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Dissolved Mineral Radioactivity In Drinking Water[1]

GENERAL

New Hampshire's bedrock contains naturally occurring radioactivity. A few examples include radon, radium 226, radium 228 and uranium. Radon is a gas; most other radionuclides are minerals.

OCCURRENCE

Radioactive minerals occur irregularly in the bedrock, similar to other minerals such as iron, arsenic and quartz. Radioactive minerals exist in all areas of New Hampshire. They dissolve easily in water. In some areas the concentration of these minerals exceeds the public drinking water standards for radioactivity. The safety standards for the permissible amount of radioactivity in drinking water are called maximum contaminant levels (MCLs).

Bedrock wells (often called artesian or drilled) can contain elevated concentrations of any or all of these radionuclides even if nearby bedrock wells have low concentrations. Wells that derive water from sand and gravel deposits, also known as dug or point wells, generally have substantially lower concentrations of both radon gas and dissolved mineral radioactivity.

HEALTH EFFECTS

The U.S. Environmental Protection Agency (EPA) sets drinking water standards and has determined that certain radioactive minerals above specified levels are a health concern. Exposure to radioactivity increases one's risk of various cancers. Other sources of radioactivity in the environment include X rays, radiation from the sun, foods from plants that concentrate radioactivity as they grow, fluorescent watch dials, and many other sources. At lower exposures, the risk of cancer is reduced. The principal health concerns for radon gas is lung cancer; uranium is toxic to the kidneys; and radium increases one's risk of bone cancer.

EPA HEALTH STANDARDS

EPA finalized new health standards for radioactivity in drinking water for public water systems in 2000. Additional revisions to these MCLs may be proposed by approximately 2005. A summary of the current mineral radionuclide standards is provided on the following page.

1. The material contained in this fact sheet was excerpted from the New Hampshire Department of Environmental Services web site (http://www.des.state.nh.us/ws.htm).

Test Name	EPA Standards
Compliance Gross Alpha*	15 pCi/L**
Uranium	30 ug/L (approx 20 pCi/L)***
Radium 226 + Radium 228	5 pCi/L
Radon	Proposed 300/4,000 pCi/L (CFR Nov. 1999)

* Compliance gross alpha equals the concentration of analytical gross alpha minus the concentration of Uranium

** pCi/L (picocuries per liter)

*** micrograms per liter (ug/L) can be converted to pCi/L by multiplying the U (mg/L) by 0.67.

REMOVAL OF RADIOACTIVITY FROM DRINKING WATER

Radionuclides can be effectively removed from drinking water. There are different processes for different radionuclides. In general these removal processes concentrate the radioactivity, thus creating the need for proper disposal.

Radon Removal Methods

Radon can be removed from water by either aeration or by adsorption onto activated carbon. The Department Of Environmental Services generally recommends aeration. "Whole-house" sized treatment devices are used when treating radon.

Mineral Radioactivity Removal Methods

In general, mineral radioactivity only needs to be removed from water that will be consumed or used in food. These devices are called point-of-use treatment and are typically installed at the kitchen sink. When only a very small amount of treated water is needed, reverse osmosis is likely the most economical water treatment method to remove dissolved mineral radioactivity. Adsorbent media also remove some mineral radionuclides.

Reverse Osmosis (RO)

RO treatment is ideal for producing a few gallons of treated water per day. In this treatment process, water under pressure is placed against a special membrane. The membrane allows water molecules to pass through, but retards the passage of other contaminants, including radionuclides. The rejected contaminants and the water that does not go through the membrane are "wasted" from this device to prevent the buildup of the contaminant(s). Typical installed cost is approximately $800-1,000.

Ion Exchange (IE)

The ion exchange method of treatment will likely be more cost effective when larger amounts of treated water are needed. This method typically removes the target contaminant by exchanging it for other non-hazardous chemicals, typically salt (sodium) which is added to the water.

