Relation of Septic-System Construction and Site Characteristics to Shallow Ground-Water Quality in Ohio

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Project duration: April 2003 through September 2004

Introduction and problem

In 1998, the Northeast Ohio Areawide Coordinating Agency (NOACA) initiated a study to evaluate the performance of home sewage disposal systems (HSDS) and semi-public sewage disposal systems (SPSDS) in seven counties in Northeast Ohio. The results of the study indicated that up to twenty percent of on-lot HSDS were malfunctioning, as evidenced by surfacing effluent (NOACA, 2001). Systems installed in soils with poor drainage characteristics were significantly more likely to malfunction than systems installed in soils having good drainage characteristics. There also was a correlation between the incidence of malfunction and the depth to the seasonal water table: the higher the seasonal water table, the more likely to malfunction.

Surfacing effluent from HSDS where soils have a limiting layer, such as shallow depth to bedrock, or where seasonal or perched water tables persist are causes of concern because of contamination from bacteria and pathogens, nutrients (nitrogen and phosphorous), chloride, organic enrichment, and hazardous waste from improper disposal of household wastes. The results of the NOACA (2001) study provide impetus for further investigation of the efficiency of HSDS in different soils and under different water-table characteristics throughout the rest of Ohio. Additionally, it is not known whether septic systems in Ohio contribute significant amounts of nitrate and bacterial contamination to nearby ground-water resources.

Failure of on-lot HSDS has been related to soil and water-table characteristics in Northeast Ohio; however, evaluation of HSDS throughout the remainder of Ohio and determination of the extent of ground-water contamination (if any) has not been done.

Goals and objectives

The goal of this study is to assess the performance of standard leach-line septic systems in environments in which they are likely to fail but show no evidence of surfacing effluent. This information will help the Ohio Department of Health (ODH) develop technical state minimum construction standards and rules for on-site sewage systems. The specific objectives of this study are to:

1. examine relations between shallow ground-water quality and soil, hydrogeologic, and septic-system characteristics at approximately 30 HSDS sites within Ohio, and
2. use source-tracking techniques to specifically define sources of septic contaminants to ground water at approximately 5 of these sites.

Approach

This project will be conducted in a phased approach. Specific details regarding the types and numbers of sites will be determined by the results of early phases; therefore, only approximate numbers are given here. The phases are summarized as follows: phase 1, first screening with GIS

and ODH survey; phase 2, second screening with water-quality sampling; phase 3, source tracking using various techniques; phase 4, database development and data analysis; and phase 5, data interpretation and report writing. Each of these phases is described in greater detail below.

Phase 1. First screening with GIS and ODH survey

The proposed project covers 10 of the 12 soil regions of Ohio. The remaining two soil regions were investigated under the NOACA (2001) study. To help select potential sites during the first screening process, the USGS will make use of a geographic information system (GIS) to store and manage digital spatial data, including soils distribution, bedrock type, depth to bedrock, depth to water, soils hydraulic conductivity and permeability, recharge rates, land use, presence/absence of seasonal or perched water table, and political boundaries.

Phase 2. Second screening with water-quality sampling

To evaluate relations between water quality and septic-system characteristics, soils, and hydrogeology, approximately 30 sites will be selected from the phase 1 survey for further analysis. Phase 2 will focus on sites with the following characteristics:

- Sites where septic-system malfunction is likely given the soil characteristics; however, no evidence of surfacing effluent was observed during the phase 1 survey,
- Site hydrogeology,
- Shallow depth to ground water (less than 30 ft), and
- Full site access granted by homeowner and willingness of the landowner to allow additional (and extensive) work described in phase 3.

Ground-water samples will be obtained from at least two sources at each site, including shallow ground water and deep ground water. For the purposes of this study, shallow ground water is defined as the zone of first saturation and may be 2 feet or less from land surface.

Samples will be collected for enumeration of *Escherichia coli (E. coli)* bacteria. Additionally, water samples will be sent to the National Water Quality Laboratory (NWQL) operated by the U.S. Geological Survey in Denver CO for analysis of dissolved chloride and nutrients, which includes forms of nitrogen (as nitrite, nitrite plus nitrate, and ammonia) and phosphate. These data will provide additional background water quality data for the screening process and database compilation

Because the goal of phase 2 is to provide a selected number of sites for phase 3 source tracking, phase 2 sampling will continue until 5 sites are found that have concentrations of *E. coli* indicative of human sources (this may be more or less than the approximately 30 sites mentioned above).

Phase 3. Source tracking using various techniques

Approximately five sites that were sampled during phase 2 will be selected for further study. The criterion used to select sites for phase 3 is the presence and magnitude of *E. coli* contamination in ground water determined during phase 2 screening. A set of at least six drive-point wells will be installed at each site in a similar fashion as in phase 2 screening. In addition to ground-water samples, water samples also will be collected from the domestic well at the site, from the curtain drain (if present), and from the septic system itself.

E. coli isolates will be collected from water samples collected at the site for subtyping by genomic fingerprinting using the rep-PCR method.A match of subtype from the septic system to off-site water would link contaminated water to the specific leach field as a source. Confirmation of the specificity of that subtype to the leach field will be done by collecting isolates from alternate sources in the area such as streams, ditches, pets, and wildlife.

Water samples also will be collected for analysis of wastewater constituents and nitrogen-isotope ratios. Wastewater constituents include nonionic surfactants, food additives, fragrances, antioxidants, flame retardants, plasticizers, industrial solvents, disinfectants, fecal sterols, polycyclicaromatic hydrocarbons, and high-use domestic pesticides. Analysis of nitrogen isotopes will permit the identification of different sources of nitrogen to ground water (such as human waste versus lawn or agricultural fertilizers) because these materials have different isotope ratios.

Phase 3 will result in evaluation of alternate tools for tracing fecal contamination in ground water to specific sources. The use of genomic subtyping using rep-PCR will allow implication of a single septic system as a source of fecal contamination to ground water. The use of wastewater constituents will provide confirmation that human-origin waste is present in the contaminated groundwater. The use of nitrogen isotopes will allow evaluation of the extent to which observed nutrient enrichment is attributable to use of inorganic fertilizers or release of organic nutrient sources, such as feces. These alternate tools may prove useful for application in routine investigations as the Ohio Department of Health continues evaluation of home septic systems.