Groundwater Quality in Kentucky Assessment and Research Watersheds

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Background

The General Assembly of the Commonwealth of Kentucky, during the 1990 Regular Session, passed a Bill (SB 271), "An Act Relating to Agricultural Chemical Usage," which required, in part, the University of Kentucky College of Agriculture to assess the influence of agricultural practices upon water resources. The assessment was to determine whether agricultural pesticides, plant nutrients, and bacteria from animal manures are present in water resources and to determine the ground water hydrogeology of representative sites. At least two or three years (1990-93) of good baseline data was acquired in those areas that were assessed for agricultural impacts on water. This report will focus on the baseline information after three years of study of the groundwater.

Several scenarios of agricultural production exist on a large scale which are important to Kentucky. These are: 1) general (tobacco-grain-forage-livestock), 2) cash grain, 3) dairy and 4) hog production. Each of these, dependent partially on the nature of the land resource on which it occurs, has a differing potential for type of and extent for water resource contamination. Based on the predominant agricultural activity in the major physiographic regions, sites were selected which represent agricultural production scenarios so the potential for affecting ground water quality could be studied.

Assessment Sites

Eleven areas were selected for the assessment. The selected study watersheds are referred to by the county in which they are located: Bourbon, Daviess, Fleming, Hickman, Hopkins, Jessamine, Logan, Russell, Shelby, Todd and Woodford. These eleven sites represent the agriculturally important physiographic regions of Kentucky: Inner Bluegrass, Outer Bluegrass, Eastern Pennyroyal, Western Pennyroyal, Western Coalfields and Jackson Purchase. The study watersheds were selected to reflect major agricultural production systems in important soil and hydrogeologic settings of Kentucky. The hydrogeologic settings were grouped into three basic types: 1) limestone, 2) alternating layers of limestone and shale, 3) alluvial and continental deposits. The sites can also be characterized as being large watershed studies or farm-sized watershed studies. The Logan and Jessamine sites are large watershed studies (4,082 and 1,903 ha., respectively) that have many land owners. The other nine are smaller farm-sized watersheds (32 to 972 ha) with the majority of the land in active agricultural use. The sites are predominantly agriculture with some residential areas in the large watersheds. One or two individuals own the land at the nine smaller assessment watersheds, which allowed the site-specific determination of land uses, plant nutrient and pesticide use rate and application time, detailed hydrogeologic and soil conditions.

Groundwater sampling points were generally sampled monthly, if water was present; while the frequency of sampling at the research sites was at least bimonthly or more frequently to reflect the research objectives at a given site. Quarterly samples were taken from research site sampling points for total water chemistry. All analyses were done in the College of Agriculture or Kentucky Geological Survey laboratories. Water sample collection for the assessment program began in October 1990 and ended in October of 1993.

Investigations at Assessment and Research Sites

Site investigations followed one of two tracks: assessment or research. There were four sites that were assessment sites (Todd, Russell, Shelby and Fleming counties). An assessment site utilized existing maps of topography, geology and soils. Field reconnaissance was conducted to validate this information. Groundwater sampling locations were limited to existing springs or domestic wells. The hydrogeology was inferred from reconnaissance and general knowledge of the hydrogeologic setting. Seven of the sites were designated as research sites (Bourbon, Daviess, Jessamine, Hickman, Hopkins, Logan and Woodford). At these sites, geologic and topographic maps were studied in detail, extensive reconnaissance was conducted, potential sites for monitoring wells and lysimeters were determined. Rock and soil coring were conducted to confirm the geology and soil horizons that were hydrologically significant for the groundwater system so that the depth location of the monitoring wells could be determined.

