Ground-Water Contamination By Septic Tank Effluents

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Abstract

Approximately 90% of New Mexicans use ground water as a source of potable supply, and 29% of state residents use on-site sewage systems, including an estimated 215,000 septic systems (septic tanks and cesspools), 2400 advanced wastewater treatment systems, and 24,000 privies or other systems. Conventional septic tanks and drainfields are a suitable means of on-site wastewater treatment and disposal when site conditions (underlying soil and geology, lot size, soil, depth to ground water, aquifer geochemistry, setback to wells and streams) are adequate for natural attenuation. Unsuitable site conditions, especially small lot size or fractured bedrock, however, have caused ground water contamination. As early as 1959, the N.M. Board of Public Health noted the unsuitability of septic systems for use in densely developed residential areas. Septic systems constitute the single largest source of ground-water contamination in the state, and have contaminated more public and private water supply wells, than all other sources combined.

Septic tank effluent contains elevated total dissolved solids (TDS), nitrogen, chloride, organic carbon, and microbes, and can contain organic compounds including surfactants, solvents and pharmaceuticals. Ground water impacted by septic tank effluent typically contains elevated TDS and chloride. In oxic conditions the ammonia in sewage can oxidize to nitrate and contaminate ground water. The “Blue Baby Syndrome” caused by ground-water nitrate contamination has occurred in New Mexico. In anoxic conditions, however, ammonia does not undergo nitrification, and is not detected in ground water at appreciable levels, suggesting that it is removed by cation exchange or by volatilization. Organic carbon in the effluent can be oxidized by ground-water bacteria, which will increase the demand for, and consumption of, available electron acceptors used for respiration. Ground-water bacteria will preferentially respirate, and chemically reduce, dissolved oxygen, nitrate (denitrification), geologic manganese and iron oxide minerals, sulfate and carbon (methanogenesis), in that order, based on decreasing energy yield to the organism. Reduction of manganese and iron oxides releases soluble metal ions into ground water, and sulfate reduction creates hydrogen sulfide gas. These anaerobic respiration byproducts (ARBs) can create severe aesthetic and economic problems, and high levels of manganese in drinking water may present neurological risks. Many regulatory programs for sewage discharges focus on protecting ground water from nitrate. Consideration also should be given to protecting ground water from ARBs where geochemical conditions allow their generation.

Septic systems in New Mexico have caused regional ground-water pollution with nitrate and ARBs, in excess of allowable standards, but these conditions are mutually exclusive. Localized microbial contamination has occurred when there are inadequate setbacks to wells, and where unsanitary well construction techniques have been used. Septic systems also have contaminated ground water with surfactants, dichlorobenzene (a household toilet deodorizer) and with chemicals used to synthesize

methamphetamine.

Chloride, a non-reactive sewage constituent, and stable isotopes of hydrogen, oxygen and nitrogen can be used to geochemically fingerprint the impacts of septic systems versus other sources of ground-water contamination. Biological and physical processes can fractionate stable isotopes creating signatures that are characteristic of various contaminant sources. Septic tank effluent is somewhat enriched with ^{15}N from biological fractionation, and this can be reflected in ground water nitrate originating from septic systems. Septic-tank effluent, however, is not subject to the degree of evaporative enrichment of ^{2}H and ^{18}O that occurs in wastewater ponds and these signatures can assist in the differentiation of these sources.

New Mexico's diverse, and sometimes complex, hydrogeology has long presented challenges for developing statewide Liquid Waste regulations. Some areas have shallow, good quality ground water that is highly vulnerable to contamination from septic systems. In other areas, ground water may be non-existent, saline, or relatively protected by geologic conditions. Recent revisions to the Liquid Waste regulations have begun to take the underlying geology into account, but the regulations still largely rely on lot size as a surrogate for the many factors that protect or leave ground water vulnerable at a particular site. It is impractical to conduct hydrogeologic analyses for the large volume of Liquid Waste permits that are issued (7000+ last year), although permit applicants have the option of performing such analysis to support a variance from lot size requirements.

Inadequate lot size has been identified as a significant risk factor for ground-water contamination by septic systems in New Mexico. The first lot size rules in the state were established in 1959, and required a minimum of either ½ acre if the lot was served by a private domestic well, or ¼ acre if the lot was served by a public water supply. In 1959, cesspools were still an allowable means of sewage disposal. Since then, lot size requirements have gradually become larger. Cesspools were banned in 1973 but many are still in use in the state. The minimum lot size for a conventional septic system serving a new three bedroom home is currently set at ¾ acre. Field studies in New Mexico, however, demonstrate that ¾ acre does not always protect ground water in fractured bedrock terrain.

Many areas of the state that were developed with septic systems and private domestic wells on small lots (less than ¾ acre) eventually experienced ground-water pollution. Publicly funded efforts to provide public water and sewer service during the last three decades have addressed some of these areas. Other areas, however, are not scheduled to receive public utilities anytime in the near future, and the ongoing degradation of ground-water quality caused by septic tank effluent continues.

A number of wastewater infrastructure options, other than individual septic systems and "big pipe" public sewer systems, are feasible. Cluster systems, for example, are being used in Cordova and Willard, and provide a cost effective alternative to large scale public sewer systems.