New England Water Treatment Technology Assistance Center
University of New Hampshire ▪ Durham, New Hampshire
NE-WTTAC
PROJECT SUMMARY REPORT

Title

GROUNDWATER RADIOACTIVITY: TRANSPORT AND FATE THROUGH SMALL COMMUNITY WATER SYSTEMS

Objectives

Due to the elemental composition of New England bedrock, some locations exhibit a high uranium endowment with the result that groundwater in these same locations has elevated concentrations of radioactivity as measured by Radium, Uranium, or alpha and beta activities. This groundwater is often the only practical option to supply small community water systems. Aside from the radioactivity, bedrock groundwater is often hard and endowed with iron and/or manganese. Various water treatment technologies (green sand filters, ion exchange, reverse osmosis, etc.) are often used to remove common contaminants (hardness, sediment, iron, etc.). These water treatment systems are effective at removing the undesirable constituents (iron or hardness, for example), and in some instances the radioactive species as well. One characteristic of these water treatment systems is that they are periodically renovated/backwashed (cleaned). In the cleaning of the water treatment systems, the backwash water is disposed of into leach fields or other disposal venues, such as on the ground surface. This backwash water can be much more concentrated with the radioactive species, either in dissolved and/or solid form than what was pumped from the well. At the initiation of this study, very little information and documentation existed regarding the fate of the radioactive species after they were pumped from the bedrock well. This project intended to develop a data set in order to assist New England regulators in assessing and permitting private or community systems that have a radioactive groundwater source.

Methodology

A technical advisory committee (TAC) was formed that included representatives of four New England states (CT, ME, NH, RI), US EPA Region 1, the New England Interstate Water Pollution Control Commission (NEIWPCC), and the New England Water Treatment Technology Assistance Center (NE-WTTAC). Based on workgroup discussions and subsequent electronic and teleconference discussions, the TAC decided that approximately three to four sites from several New England states were to be targeted for field investigation. The objective was to have each system be somewhat unique allowing for a variety of conditions to be evaluated. Preferably, both private homeowner and small community systems (serving less than 500) discharging to varying on-site wastewater systems in clay or gravel settings. Site diversity rather than state diversity was to govern the final site selections. Preference was to be given to Vermont sites if suitable. The NEIWPCC distributed a site selection survey to the project workgroup and state responses indicated that although various sites existed, many system owners did not wish to participate in the study, primarily for fear that the results might lead to regulatory action on those sites.

Ultimately, four sites were studied: a retirement community in Morris, CT; an elementary school in Middleton Springs, VT; and two condominium complexes, one in Pelham, NH, and the other in Bedford, NH. None of the sites had water meters and all appeared to have kept poor records on system components (tank volumes, tank pumping, well construction), thus accurate estimates of the fate and

transport of radioactive species was not possible, however a coarse mass balance estimate was performed. The influent radioactive mass was estimated by multiplying the sum of gross alpha and gross beta concentrations times the estimated daily flow, times the interval between tank pumping or a finite interval. This was then compared to the radioactivity mass in the tank (radioactivity concentration times tank volume plus solids concentration in the liquid times tank volume times solids radioactivity concentration). At the ultimate disposal to the ground, the mass of radioactivity in the soil was computed by the soil volume times the soil density times the soil radioactivity concentration.

Results

Figures 1 through 4 depict the progression of radioactivity (the sum of gross alpha and gross beta) through each system, for both liquid and solid forms. The water and sediment values are displayed in normalized fashion: water is normalized to the ambient bedrock groundwater value and sediment is normalized to the ambient soil value. Solids Concentration Factors greater than one indicate that the solid has higher radioactivity than the ambient soil. Water Concentration Factors less than one indicate that water is less radioactive than the pumped bedrock groundwater.

At the Bedford, NH site, liquid radioactivity concentrations actually increased after the green sand filter, however this could be within the range of variability. The green sand filter removes radioactivity and during backwash this radioactivity is flushed to the disposal area. There is some radioactivity in the shallow groundwater leaving the disposal area however the majority of the radioactivity is contained in the soil (Figure 1). A mass balance indicates that the majority of the influent radioactivity pumped in the groundwater is trapped in the disposal area soil: as deep as two feet. Since disposal of the backwash is onto the land surface, the biggest exposure risks are direct contact as well as the fact that erosion of these sediments can find their way into the nearby stream.

