 to 85.5 mg/L with an average value of 6.91 ± 0.291 mg/L. The depth of wells ranged from 10 feet to 320 feet with an average value of 109 ± 2.17 feet. The linear regression analysis showed that an increase of 1 foot of depth, lowered the nitrate concentrations by 0.044 mg/L (R = -0.334, p < 0.05). In the weighted overlay, spatial data on land use, depth to water table, hydraulic conductivity, net recharge, topography, and impact to vadose zone were correlated. Each parameter was reclassified to a standard vulnerability score ranging from 1 to 5, from less to more vulnerable, for ground water contamination. The weighted overlay analysis indicated that the north and south eastern part of the county were the most vulnerable areas for nitrate contamination. The vulnerable areas were then correlated with existing private well nitrate concentrations, and the conclusion was significant indicating that the relationship was not due to chance.

Keywords: Nitrate concentration, Vulnerability, Private wells, Black Hawk County

INTRODUCTION
Nitrate in ground water are a problematic and widespread contaminant (Cantar, L.W., 1997) that occurs due to natural and anthropogenic sources. Increased nitrate concentrations in ground water of Iowa are mainly due to various agricultural practices such as nitrogen fertilizers and intensive animal farming (Weyer et al., 2001). Populations drinking private well water on or near agricultural land are at a higher risk of nitrate contamination exposure. Approximately 67% of Iowa residents depend on ground water from private and public wells to meet daily water needs. Federal and state laws only require that public water supplies be tested regularly for quality, so there is no mandatory requirement for water testing of private wells. Therefore these private well owners could be consuming water that is of uncertain safety, and a significant percentage of individuals may be drinking water that is not safe to drink (CHEEC, 2009). Measuring ground water vulnerability is important because it helps estimate possible contaminated areas and raises public awareness. This study adopted the DRASTIC model to assess groundwater vulnerability in Black Hawk County. This model is a standardized technique for evaluating ground water vulnerability to pollution by using various hydrologic settings (Aller et al., 1987).

OBJECTIVES
To assess vulnerability to potential nitrate contamination in Black Hawk County, Iowa. 
Correlate existing ground water nitrate concentration with vulnerability areas.

HYPOTHESIS
H₀: There is no statistically significant relationship between mapped vulnerability and the level of nitrate contamination measured in wells.
H₁: There is a relationship between vulnerability mapping sites of potential nitrate contamination and existing nitrate contamination points.

RESULTS

RESULTS (cont.)
The Final Weighted Overlay map produced by considering six parameters indicated that there are many areas (represented by score 5 & 4) that might be vulnerable to potential nitrate leaching to ground water. To confirm the hypothesis, existing nitrate concentrations were used and assigned a respective raster cell value using the Extract Values to Points tool. Statistical analysis, one way ANOVA, showed that differences between the mean nitrate concentrations were statistically significant among the vulnerability scores including relatively high nitrate concentrations found coincident with high vulnerability score sites i.e. 5 and 4. Therefore, we reject the null hypothesis and conclude that nitrate concentration was weighted over calculated data on land use. Although the study tried to consider six parameters, there might be other parameters that also contribute to groundwater contamination. Therefore further investigation with more parameters should be considered.

REFERENCES