Project Summary

Impacts of a rural subdivision on groundwater: results of a decade of monitoring

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Background/Need: Understanding how rural subdivision developments using onsite septic systems impact groundwater quality and quantity is important for land-use decisions. In 1998, an unsewered subdivision near Sun Prairie, WI became part of a long term groundwater monitoring project. Prior to being converted to residential lots, the area consisted of agricultural land, woods, and a wetland. Investigations in 2002 and 2005 showed that groundwater beneath the site had been impacted by nitrate and atrazine from previous agricultural use, and that significant temporal and spatial variation in groundwater quality occurred. One of these studies detected three wastewater indicator compounds in septic drainfield effluent, but none of the compounds were detected in groundwater.

The present study is a long-term follow-up to the previous studies and was designed to examine the impact of septic systems after a longer period of use. In addition, new technology allowed the analysis of numerous wastewater indicators such as human viruses and artificial sweeteners.

Objectives: The objective of the project was to update the earlier studies by analyzing water samples from monitoring points for inorganics, human enteric viruses and indicator bacteria, pesticides, wastewater indicators such as pharmaceuticals and artificial sweeteners, and stable isotopes oxygen-18 (^{18}O) and deuterium (^{2}H). Other objectives included updating the site information by locating all new domestic wells and septic fields installed in the subdivision using GIS, compiling all the existing data into a single relational database, and developing a detailed numerical model based in large part on the new regional groundwater flow model developed for Dane County.

Methods: During 2013 and 2014 investigators sampled sixteen monitoring and domestic wells. Water samples were analyzed for inorganics, human enteric viruses and indicator bacteria, pesticides, wastewater indicator compounds such as pharmaceuticals and artificial sweeteners, and stable isotopes oxygen-18 (^{18}O) and deuterium (^{2}H). Investigators also collected water samples from six lysimeters installed under septic drainfields; these samples were analyzed for most of the same constituents.

Investigators also created a refined version of a recently-developed groundwater flow model for Dane County using the USGS MODFLOW code. The model is a three-dimensional finite-difference model representing the county geology as 12

hydrostratigraphic layers. It uses model cells 50 feet on a side within the subdivision to simulate particle movement near septic drainfields.

Results and Discussion:

Human viruses, artificial sweeteners, enteric bacteria and a trace amount of a pharmaceutical compound were found in some domestic and monitoring wells in the subdivision. Over the past decade, nitrate-N concentrations in groundwater beneath the site have generally decreased, although concentrations in two wells increased. Chloride concentrations in groundwater beneath the site increased significantly at 58% of the monitoring points over the past decade, possibly due to the local application of road salt and the presence of nearby septic systems. Trace amounts of atrazine, were present in most monitoring and domestic wells. Simulated groundwater flow paths extend from septic drainfields to domestic and monitoring wells. In contrast, site development has had little measurable impact on long-term groundwater levels. The presence of the wastewater indicator compounds in groundwater indicates that rural subdivisions can impact groundwater quality from runoff and effluent from properly constructed and operated, state-of-the-art onsite septic systems.

The presence of trace amounts of atrazine in all the monitoring and domestic wells is important because although the concentrations were below the level of detection for most labs, the compound was present even though it has not been used at the site for over a decade. This raises concerns about the source of the herbicide and whether atrazine is much more persistent in the subsurface than previously thought.

Conclusions/Implications/Recommendations:

Even though the subdivision site has a small number of houses, low housing density, and state-of-the-art septic systems, the conversion of agricultural land to a subdivision has had a small but measurable impact on groundwater quality. Subdivisions with a higher housing density might have a more serious effect on groundwater quality. Contaminants thought to originate in onsite septic systems took nearly ten years to reach shallow monitoring wells. These relatively long travel times are consistent with modeling results and demonstrate that short-term monitoring studies (1-2 years) may generally be too short to detect water quality changes. Long-term studies such as this one are necessary to determine the true impacts of subdivisions on groundwater quality and quantity.

Related Publications:

Key Words: septic, groundwater, indicator compounds, contamination, domestic wells, subdivision

Funding: The Wisconsin Department of Natural Resources

Final Report: A final report containing more detailed information on this project is available for loan at the Water Resources Institute Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069.