LAND USE IMPACTS ON WATER QUALITY IN SMALL KARST AGRICULTURAL WATERSHEDS

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Background

Identification of the impacts of agriculturally related activities on surface and ground water quality in limestone and karst terranes is important for the management of this natural resource. Kentucky has highly vulnerable water resources in aquifers located in limestone that underlie approximately 50 percent of the state. Karst conditions occur in about 25 percent of the state, and much of the state's most productive agricultural soils are found in these same regions.

Eight years ago, there was very little information about agricultural effects on water resources in Kentucky. The extent and level of contamination of water resources by pesticides and nitrate-N had not been documented in areas of important agricultural production. The Kentucky Agricultural Chemical Use Impacts Assessment Program (SB-271 Project) studied the water quality in several representative and agriculturally significant areas. This program was conducted from October, 1990 to September, 1993. An analysis of the types of agricultural land uses (row crop and hay/pasture) and their areal percentages was conducted to determine the correlation to the quality of water discharging from eight small agricultural watersheds using the data base developed during the study. These eight watersheds were located in limestone geological settings. This report presents a comparison of these eight Kentucky watersheds to other water quality studies of karst/limestone watersheds that were found in the literature.

Following the passage of the Federal Water Pollution Control Act Amendments of 1972, several studies were published that began to identify the significance of different land use impact on the watershed water quality. Several of these studies found significant positive correlations between nitrogen concentrations in the discharge water and the area of a watershed in agriculture or row crop. Several papers established the influence of the dominant geology (sedimentary, igneous, metamorphic) on the nitrogen concentration in the water exported from basins. Limestone geology was identified as a significant sedimentary geology. Of all the geologies identified in the 1976 US National Eutrophication Survey of 930 watersheds, limestone hydrogeologic settings were found to have the highest inorganic nitrogen concentrations for agriculturally dominated basins. A 1974 reconnaissance study of seven Kentucky agricultural watersheds also supported the latter determination. Soil texture was also a significant influencing factor on the nitrogen concentration. These early studies did not present data concerning agricultural pesticides.

Since the mid-80’s, studies have extended the understanding of the influence of land use on the inorganic nitrogen and pesticide concentrations in limestone hydrogeologic settings. Positive correlations between the percentage of agricultural land and nitrate-N concentrations in springs, draining basins in karst limestone terranes, were found in Pennsylvania, West Virginia, and Kentucky. In addition, concentrations of the triazine herbicide group have been reported in the literature. A positive association of the triazine concentration of basin drainage water with the intensity of agricultural land-use have been presented in the National Water Quality Assessment Program which started in 1991 and in limestone hydrogeologic settings in Kentucky.

The literature was searched for additional water quality data sets in karst/limestone hydrogeologic settings to be included with the nitrate-N and triazines concentration data sets of eight Kentucky watersheds. The objective was to determine whether agricultural practices for crop production in these Kentucky watersheds impacted water quality in a different manner when compared to other watersheds in a karst/limestone setting.

Methodology

<u>Kentucky Agricultural Chemical Use Impacts Assessment Program (SB-271)</u>

The details of this study can be found in a series of reports published by Departments of Agronomy and Biosystems and Agricultural Engineering in the College of Agriculture and the Kentucky Geological. Eleven areas were selected for the assessment. Eight of these sites were located in limestone hydrogeologic settings and these data are being used for this report. The limestone watersheds are referred to by the county in which they are located: Bourbon, Fleming, Jessamine, Logan, Russell, Shelby, Todd and Woodford.

<u>Published Water Quality Studies of Watersheds in Carbonate Terranes</u>

A search of the literature found fourteen water quality study areas which reported nitrate-N and/or triazine concentrations of water discharging from agricultural watersheds in carbonate terrains. These studies were in Arkansas (2 studies), Illinois, Indiana, Iowa, Kentucky, Pennsylvania (3 studies), Tennessee, Virginia, and West Virginia (2 studies). Not all these sites were included in this report. Some reports covered a few synoptic water quality samplings or quarterly water quality samplings and were not used to compare to the Kentucky assessment watersheds. The chosen studies were Big Spring in Iowa, three springs at Mammoth Cave in Kentucky, two springs in Cumberland Valley and four springs in Nittany Valley in Pennsylvania, and four springs in the Greenbrier Hydrologic Unit in West Virginia. Two investigations did not include the land use: Monroe County Illinois (2 springs) and Lost River in Indiana. For these basins, sampling points were able to be identified on soil and topographic maps. USGS Topographic quadrangles (7.5 minute) were used to estimate the areas of the watersheds, assuming the surface watershed matches the groundwater basin, and aerial photography from soil surveys were used to estimate land uses.

Studies included in the comparison are those with monthly data that spanned at least one year with reported data in 10 or more months each year. Further, the reports needed to include the percentages of the watershed in row crop, pasture/hay, and/or agriculture. The dominant soils of these watersheds were silt loam

Results

Nitrate-N. The nitrate-N concentration of Big Spring in Iowa stands well above the rest of the watersheds and was not used in the following statistical analysis. A significant linear regression for nitrate-N versus row crop was found for the watersheds ($\alpha = .001$). There was no significant difference ($\alpha = .025$) between Kentucky 271 watersheds and the published watersheds when watersheds, with more than 80 percent of the land in forest, were removed from the analysis. The four forested watersheds lie outside one standard error from the regression line. When the land use is designated as percent in agriculture, the 24 watersheds (excluding Big Spring IA) yield a significant linear trend ($\alpha = .001$) with the nitrate-N concentration. Significant linear relationships between watershed mean nitrate-N and percent of the watershed in agriculture were also found in West Virginia and Pennsylvania. The eight Kentucky watersheds are clustered above 80 percent agriculture. A t-test was ran on the nitrate-N means of published watersheds above 79 percent in agriculture and the Kentucky SB-271 watersheds. The nitrate-N mean of the Kentucky 271 watersheds was significantly lower ($\alpha = .05$).

Triazines. A significant linear regression for triazine geometric mean versus row crop percentage was found for these watersheds ($\alpha = .001$). There was no significant difference ($\alpha = .05$) between Kentucky 271 watersheds and the published watersheds. When the land use is designated as percent in agriculture, the 13 watersheds do not yield a significant linear trend ($\alpha = .05$) with the triazine concentration. A t-test was ran on the triazine geometric means of published watersheds and the Kentucky 271 watersheds and no significant difference was found ($\alpha = .05$).

Discussion

The mean nitrate-N and geometric mean triazine concentrations in water discharging from watersheds in limestone geologies in Kentucky 271 Assessment Program are not significantly different than other agricultural limestone watersheds when land use is identified as percent of the watershed in row crop agriculture. This positive relationship occurred even when water quality data was taken in different years, different geographic locations, and possibly different weather conditions; primarily intensity, yearly total and timing of precipitation relative to crop production. The one difference was Big Spring IA where the nitrate-N concentration is 4 ppm higher than the regression line. This watershed was identified as not crediting legume and organic N fertilizers when determining the recommended commercial N fertilizer level. Nitrogen fertilizer usage in the Kentucky 271 Assessment watersheds were at recommended levels, e.g. ~170-200 kg/ha. for corn. When the watershed land use is identified as percent agriculture, the relationship does not exist and, for similar agriculture land percentages, Kentucky 271 Assessment watersheds were significantly lower. It is apparent that studies agricultural chemical concentrations in water discharging from watersheds should identify row crop land uses within the study area. A stronger relationship between triazine concentrations and the percent of a watershed in corn production would also lead to a stronger relationship than was found with row crop percent.