Shallow Groundwater Quality Sampling in Kane County

October 2003

Illinois State Water Survey (1895)

Illinois Department of Natural Resources

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In October 2003, Illinois State Water Survey (ISWS) scientists collected water samples from 70 shallow domestic and industrial wells in Kane County for analysis of groundwater quality. The primary objectives were to provide a "snapshot" of water quality in these shallow aquifers and compare water quality from different parts of Kane County, especially the eastern urban corridor and the western rural region.

Wells chosen for sampling were less than 250 feet deep and were approximately equally divided between eastern and western halves of Kane County. About two-thirds of the wells were in shallow bedrock, usually dolomite, and the remainder were in shallower unconsolidated sand-and-gravel deposits found in glacial till overlying bedrock.

Samples were collected for analyses of inorganic chemistry, total organic carbon, and coliform bacteria. Some wells were also sampled for atrazine and hydrogen sulfide. The ISWS Public Service Laboratory (PSL) in Champaign conducted all the analyses.

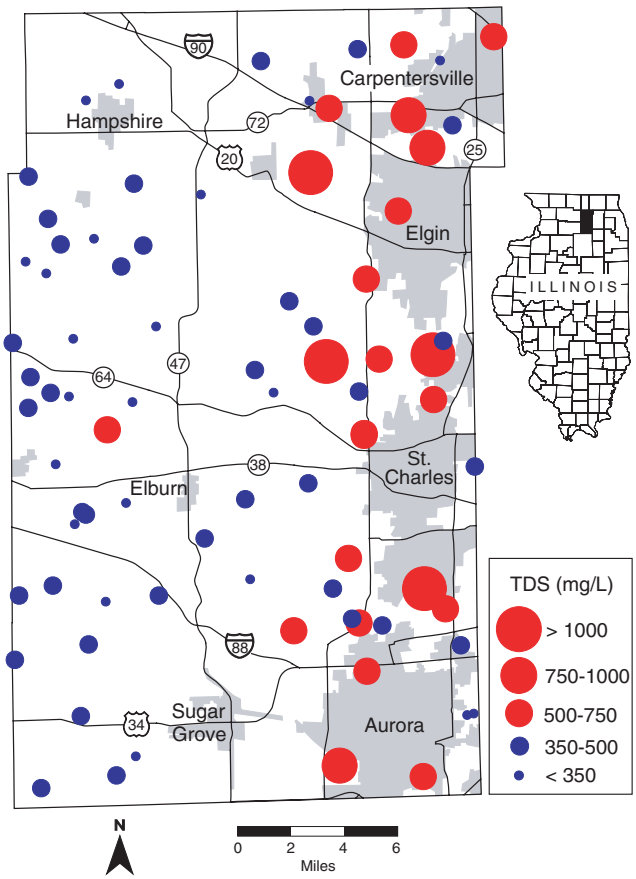
Results and Discussion

Dissolved Solids and Major Ions

Total dissolved solids (TDS) are a measure of the dissolved minerals in water and also a measure of drinking water quality. There is a secondary drinking water standard of 500 milligrams per liter (mg/L) TDS; water exceeding this level tastes salty. Groundwater with TDS levels greater than 1500 mg/L is considered too saline to be a good source of drinking water. A map of the TDS concentrations in Kane County (Figure 1) indicates a difference in the shallow groundwater quality between the urban corridor and the rest of the county: values were much higher in eastern wells than in western or central wells. Concentrations in 20 wells exceeded 500 mg/L (represented by red circles in Figure 1), including 60 percent of the wells in the eastern third of the county. Concentrations in two wells exceeded 1,000 mg/L.

The eastern urban corridor had significantly higher concentrations of all major ions [calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^{-}), and sulfate (SO_4^{2-})]. The most likely explanation for these high chloride and cation (Ca^{2+}, Mg^{2+}, and Na^{+}) concentrations is road-salt runoff.

A map of chloride concentrations with the locations of all roads in Kane County is shown