The Pelham, NH site is very similar in radioactivity fate and transport characteristics as the Bedford, NH site. As soon as the pumped groundwater goes into the treatment process, the radioactivity is successively removed in each treatment step, and ultimately the finished water has only 6% of the original radioactivity of the bedrock groundwater. The backwash from all treatment trains flows to a surface disposal area. The shallow groundwater leaving the disposal area is over an order of magnitude higher in radioactivity than that of the ambient groundwater, however the concentration data and the mass balance indicate that the lion's share of the radioactivity is bound to the soil in the disposal area and has penetrated as deep as two feet (Figure 2). Since disposal of the Pelham system backwash is onto the land surface, the biggest exposure risks are direct contact as well as the fact that erosion of these sediments can find their way into the nearby stream.

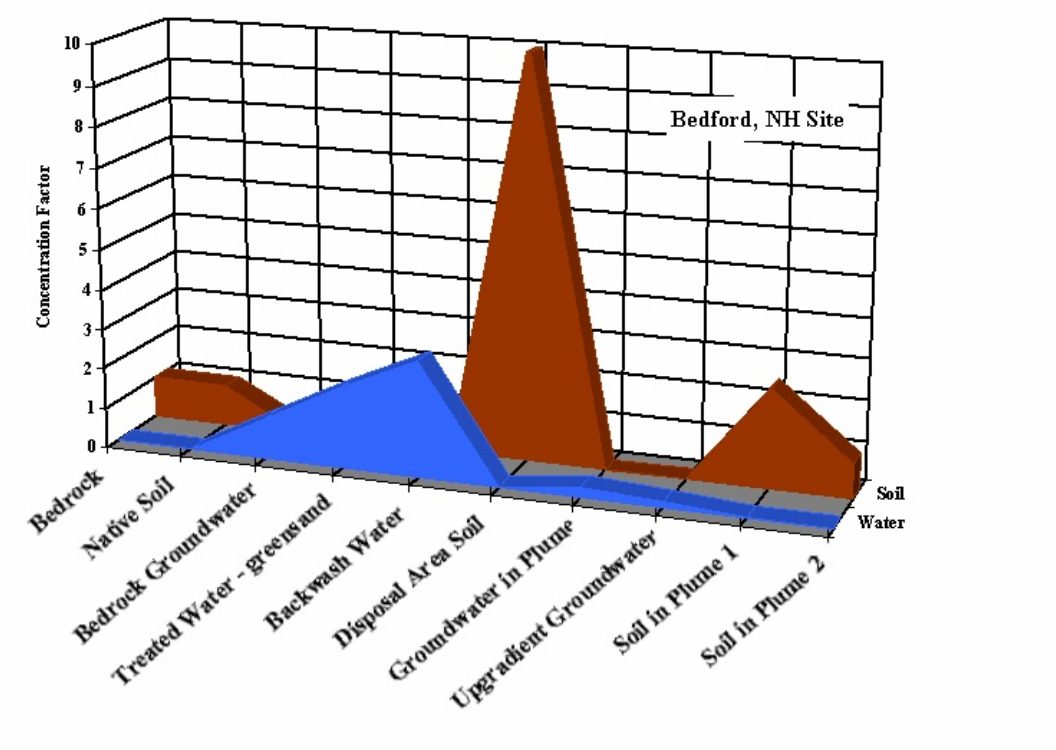

Figure 1. Genesis of radioactive fate in the Bedford, NH system.

In comparison, the ion exchange system (Pelham system) removes much more of the radioactivity than the green sand filter (Bedford system).

The Middleton Springs, VT site had the highest radioactivity of any of the four studied sites. Since there is no treatment on this system, the water goes directly to users, and what is not consumed flows to the septic tank. Most interesting for this site was that when the groundwater well pumps for short bursts, the radioactivity is about one order of magnitude lower than when it is pumped for longer durations. Since there is no water treatment at this site, it can be seen that the radioactivity of the liquid in the septic tank and the pumping tank are very similar to that of the short duration well water radioactivity. The septic tank solids do contain a relatively high radioactive content (Figure 3), however on a mass basis; it is miniscule compared to the radioactivity on the water. Therefore the majority of the radioactivity in this system heads to the leach field. The 50-ft by 75-ft leach field is dosed from the septage pumping tank, and therefore the wastewater is dosed fairly uniformly in the leach field. There is actually less radioactivity in the groundwater below the leach field than in the shallow, groundwater upgradient, and two orders of magnitude less than in the bedrock groundwater. The leach field soils have much lower radioactivity than the solids in the septic tanks, however on a mass basis, the leach field can contain decades of radioactivity. The data from this site implies that the radioactivity from the septic tank liquid is not reaching the groundwater just below the leach field and therefore is being bound to the soil in the leach field.

