SINKHOLES, HYDROGEOLOGY, AND GROUNDWATER QUALITY IN NORTHEAST IOWA

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ABSTRACT

Northeastern Iowa is considered to have Iowa's most abundant supplies of good quality groundwater. The most widely accessible aquifers (water-producing geologic units) are comprised of carbonate (limestone or dolomite) rocks. Unfortunately, these carbonate aquifers are much more susceptible to contamination from sources at the land surface than other types of aquifers. This is because the groundwater flows through openings in the rock, enlarged by chemical solution, which range in size from microscopic fractures to large caves. When these larger openings extend to the land surface, they form depressions, called sinkholes. The open sinkholes provide a direct conduit for surface waters, and contaminants which they may carry, to run directly into the underground cavities in the carbonate rocks, and join the groundwater system. Where sinkholes are abundant they form distinct landforms, collectively called karst topography.

Documented, local occurrences of serious groundwater contamination in the karst area have raised the concern of whether or not regional groundwater contamination is occurring. If so, are regional or local control measures necessary to alleviate the problem? These are vital questions because water-quality problems may impact public health as well as the region's economic well-being.

To address these issues a systematic analysis was undertaken for the karst regions and the carbonate aquifers in 22 counties in northeast Iowa. Pertinent geologic, hydrologic and water quality data were compiled, and analyzed, including over 14,000 water analysis records provided by the University Hygienic Laboratory (UHL). The distribution of over 12,700 sinkholes was mapped. "Soil-materials" cover the bedrock to depths varying from 0 to 500 feet, but the sinkholes are only found in certain areas where the "soil-materials" are less than 30 feet thick. There are three main areas of sinkhole concentrations: one in the area of exposure of the Galena aquifer, in southwestern Allamakee County, and adjacent areas; and two areas in the Silurian-Devonian aquifer, in southern Clayton County and adjacent areas, and adjacent to the Cedar River, mainly in Floyd and Mitchell Counties.

Results of the geological studies were used to subdivide the area into three geologic regions: Karst--areas with significant concentrations of sinkholes; Shallow Bedrock--areas with less than 50 feet of "soil" covering the bedrock, but with few sinkholes; and Deep Bedrock--areas with more than 50 feet of "soil" covering the bedrock.

Groundwater in the Karst and Shallow Bedrock areas exhibits significantly higher concentrations of nitrate than in the Deep Bedrock areas, particularly to depths of 150 feet. The greatest differences occur in the 50-99 foot depth range, where the medium nitrate concentration in the Karst regions (34 mg/L) is 1.8 times greater than in the Shallow Bedrock regions (19 mg/L) and nearly 6 times greater than in the Deep Bedrock regions (6 mg/L). Below 100 feet the Karst and Shallow Bedrock areas show similar levels of nitrate. This is attributed to the direct flow of nitrate in surface waters into sinkholes in Karst.
regions, combined with significant diffuse recharge of nitrate to the aquifer in both the Karst and Shallow Bedrock regions. For perspective, the median nitrate values from all areas are below the 45 mg/l drinking water standard. For the study area, 18% of all samples exceed 45 mg/l. Within the different geologic settings, 25% of analyses from the Karst areas, 19% in the Shallow Bedrock, and 15% in the Deep Bedrock areas exceeded 45 mg/l. Much of the excessive nitrate contamination is localized to individual wells, but nitrate levels are clearly elevated regionally as well.

The source of the nitrates is clearly man's activity; natural background levels of nitrate are generally less than detectable. Little data is available regarding other widely used chemicals. What data there is indicate that pesticides, albeit in low concentrations, are entering the groundwater system is unclear, as are the possible health effects of these low concentrations. The physical setting in both the Karst and Shallow Bedrock regions present potential hazards for groundwater contamination. Any management strategies developed for protection of these water resources must consider both of these settings, which in total constitute about 6,800 square miles of land overlying important bedrock aquifers.

The relationship between the sinkholes and the groundwater flow system in the carbonate aquifers suggests that the bulk of these surface contaminants in the karst regions should be contain within the shallow portion of the flow system. This may, in part, explain why significant nitrate contamination is confined to relatively shallow depth (less than 150 feet). However, because of the lack of detailed data about the aquifers, an alternative which must be considered is that the deeper portions of the aquifer show less contamination because there has not been enough time for the nitrates to diffuse this deep.

Further research is needed on the nature of bacterial contamination of groundwater in the Karst areas. Analysis of bacterial data indicates that bacterial contamination of rural water supplies requires attention. Thirty-five percent of all analyses from UHL for the study area do not meet health standards. This contamination appears to be primarily related to problems in individual rural domestic water systems, but in Karst regions may be increased by influx of surface water.

The magnitude of chemical and bacterial contamination of an individual well is also related to problems of poor well construction, maintenance and/or well placement. Contamination of a well from surface sources may also introduce contaminants into the aquifer. Shallow wells, less than 50 feet deep, statistically show high nitrate values regardless of their geologic setting. Shallow wells throughout Iowa, regardless of the aquifer involved, are susceptible to contamination by nitrates, and indeed are exhibiting significantly high levels of nitrate contamination.

Groundwater in the Karst areas is readily susceptible to contamination from hazardous substances which locally may be discharged at the surface. On the regional level, nitrates, bacteria and pesticides are the three general contaminants of concern for public health. Both point and non-point sources can be identified. Land use patterns and other studies suggest that non-point sources, primarily infiltration, tile drainage, and water and sediment runoff from agricultural lands are the most significant. Point sources, however, should be eliminated where possible. There are existing rules and regulations to control these point sources, but many of these rules are difficult or impossible to enforce. Non-point source problems are particularly difficult to resolve, and given the complex interaction of climate and farming practices some delivery of these contaminants into the groundwater in the Karst areas is unavoidable. Possible control measures or best management practices (BMPs) must take into account these complex variables, as well as the needs of particular farm operations, and the nature and extent of existing tile drainage.

Before any effective management scheme can be developed, further research must address the details of the delivery and fate of these contaminants in the groundwater system, locally and regionally. Also, there is a pressing need for a water-quality monitoring network to provide a base of information on
Iowa's water resources. This should include improvements in present water-quality data collection schemes.

The development of a management plan and BMP's to protect groundwater quality in these carbonate aquifers will require the integrated cooperation of many agencies and people. Implementation of any effective measures will require an effective program of public education.

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