ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

29 Hazen Drive, Concord, New Hampshire 03301 • (603) 271-3503 • www.des.nh.gov

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Dissolved Mineral Radioactivity in Drinking Water

General

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

Occurrence

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

Bedrock wells (also 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 as specified above 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 associated with regulated radionuclides in water include: radon gas increases the risk of lung cancer; uranium increases toxicity risk 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 2005-2006. The following is a summary of the current mineral radionuclide MCLs.

Test Name	Radiation Type	EPA Standards
Radon	Alpha	Proposed 300/4,000 pCi/L (CFR 11/99)
Compliance Gross Alpha*	Alpha	15 pCi/L**
Uranium	Alpha	30 ug/L (approximately 20 pCi/L)***

{Radium 226	Alpha	}
{Radium 228	Beta	} Total of 226 & 228 = 5 pCi/L
Beta	Beta	4 millirems per year

* Compliance gross alpha equals the concentration of analytical gross alpha (in pCi/L) minus the concentration of uranium (in pCi/L)
** pCi/L (picocuries per liter)
*** micrograms per liter (ug/L) can be converted to pCi/L by multiplying the U (ug/L) by 0.67.
CFR = Code of Federal Regulations (proposed rule)

Removal of Radioactivity in 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.

Addressing Radioactivity in Drinking Water
This fact sheet focuses on reducing dissolve mineral radioactivity in drinking water. See fact sheet WD-WSEB-3-12 for information concerning reducing radon gas.

New Well or Connection to a Public Water System
Wells that derive their water from the soil strata (i.e. sand and gravel) generally do not have meaningful amounts of radionuclides. Such wells are commonly called dug or point wells. See fact sheet WD-WSEB-1-4 or WD-WSEB-1-5 respectively for more information on these other types of wells. Another method of achieving a safe water supply would be to extend the piping of a public water system if nearby.

Wells that derive water from the bedrock may have high concentration of radionuclides. The best way to determine if another well into the bedrock would have a reasonable chance of better quality is to do a neighborhood survey of all homes with bedrock wells and evaluate their radionuclide data and well locations.

Treatment to Remove Nucleotides
All radionuclides contaminants can be removed from well water. There are different processes for different radionuclides. In general these removal processes concentrate the radioactivity, thus creating the need for proper handling and disposal of waste by-product and possible shielding of the treatment devices where concentrations are very high.

Size of Treatment Devices
Treatment devices come in two sizes. A **whole house** device typically treats 200-300 gallons of water per day per home, enough for a typical family of four persons; while a **point-of-use** sized device typically treats two-five gallons per day, enough for only drinking purposes.

Point-of-Use versus Whole House
In general, mineral radioactivity contaminants only need to be removed from water that will be consumed or incorporated into food. Thus a point-of-use (POU) device will typically be adequate. There is no appreciable skin adsorption of radionuclides. To protect young infants that might occasionally swallow bath water, DES recommends whole house sized treatment where the radionuclide concentration is above the level shown below:

Contaminant	**Concentration**

Compliance Gross alpha	250 pCi/L
Uranium	500 ug/L
Radiums	80 pCiL
Beta	Pending

Information Concerning Gross Alpha and Valance. There are many elements that are radioactive and produce alpha emissions. The analytical gross alpha test identifies all alpha radiation from all radionuclides minerals. Precisely identifying each element producing the alpha radiation is not needed. Rather it is sufficient to determine which treatment process will provide an adequate amount of reduction of the gross alpha concentration to meet the compliance gross alpha MCL of 15 pCi/L.

Definition of Valance. An ion is the dissolved form of an atom or molecule. Mineral contaminants can dissolve in water producing either of two types of ions: those with a negative electrical charge (i.e. valance) called anion, and those with a positive valance (called cation). The ion exchange processes is commonly used to remove radionuclides ions of either type.

Gross Alpha Identification. Contaminants producing gross alpha radiation can dissolve into water producing both positive and negative radioactive ions

Point-of-Use (POU) Sized Devices
There are two sizes of point-of-use devices: **under-the-sink** and **screw-on**. Screw-on devices are typically very small, and are placed by the homeowner on the end of the kitchen faucet. They have a brief service life. They remove the contaminant types described on the label. **Under-the-sink (POU)** devices are typically larger, installed by **professionals**, and have a substantially longer operational life although still shorter than whole house treatment equipment.

Screw-on devices have a first time lower purchase cost than under-the-sink type systems. However, long-term operational costs are generally higher for frequently replaced screw-on devices. Point-of-use devices generally, being much smaller, typically have lower operational cost than whole house treatment devices. This document does not further evaluate screw-on devices.

POU Treatment Methods for Removing Radium, Uranium and some Gross Alpha
The radiological concentrations at most homes can be very adequately addressed by installing point-of-use sized equipment.

Reverse osmosis (RO) treatment addresses all uranium, radium and gross alpha contaminants. In this treatment process, water under pressure is placed against a special membrane. The RO 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 overall buildup of the contaminant(s) on the untreated side of the membrane. See fact sheet WD-WSEB-2-11 for more information on RO. Typical installation cost of RO is approximately $900-$1,100. The benefits of RO treatment are that it will take out all dissolve mineral radionuclides, whether positive or negative valance, and any other unrecognized contaminants. In addition, there is no concern about the contaminants accumulating within the treatment device.

