

Proposed Regional Synthesis Report

Glacial, Cambrian/Ordovician, and New England Crystalline Aquifers

Occurrence of radon-222 and uranium and related factors in ground water from glacial and bedrock aquifers in the northern United States

Scope (NAWQA components / constituents):

Study Units: New England Coastal Basins (NECB), Connecticut, Housatonic, and Thames Rivers Basins (CONN), Hudson River Basin (HDSN), Delaware River Basin (DELR), Long Island-New Jersey (LINJ) Red River of the North Basin (REDN), Upper Mississippi River Basin (UMIS), Western Lake Michigan Drainage (WMIC), Upper Illinois River Basin (UIRB), Lower Illinois River Basin (LIRB), Lake Erie-Lake St. Clair Drainage (LERI), Eastern Iowa Basins (EIWA), Puget Sound (PUGT), Cook Inlet, Alaska (COOK), Central Plateau, Washington State (CCPT), White River Basin (WHIT), Miami River Basin (MIAM), and High Plains Ground Water (HPGW).

Principal Aquifers: Cambrian-Ordovician, New England-New York Crystalline Bedrock, and glacial aquifers within or near the boundaries of the Laurentide and Cordilleran Ice Sheets in the northern United States

Time period: 1991 to present, where radon and uranium ground-water-quality data are available.

Land use(s): Primarily agricultural and urban land uses for glacial wells installed as part of a land-use study and mixed land uses for the Cambrian/Ordovician and Crystalline-bedrock wells

Is this an inter- principal aquifer regional proposal? No, but it should be noted that other parts of the Appalachian Mountains have aquifers with radon levels exceeding 1,000 pCi/L (such as in the Piedmont aquifer in the SANTEE basin). If the study results prove compelling, this study could be expanded into a national study in FY06 or later.

Expected authors – Lead: Joe Ayotte

Contributing: Sarah Flanagan, William Morrow Jr.

Objectives: Evaluate geologic settings at a regional scale and geochemical factors at the local scale that may control uranium and radon concentrations in ground water.

Data interpretation approach & feasibility

Number of sites / components (eg: nutrients, pesticides): NAWQA ground-water samples collected from aquifers listed above with radon (Rn) and/or uranium (U) water-quality data (nearly 1,600 samples in LUSs and MASSs). There will be more radon data available than uranium data, since most of the uranium data was collected from the 1994 and 1997 study units. Also compile and compare radiochemical data to other water quality data: field parameters, nutrients, major ions, and trace elements Other data which might prove useful are: isotope (age-date) data, ancillary data such as well construction, geologic logs, water use, land use, and various geologic datasets.

Methods (standard? new?): standard statistical correlation methods, such as spearman's rho correlation, Mann-Whitney test, and univariate analysis. We will be using Denis Helsel's recommended guidelines for handling data censored below the laboratory reporting levels.

Data availability & processing: Water-quality data will be primarily NAWQA data (from the Data WareHouse). When analyzing the data in terms of geologic factors, the scale of analysis will be at the regional level: wells will be grouped together based on large-scaled maps such as the Ground-Water Atlas of the United States (Miller, 2000) and the glacial region stratification scheme devised by the Glacial Aquifer Planning Team (<http://hexe.er.usgs.gov/usgs/uiirb/gapt/index.html>).

Relations between radon and uranium chemistry and well construction data (such as depth of well) will also be explored. In addition, the relations between the radiochemical and geochemical data from these

wells will be explored by comparing radon and uranium concentrations to redox conditions (pH and DO), and to major ion and trace-element concentrations.

Other Data Layers: Summary data (Hitt) from available national GIS data layers will also be examined.

Staff availability: Joe Ayotte is proposed to be lead author, with William Morrow (Illinois District), Sarah Flanagan (N.H. District) doing most of the early data compilation and analysis in FY04.

Complexity: Naturally occurring uranium and radon-222 gas behave differently in the environment dependent on differences in their own chemistry and differences in the solid and aqueous geochemistry of the local rock, sediment, soil and the ground waters they occur in. The relation between geology and the occurrence of radon in ground water has long been known (Brutsaert and others, 1981; Norton and others, 1989), but less research has been done on uranium in ground water.

Other Program contacts: Neil Debrovsky (TE/Nutrient National Synthesis Team), Kelly Warner (Glacial Aquifer Team Coordinator), Zoltan Szabo and Jeff Fischer have another radiochemical proposal to look at radium data collected from domestic wells as part of a synoptic study funded originally by the TE NST.

Expected Outcome: An improved understanding of the possible geochemical controls that relate to the presence of radon and uranium levels in ground water at the local scale and the identification of aquifers at a regional scale that are likely to have high radon and uranium concentrations.

Since radon originates from the radioactive decay of uranium, high radon and uranium concentrations can co-exist in the same ground waters, but there are geologic and geochemical conditions where this co-existence does not occur. This report will attempt to identify those conditions where high radon levels occur in the presence of low uranium and where high uranium concentrations (> 30 ug/L) occur in the presence of low (less than 1,000 pCi/L) radon levels.

If the analysis shows results that could be further examined, the investigation could be expanded in FY06 and beyond for other toxic (such as cadmium, lead, selenium, cobalt, aluminum, etc...) elements with known drinking-water standards or the scope of the study could be expanded to a national level.