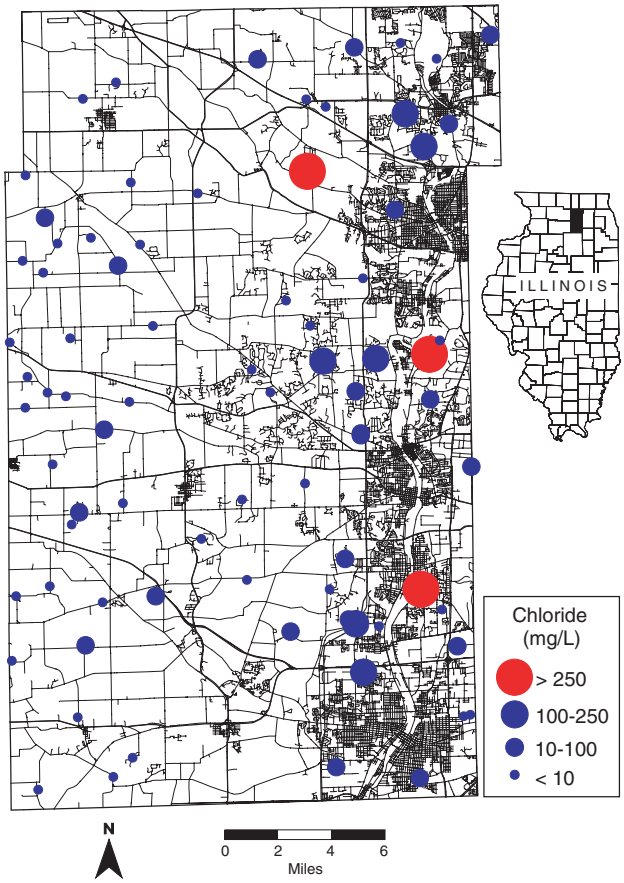


Notes: Lines are major roads; shaded areas are municipalities.

Figure 1. Total dissolved solids concentrations in Kane County

(Figure 2). Red circles represent wells with chloride concentrations above the secondary drinking water standard (250 mg/L). The mineral halite (NaCl), better known as rock salt, historically has been the primary deicer used on roads. Chloride can move rapidly in the subsurface, and concentrations have been increasing in many shallow wells in northeastern Illinois since the 1960s, when road salt use in large quantities began (Kelly and Wilson, 2003). Sodium ions entering the subsurface can exchange with calcium and magnesium ions on clay surfaces, releasing $Ca^{2+}$and Mg^{2+} into the water. Thus, concentrations of all three major cations may increase as a result of road-salt runoff.

Chloride and sodium also may enter groundwater from domestic septic systems that discharge softened water, although this is likely to be a relatively small source and not widespread. Sodium chloride typically is used to recharge ion-exchange resin columns in water softeners. High-density housing with private septic systems may be a source of chloride and sodium to groundwater.



Notes: Heavy lines are major roads; light lines are secondary roads.

Figure 2. Chloride concentrations in Kane County

Iron is abundant in the shallow aquifers in Kane County. Concentrations in more than 80 percent of the samples exceeded the secondary drinking water standard of 0.3 mg/L, and more than 60 percent exceeded 1 mg/L.

Atrazine

Atrazine, the most common row-crop herbicide used in Illinois in recent decades, also is the most environmentally persistent pesticide in the Midwest. No atrazine was detected in any sample collected from the rural regions of Kane County. This is not surprising because atrazine is adsorbed by clay minerals and organic matter in the unconsolidated glacial drift of the shallow subsurface. Thus, atrazine transport is limited in most groundwater systems.

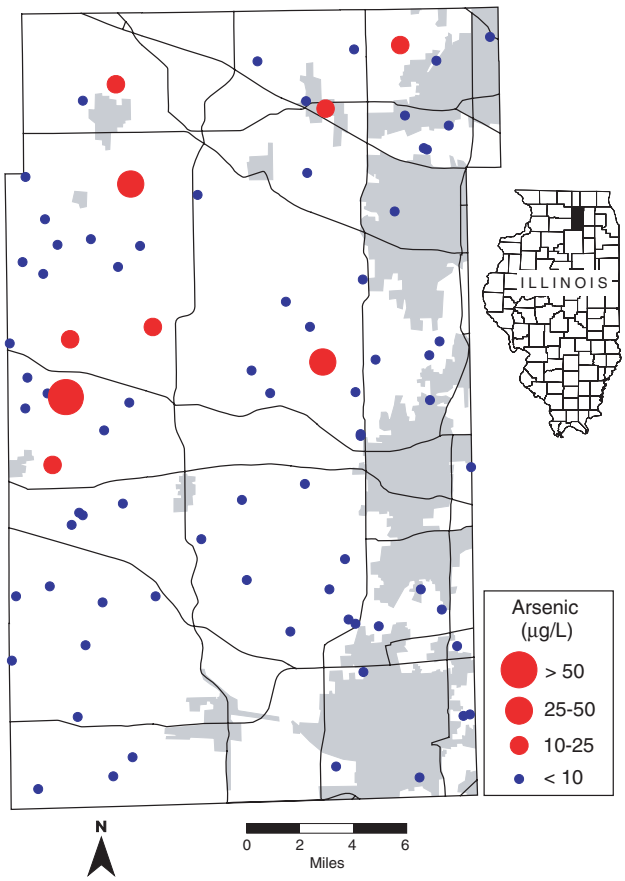
Nitrate

Elevated nitrate-nitrogen (NO_3-N) often occurs in groundwater in agricultural regions due to leaching of synthetic fertilizer and natural soil nitrogen from the soil zone. Only 10 percent of the samples had detectable NO_3-N (> 0.07 mg/L), with the highest concentration being 4.1 mg/L, well below the drinking water standard (10 mg/L).

This is quite different that what other researchers have found in similar settings throughout Illinois. For example, concentrations in many McHenry County wells exceed 10 mg/L (H.-H. Hwang, Illinois State Geological Survey, personal communication, 2005). Several factors may be contributing to the low NO_3-N concentrations in shallow Kane County groundwater. Much of the farmland in Kane County is tile drained, and thus most surface-derived nitrate may be transported to streams and drainage ditches rather than remaining in groundwater. Shallow groundwater also is generally under reducing conditions, which would promote microbially driven denitrification reactions that convert nitrate to nitrogen gas. Further study would be necessary to determine the fate of nitrate in the shallow aquifers of Kane County.

