

Title: Long-term Transformation and Fate of Nitrogen in Mound-type Soil Absorption Systems for Septic Tank Effluent

Project I.D.: DNR Project No. 103

Investigators: John Harkin, Professor, UW-Madison Dept. of Soil Science
Chen Peng Chen, UW-Madison Water Resources Center

Period of Contract: July 1, 1992 through September 30, 1994

Background/Need: The potential for groundwater contamination by fixed nitrogen forms originating from septic tank soil absorption systems is a widespread and growing concern. This concern is exacerbated by significant difficulties and uncertainties in predicting the transformations and fate of nitrogen in any given soil-based wastewater infiltration system. Monitoring to evaluate the extent to which various domestic on-site wastewater treatment systems comply with state groundwater quality standards and to reduce the difficulty and uncertainty in estimating long-term nitrogen transformations and fate in soil-based private wastewater treatment systems is important as a guide to regulatory control.

Objectives:

1. Identify several representative septic systems in operation for more than 15 years that have been monitored in previous studies for water quality parameters and fixed nitrogen removal during their initial operation.
2. Obtain monthly septic tank effluent and representative groundwater samples at the above sites and determine their fixed nitrogen concentrations and indicator-organism populations.
3. Compare the above results to data obtained from corresponding samples collected at these sites during the previous studies; Compare results generated in the current study for systems of three different designs (conventional, pressurized-dosing, and mound systems).
4. Evaluate the long-term effectiveness of the systems at the above sites in reducing septic tank effluent nitrogen concentrations in soil and groundwater.

Methods: Twelve septic tank\soil absorption systems in south-central Wisconsin previously studied in detail were identified and selected for monitoring groundwater in the vicinity of these systems was sampled monthly from June 1993 to August 1994 from monitoring wells installed during the original studies. Groundwater and septic tank effluent samples were analyzed for contents of total Kjeldahl nitrogen, ammonium nitrogen, and nitrate nitrogen following the semimicro Kjeldahl procedure and for populations of total coliform, fecal coliform, and fecal streptococci using the membrane-filtration techniques. Comparisons were made between results newly obtained and data from the corresponding previous studies.

Results: Nitrate in the groundwater in the vicinity of most systems investigated was effectively reduced to a safe level, i.e. less than the 10 mg/L NO₃-N Wisconsin Enforcement Standard, within a distance of 6.3 m (20.7 ft) from the edge of the soil absorption bed. No significant variation in the long-term performance of the systems was observed. Among systems of different designs, Wisconsin mound systems removed the most ammonium-nitrogen from the septic tank effluent as well as generated the highest

mean concentration of nitrate entering groundwater, followed by a rapid dissipation.

Conclusion: Septic systems investigated in this study have maintained the same high level of efficacy during operation over the years as their original performance in terms of nitrogen and bacterial attenuation. Even in these worst-case areas with high water tables, because of their high fixed-nitrogen-eliminating efficiency, septic systems are not posing a nitrate contamination problem that would restrict domestic use of groundwater. Attenuation of nitrate in groundwater was greatest in shallow aquifers with high water tables near mound systems, probably as a result of their pressurized dosing systems, combined with increased hydrodynamic dispersion and enhanced denitrification in groundwater under high water-table conditions.

**Recommendations/
Implications:**

1. The results of this and previous studies indicate that septic systems installed and operated according to Wisconsin design specification and sanitary codes provide excellent renovation of private small-scale wastewater flows over extended periods and do not pose any significant threat to groundwater quality in terms of bacterial or nitrate contamination; the findings do not lend support to justify stricter regulation of on-site wastewater treatment systems of increasing setback distances based on groundwater-quality criteria.
2. In continued research, the contributions of biological mats (crusts) at the gravel/sand interface, hydrologic parameters associated with contaminant plume transport, and denitrification in groundwater should be examined to establish plausible mechanisms for the rapid dissipation of nitrate in aquifers below septic systems.

Key Words: nitrate, septic systems, mounds, coliform

Funding: DNR

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