An ion is the dissolved form of an atom or molecule. Contaminants can dissolve in water in either of two forms: those with a negative electrical charge (called its valance), and those with a positive valance. (Ion exchange process and address radionuclides and functions is as follows.) After purifying a substantial quantity of water, the ion exchange media needs to be regenerated by immersion in the appropriate regeneration solution. The concentrated radioactivity is forced out of the ion exchange media while part of the regeneration solution, either the sodium (Na+) or chloride (Cl-), is taken onto the media. Once returned to normal operation, the radionuclide minerals are taken out of the raw water while Na+ or Cl- ions are put in.

Radium 226 and 228 Removal

Radium dissolved in water has a "plus two (++)" valance. Radium treatment consists of passing the water through a bed of **cation** exchange media, commonly known as a water softener. This media attracts contaminants with a plus two (++) electrical charge, such as radium 226 and 228 or higher. Regeneration of the media uses the sodium portion of salt. Potassium chloride can be substituted for sodium chloride if it is desired to reduce sodium addition to the drinking water. Since the valance is low, (i.e. ++) regeneration will be needed approx. every four days.

Uranium Removal

Above pH = 6.0, uranium is typically an anion (ion with a negative valance). Below pH 6.0, uranium may be either an **anion** or non-ionic. Above pH = 8.2, uranium may precipitate. Thus, pH is an important treatment efficiency parameter. Treatment consists of passing the water through a bed of anion exchange media. This media attracts contaminants with a **minus** two or greater charge. Uranium has a valance of approximately minus 6. Regeneration of the anion exchange media uses the chloride in the salt. Given the extremely heavy molecular weight of uranium and it valance, the longevity of anion exchange resin would likely be one to two years for a conventionally sized treatment unit before regeneration was needed. It would likely be less expensive to properly dispose of the uranium-saturated resin then to regenerate, since regeneration produces a larger volume of liquid radioactive waste. A high salt setting is needed for ion exchange to force the release of the tightly held uranium.

Multiple Radionuclide Contaminants

Where one radioactive contaminant is present, a single ion exchange media can be used. When uranium and radium or other radionuclides are present together, a "mixed bed" ion exchange media can be used. These two media are sometimes combined into one tank or can be kept separate.

Radionuclide Removal In The Presence of Iron and Manganese

Where iron or manganese are present, and where an oxidation filter such as potassium permanganate greensand or birm is used, some removal of mineral radioactivity can be expected. The amount of removal varies. Thus, it is necessary to sample the treated water to determine how well this treatment mode will work on any particular water quality.

DISPOSAL OF THE WASTE

The spent regeneration solution and concentrated radionuclides are typically discharged to the home's septic system or a separate dry well. Proper disposal of the concentrated radioactivity is an important aspect of any treatment process and should be discussed with the staff of the N.H. Department of Health and Human Services Bureau of Radiological Health at 271 4588

TESTING FOR MINERAL RADIOACTIVITY

From the laboratory perspective, multiple tests are necessary to fully categorize the radioactivity level of a drinking water supply. These tests include:

Radon test
Analytical gross alpha
Uranium
Analytical beta test

For approximately 75 percent of the bedrock wells in New Hampshire, the first two tests identified above will be sufficient to determine a well's general level of radioactivity (when sampled in accordance with EPA public water supply protocol). Testing for beta radioactivity can be considered where other mineral radionuclides are elevated. There is no dependable relationship between the occurrences of these individual radioactivity forms. A low radon test does not imply there will be low uranium or radium concentrations, nor does low uranium or radium concentrations imply low radon levels.
The mineral radioactivity level of well water can vary substantially based on rainfall and other factors. Thus, at least two samples (taken a month or two apart, if possible) should be taken before conclusions are reached regarding the average concentration of any radionuclide.

TESTING YOUR WATER

EAI Analytical Labs will provide you with your free water testing kit containing: sample bottles, detailed sampling instructions and a tracking form. Bacteria samples bottles are distributed pre-sterilized and all sample bottles contain their necessary preservatives. Kits are available for pickup or they can be mailed to you. If you are interested or have any questions regarding the analysis of your water, please give us a call.