Ground Water Quality On The Assessment And Research Sites

Ground water in the assessment and research sites can be separated into two zones: 1) the shallow, rapid circulation ground-water zone (SRC) and 2) the deep, slow circulation ground-water zone (DSC) underlying the near surface zone. These zones were confirmed at research sites through rock coring and water testing from the monitoring wells at the research sites. This information was extended to the assessment sites by interpretation of geology, soils, topography and hydrogeology. Depth of the SRC zone can be 10 to 30 feet in the Purchase area and the lacustrine deposits at the Daviess and Hopkins county sites. In the limestone regions of the Eastern and Western Pennyroyal and the Inner and Outer Bluegrass regions, the depth of SRC zone varies by degree of weathering of the limestone bedrock. This zone is defined as the epikarst zone. In areas of immature karst, the base of the epikarst can reach a depth of 10 to 20 feet below the soil-bedrock interface in most areas and up to 55 feet in fracture (regions of high bedrock weathering). In areas of mature karst development, the depth of the SRC zone can extend 60 to 150 feet below the land surface.

The SRC zone is divided into two categories: 1) agricultural production areas with high chemical inputs (nitrogen fertilizer and herbicides), designated as SRC-HI groundwater zones and 2) areas of low inputs, designated as SRC-LO groundwater zones. The SRC-LO zones are pastures or woods. A sampling site in an area that had fields used for row crop production (even if the percentage in row crop was small) is labeled as a SRC-HI zone unless hydrologic information indicated otherwise. Spring sampling sites with an unknown drainage basin are designated as SRC-HI zone if row-crop production areas had the potential to be within the basin. Springs or well nests were designated as SRC-LO zones if the areas had minimum to no fertility inputs or were in pasture. Groundwater sampling points were not included if they had been identified as being contaminated by point source pollution. Data from groundwater sampling sites that used lysimeters are separated from spring and well sampling sites because lysimeters were placed at depths within the soil that are predominately unsaturated, *i.e.* the soil contains capillary water, not free-flowing ground water.

Nitrate-N. On the assessment and research sites where statistical comparisons can be made, mean nitrate-N concentrations are significantly higher in the SRC-HI ground-water zone than the DSC and SRC-LO ground-water zones. Mean concentrations in the DSC and the SRC-LO zone are not significantly different. The lysimeter and SRC-HI zone concentrations are significantly different only in Hickman County site. At the Hickman County site significant differences exist in two groups of DSC ground-water wells. Group 1 has a mean concentration of 1.82 ppm whereas Group 2 is 10.69 ppm. In SRC-HI zones, nitrate-N concentrations range from 1.25 ppm to 13.56 ppm whereas the lysimeters range from 0.03 ppm to 15.03 ppm. The overall mean for SRC-HI zone is 5.22 ppm, and the lysimeters is 7.45 ppm. The DSC zone concentrations range from 0.23 to 2.10 ppm nitrate-N (excluding Hickman County) with an overall mean of 1.43 ppm. The mean SRC-LO zone concentrations has a range of 0.23 to 2.76 ppm nitrate-N with an overall mean for all sites of 2.00 ppm. The overall DSC and SRC-LO zones concentrations are not significantly.

Triazines. For triazine concentrations on the assessment and research sites where statistical comparisons can be made, the SRC-HI ground-water zone concentrations are significantly higher than the concentrations in the DSC ground-water zone and the SRC-LO ground-water zone. The concentrations in the DSC and SRC-LO zones are not significantly different. In SRC-HI zones on the sites, the triazine concentration means range from 0.11 ppb to 1.05 ppb . The DSC zone mean concentrations range from 0.01 to 0.19 ppb. The SRC-LO zone concentrations has a range of 0.01 to 0.06 ppb triazines.

Examination of overall data indicates that the SRC-HI zone has the highest mean concentration of triazine and this mean is statistically greater than the mean concentrations in the SRC-LO and DSC zones. This result is consistent with those discussed above with respect to nitrate-N concentrations as they relate to land-use and type of ground-water flow system.

In summary, these monthly data indicate that agricultural land-uses have an impact on ground-water quality. Improper disposal of herbicide containers in sinkholes and poor herbicide practices around wellheads can lead to contamination of ground water. As seen previously with respect to nitrate-N and site specific data regarding triazines, the shallow, rapid circulation systems located in high input areas show greater effects of triazine use than do the shallow, rapid circulation zones in low input areas and deep ground-water flow systems that are somewhat isolated from land-use activities.