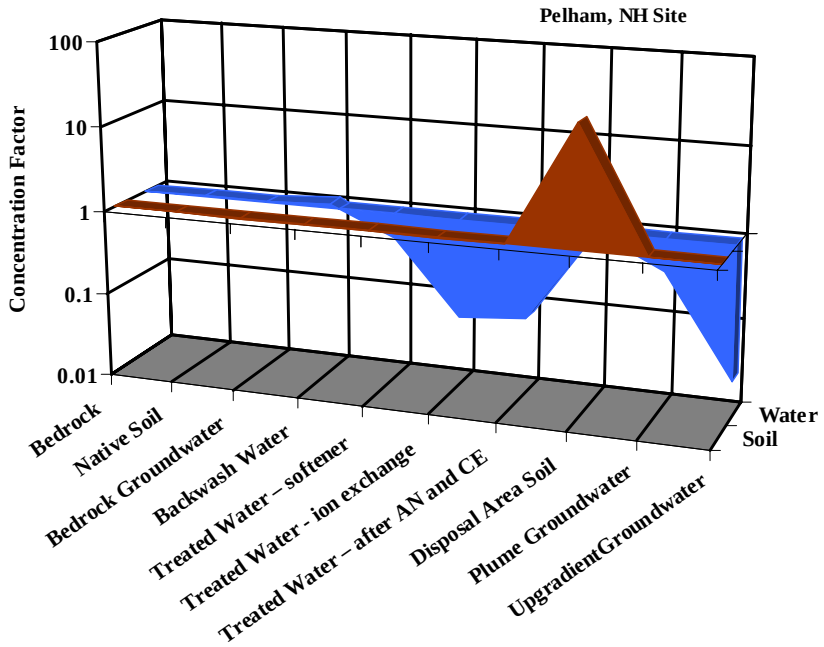

Figure 2. Genesis of radioactive fate in the Pelham, NH system.

The Morris, CT site had the lowest groundwater radioactivity of the studied sites. Figure 4 demonstrates that the backwash water is concentrating the radioactivity, and this fluid flows to the septic field. Because of the low radioactivity at this site, a mass balance could not be estimated, however the annual influent radioactivity pumped from the well at this site is two orders of magnitude lower than at the other three sites.

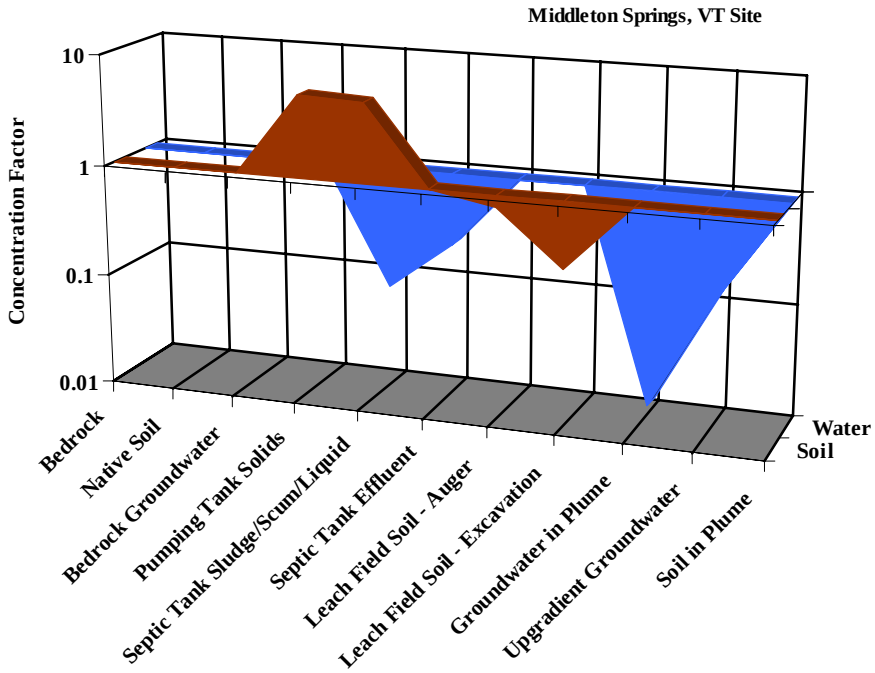

Figure 3. Genesis of radioactive fate in the Middleton Springs, VT system.