Other POU Treatment Equipment Ion Exchange: Radionuclides can also be removed by cartridge size cation and anion exchange medias and certain adsorptive medias. Cation exchange (+) will address all radium contaminants and that portion of the gross alpha which has a positive valance. Anion exchange (-) addresses uranium and the remaining factors contributing to gross alpha. These radionuclides accumulate on the ion exchange cartridge until the cartridge removal capability is equaled; thereafter all contaminant could get through. Most modern devices have a water meter to alert the user when the treatment capability is used up. First cost should be lower than RO. Operating cost should be reviewed.

Adsorptive Media (possible associate with arsenic treatment) are being packaged in cartridge forms and may reduce uranium and some portion of gross alpha. The holding capacity and their economies of these medias are being determined. See fact sheet WD-WSEB-2-12. First cost of adsorptive media should be lower than RO. Operating cost should be reviewed with your sales representative before purchase.

Distillation is also another point-of-use treatment process which will address all mineral radionuclide types in one treatment process. Radon gas is not fully addressed by distillation.

Whole House Treatment
Whole house treatment will process 200-300 gpd. Whole house treatment might be used for very high radionuclide concentrations or where the user is highly concerned about the contaminant.

Introduction to Ion Exchange Treatment
General. At 200 + gallons per day, ion exchange (water softening) is likely the most cost effectively treatment process for whole house treatment of radionuclides. This method typically removes the target contaminant by exchanging it for other non-hazardous chemicals, typically salt (sodium or chloride) which is added to the water. See fact sheet WD-WSEB-2-12 concerning the specifics of ion exchange.

After purifying a substantial quantity of water, the ion exchange media needs to be regenerated by immersion in the appropriate regeneration solution. During regeneration 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 resin media. The exchange rate is proportional to the contaminant valance.

Treatment Methods for Radium 226 and Radium 228, and Some Gross Alpha
Radium dissolved in water has a "plus two (++)" valance. Some fraction of gross alpha also have a positive 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 (++) or greater electrical charge, such as radium 226 and 228 and some gross alpha. 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.

Treatment for Uranium and the remainder of Gross Alpha
Anion exchange is the version of ion exchange used to remove uranium and the remaining portion of gross alpha from drinking water. 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. **Anion** exchange will not treat non-ionic uranium. Above pH = 8.2, uranium may precipitate to form a solid which also will not be treated by anion exchange. 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 two or greater negative valance. Chloride is the chemical exchanged when contaminants are removed from the water.

Regeneration of the anion exchange media uses the chloride portion of salt. Given the extremely heavy molecular weight of uranium and its valance, the longevity of anion exchange resin would likely be one to two months or more between regeneration cycles. Uranium is very tightly held by the anion resin and thus a very high concentration of brine is needed to regenerate the resin. Environmentally, less frequent regeneration can compensate for the high salt usage needed when regeneration is performed.

Anion exchange removes alkalinity from the water and thus could make the water somewhat more corrosive for lead and copper in the plumbing system. This can be partially mitigated by using soda ash in the regeneration solution.

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. Iron and manganese removal is described in the DES fact sheets "Iron and Manganese in Drinking Water - A Technical Summary" WD WSEB 3-7.

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

Radon test
Analytical gross alpha
Uranium
Radium 226, 228
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 occurrence of these individual radioactivity forms. A low radon test does not imply there will be a 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, seasons and other factors. Thus, at least two samples (taken a few months if possible) should be taken before conclusions are reached regarding the average concentration of any radionuclide.

The DES laboratory can test for the following types of radioactivity in drinking water. Sample bottles can be obtained by calling 271 3445/3446 or by writing to: DES Laboratory Services Unit, PO Box 95, Concord, NH 03302-0095. The fee schedule for these tests by the DES Laboratory, as of July 1, 2004, is shown below:

Element	Cost	Volume Required
Analytical gross alpha	$ 50	Pint*
Uranium as measured by activity as measured by weigh Radon	 $ 150 $ 10 $ 20	 Two Qts* Small Vial
Radium 226	Not offered by DES. See below.	
Radium 228	Not offered by DES. See below.	

Please see document http://www.des.nh.gov/WSEB/pdf/RadLabs.pdf [pdf] for a list of certified specialty radionuclide laboratories that process radium and other radiological factors.

For More Information

For more information concerning the **health** effects of **mineral** radioactivity call the State's Bureau of Radiological Health at 271 4588. For health information concerning **airborne radon**, telephone 271 4764 or 1 800 852 3345 ext. 4764. If purchasing water treatment equipment, see the DES fact sheet WD WSEB 2-5 entitled, "Considerations When Purchasing Water Treatment Equipment."

For additional water information, please call DES at 271 3139. We would appreciate your suggestions concerning this fact sheet and your experiences in treating for mineral radionuclides. Drinking water fact sheets are available through the DES web site at: http://www.des.nh.gov/wseb then select **fact sheets**. Please check the DES internet site annually for changes to this document. 10/04