Arsenic

Arsenic, a natural contaminant, was above the new drinking water standard (10 micrograms per liter or µg/L) in nine wells, the greatest concentration being 57 µg/L. Wells with high concentrations were in the central or northern half of the county (Figure 3). Red circles represent wells with concentrations above 10 µg/L. Eight wells are finished in the shallow



Notes: Lines are major roads; shaded areas are municipalities.

Figure 3. Arsenic concentrations in Kane County

bedrock aquifer, although the well with the highest arsenic concentration is in an unconsolidated sand-and-gravel aquifer.

Other Contaminants

There are drinking water standards for about 100 inorganic and organic chemicals, microorganisms, disinfectants and disinfection products, and radionuclides. Of the 21 regulated parameters for which samples were analyzed, including barium and fluoride, contaminants common in deeper aquifers in the region, only arsenic was above the drinking water standard in any samples.

Water Quality as a Function of Well Depth and Source Aquifer Material

Calcium, iron, magnesium, manganese, chloride, and sulfate occurred at significantly greater concentrations in wells less than 100 feet deep compared to wells between 100 and 250 feet deep. Relatively elevated chloride in shallower wells was expected, assuming the primary source was road-salt runoff. Relatively elevated sulfate in shallower wells may reflect surficial sources of sulfur, such as vehicle exhaust and industrial discharges. Differences in water-quality data between unconsolidated sand-and-gravel and shallow bedrock aquifers were relatively minor.

Conclusions and Recommendations

Study results indicate generally good shallow groundwater quality, especially in the western and central thirds of Kane County. Nitrate-N concentrations were low and no atrazine was detected in any well, suggesting that any degradation of groundwater quality from agricultural activities is slight enough that it does not present a human health hazard. Arsenic was above the drinking water standard in slightly more than 10 percent of the wells. Iron and manganese were elevated in most wells, but this is common in aquifers throughout Illinois. Toxic metals other than arsenic were not present at concentrations exceeding their standards in any well.

The TDS and major ion concentrations of samples from the urban corridor were significantly greater than elsewhere in Kane County. Road-salt runoff, vehicular exhaust, and industrial discharges are the most likely sources of these elevated solutes.

Common treatment processes such as water softeners usually remove some contaminants found in raw water samples. These processes are designed to remove excess calcium and magnesium, but also tend to reduce iron and manganese levels. They may be effective in removing arsenic and other metals: five treated samples collected had arsenic concentrations well below the drinking water standard.

Because groundwater movement is slow, usually measured in feet per week or even feet per year, widespread high TDS groundwater in the eastern, urban corridor of Kane County suggests a fairly long history of shallow groundwater contamination. As Kelly and Wilson (2003) demonstrated, chloride levels in shallow aquifers in this region have been increasing since the 1960s. Even if road-salt activities stop immediately, chloride concentrations may not decrease for a long time and groundwater quality could remain degraded for decades. Contamination from road-salt runoff is widespread but not a serious human health concern. Increased levels of dissolved solids, however, do lead to increased treatment costs. In addition to a water softener, reverse osmosis or distillation typically are used to remove excess dissolved solids from domestic systems.

It may be inevitable that intensive urbanization will degrade groundwater quality in shallow aquifers, currently a problem in many cities throughout the world. Development in Kane County generally is moving from east to west. Protecting the very good shallow groundwater quality in the central and western thirds of Kane County should be a principal goal of water resource planners.

Collecting all contaminated water such as road runoff is impractical and cost prohibitive. However, some mitigation measures can be taken county wide to limit the impacts of road-salt runoff. These include:

- Diverting runoff from sensitive areas through drainage improvements.
- Reducing road-salt application in the vicinity of public water supplies.
- Using other, more environmentally benign deicing agents, such as sand or calcium magnesium acetate.

The Northeastern Illinois Planning Commission's (NIPC) brochure *Pavement Deicing: Minimizing the Environmental Impacts* contains these and other recommendations, and is available from NIPC (222 S. Riverside Plaza, Suite 1800, Chicago, IL, 60606).

For more information about this study or to get a complete report with all data from this investigation, contact Walt Kelly at the ISWS (217-333-3729; kelly@sws.uiuc.edu).

Reference

Kelly, W.R., and S.D. Wilson, 2003. Temporal Changes in Shallow Groundwater Quality in Northeastern Illinois. *Proceedings of the 12th Annual Illinois Groundwater Consortium Conference, Makanda, IL (*www.siu.edu/orda/igc/proceedings/03/kelly.pdf, accessed Feb. 2, 2005).

Water-Quality Analyses

The ISWS provides water quality analyses for owners of domestic wells free of charge. If you would like to have your well tested, contact Brian Kaiser, ISWS PSL (217-333-0802; briank@sws.uiuc.edu).