Conclusions & Recommendations

From the data collected at these four field sites, it seems apparent that at these locations, the radioactivity pumped from the ground and dissolved in groundwater has a tendency to quickly return to insoluble forms. The radionuclides from bedrock groundwater find their way to association with solids, whether the solids be in the septic tank, a treatment process, or the disposal fields. This is supported by many geochemical stability studies (Garrels and Christ, 1964). If the objective is to remove radioactive species for the purpose of domestic use of groundwater, the treatment systems should provide the opportunities for this to happen. However the backwash or cleaning of these same treatment systems must take into consideration the fate of backwash fluid and solids. Backwash is not appropriate for direct disposal onto the ground surface, but may be suitable in subsurface disposal systems on a site specific basis. The primary consideration in the design of the leach field is the sorption capacity for radioactive species over the leach field system design life. Radioactive contamination does not appear to leave the disposal area in surface or groundwater at significantly elevated concentrations.

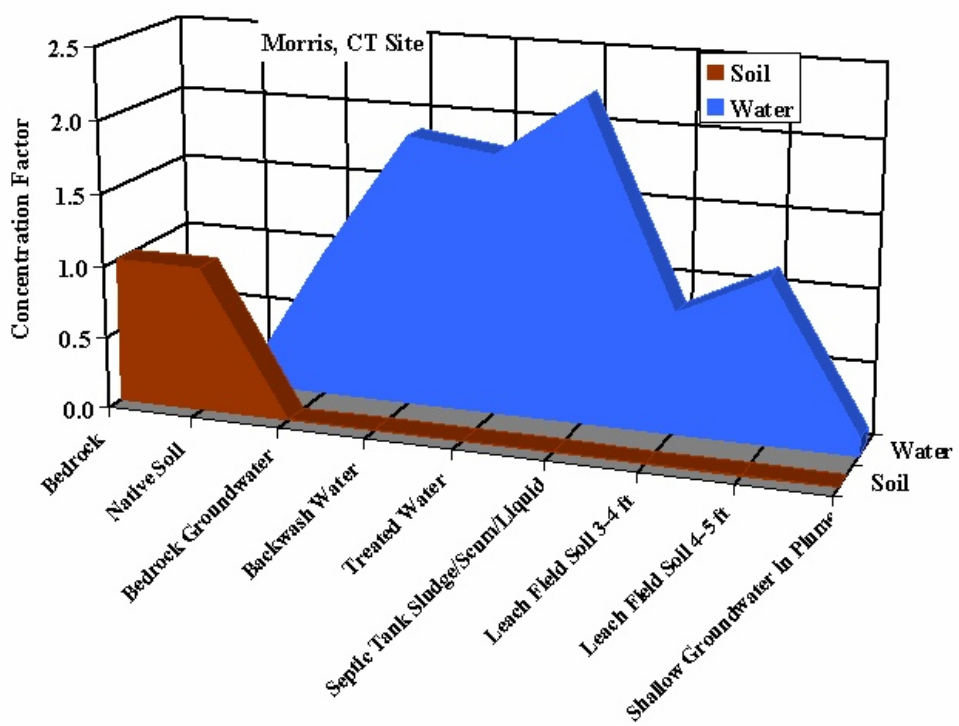

Figure 4. Genesis of radioactive fate in the Morris, CT system.

Principle Investigators

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Presentations

"Fate and Transport of Rads in Septic Systems: Lessons from the UNH/VT study & discussion". Radionuclides in Drinking Water, Workshop on Implementing the Radionuclides Rule. Sponsored by the U.S. Environmental Protection Agency, EPA Regional Lab, Chelmsford, MA, Tuesday, April 3rd 2007

Disclaimer

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