Why is this topic important to report on? Radon and uranium are naturally occurring contaminants found in many geographic areas throughout the U.S. Indoor inhalation of radon gas is the 2nd leading cause of lung cancer in humans (National Academy of Sciences, 1999). An estimated 20,000 people in the U.S. die each year as a result of exposure to high radon levels. Preliminary examination of NAWQA data show that the highest levels of radon gas in ground water are in the northeastern part of the U.S. and also occur more frequently and at higher concentrations in bedrock aquifers than in glacial aquifers. The highest concentrations of radon in ground water from samples collected as part of the NAWQA program have been from crystalline-rock aquifers in the New England-NY, Piedmont, and Blue Ridge regions.

Uranium is a known kidney toxin, and may be a carcinogen for other body organs. The USEPA set a MCL of 30 µg/L for uranium in 2003. In Canada, the Health Canada Agency lowered the drinking water health advisory level (HAL) for uranium to 20 µg/L in 2001. The World Health Organization (WHO) has a recommended guideline of 2 µg/L for uranium. Recent studies are showing there may be a relation between human health effects and exposure to low levels of uranium in drinking water (Kurtio and others, 2002). The States of New Hampshire and Vermont (<http://www.healthyvermonters.info/hp/rad/uranium.shtml>) recommends residents consider treatment options for their well water if uranium levels exceed 20 ug/L. Similarly, in Maine, residents are instructed to "switch to bottle water" and to find a treatment system that removes uranium from their drinking water if the uranium concentration exceeds 30 ug/L. (<http://www.maine.gov/dhs/ehu/wells/Ubrochure.shtml>). In Connecticut, residents with private wells are advised that treatment of their water is necessary if the uranium concentration is above 30 ug/L, but are also advised to "increase their safety margin" by considering water treatment (with an ion-exchange filter) if their uranium levels are between 10-30 ug/L.

In a study done for arsenic in southeastern New Hampshire (where uranium and other water-quality data were also collected), over 6 percent of public wells had uranium concentrations greater than 20 ug/L. One percent of samples had concentrations exceeding 100 ug/L. Preliminary analysis shows that there is a link to geologic factors. Uranium continues to be a concern for most state health agencies in New England and is one of the contaminants watched by the state of New Hampshire:

(<http://www.dartmouth.edu/~toxmetal/Arsenic%20Newsletter.pdf>).

At Dartmouth College, uranium is one of the several toxic elements under investigation as part of a \$15 million grant to study metals epidemiology and toxicology; most of the work takes place in and around New England (<http://www.dartmouth.edu/~cehs/restws.shtml>).

Why does this topic need to be addressed now? There is growing anecdotal evidence that uranium may be a more common contaminant of concern to public health than has previously been thought, much like arsenic has been for the last decade. The N.H. Water Supply and Engineering Bureau, has recently discovered private bedrock wells in a town in southern New Hampshire that had uranium concentrations ranging from 1,000 to 5,500 ppb. Large-scale mining activities, with the exception of sand and gravel mining, are rare in New England and so these uranium values are thought to be naturally occurring, but the factors leading to these high values remain unknown. Individuals from other state drinking-water programs (such as in Maine) and health agencies may have similar information on uranium, but with few resources to conduct meaningful studies that can be referenced. Any research that the USGS can do to provide good scientific information on this emerging health concern of uranium in drinking water would be a benefit. The NAWQA program has collected over 1,500 radionuclide ground-water-quality data within the proposed study area (and to a much lesser extent, radium and gross alpha/beta data) since 1991, but this NAWQA dataset has yet to be analyzed in detail or at this regional scale. There is ongoing research by the National Cancer Institute (NCI) studying the relation between high radon and uranium and their health effects in New England. Our ability to study geologic/geochemical controls on these natural contaminants would 'dovetail' nicely with these health studies.

Why is it appropriate for this topic to be addressed by USGS? NAWQA? This regional Team? It is appropriate for this topic to be addressed by the USGS and NAWQA because of the extensive dataset collected by the NAWQA Program and readily available for this regional study. Some of the highest radon/uranium concentrations are in the glaciated northeast and upper Mid-western United States—the location of this Regional Team. Since the USEPA established the MCL for uranium only since 2003, it is timely to report on uranium concentrations found in the NAWQA program to date.

Who cares and why? Currently, only proposed USEPA drinking-water standards exist for radon gas. Results from this study could help the USEPA in further addressing water-quality issues for radon.

State and federal health agencies and state drinking-water programs are increasingly concerned about the geographic (or geologic) areas and the geochemical conditions that favor high concentrations of radon and uranium. The National Cancer Institute (NCI), as well as Dartmouth College is currently collecting Gross Alpha/Beta and/or uranium data from drinking-water sources for a large-scale, case-control bladder cancer study in northern New England. They have a strong interest in understanding the geochemical controls on radionuclides in ground water used for drinking water and are interested in published findings from studies in the region and elsewhere.

The people most at risk at drinking ground waters with elevated levels of radon, radium, and uranium are those using unregulated, private drinking-water wells. Community well suppliers, homeowners and the real-estate industry have long been aware of the health effects related to exposure to very high levels of radon in the air space of their homes and in their drinking-water wells, but only in recent years have they also become more aware of the health issues related to exposure to uranium in their drinking water.

Selected References:

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