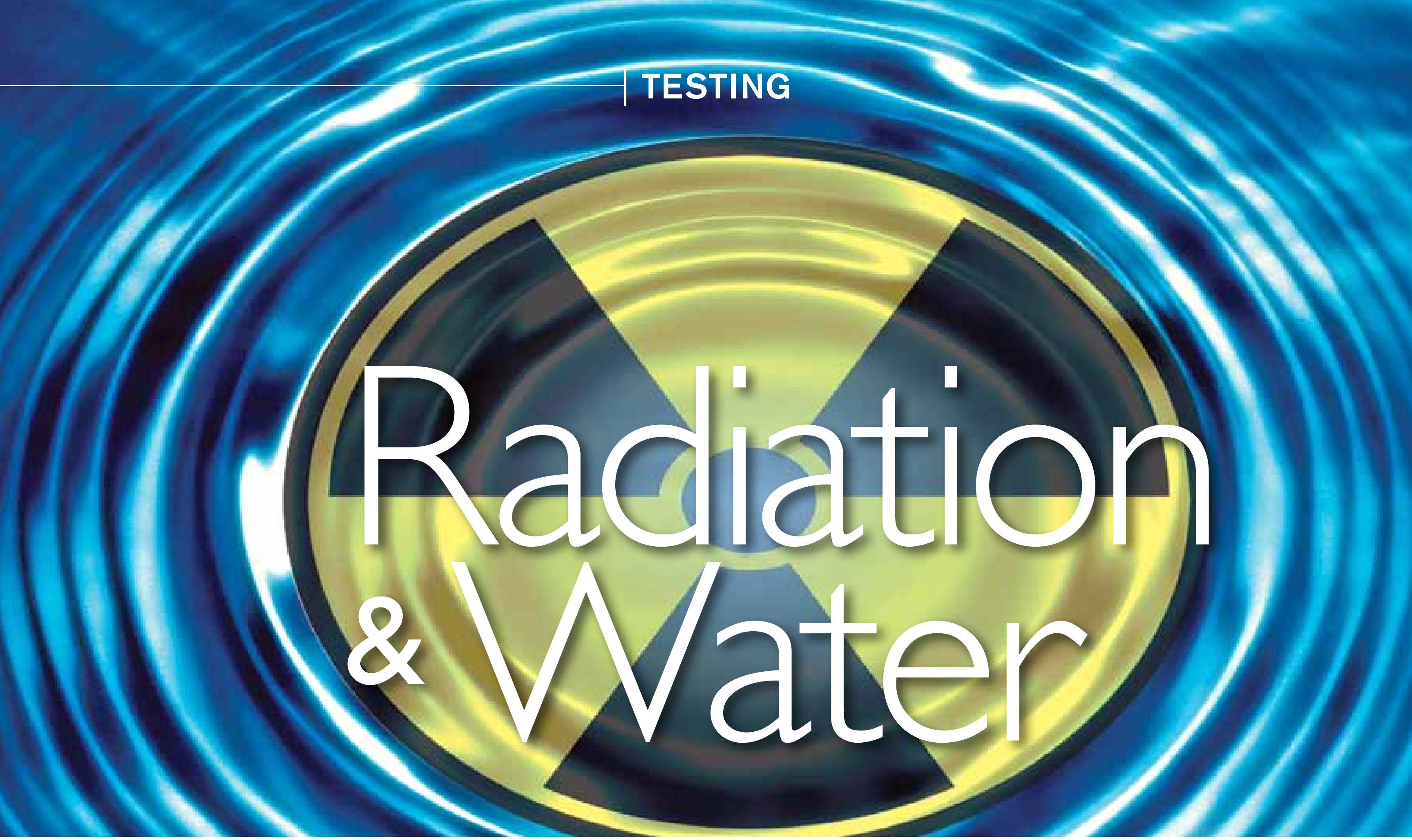

Radiation & Water

Risks, testing & treatment of radionuclides in drinking water

By Marianne Metzger

Radiological contamination of water is due to the presence of radionuclides, which are defined as atoms with unstable nuclei. In an effort to become more stable, a radionuclide emits energy in the form of rays or high-speed particles. This is called ionizing radiation because it displaces electrons, which creates ions. The three major types of ionizing radiation are alpha particles, beta particles and gamma rays.

One of the biggest differences between these types of radiation is level of penetration. Alpha particles, for example, are not able to penetrate human skin, beta particles can penetrate the top layer of skin, and gamma rays are easily able to penetrate several layers of human tissue. The size of each particle also plays a part.

Humans are exposed to radiation in a variety of ways, including from air, food, water and medicine. When people are exposed to radiation in the air, alpha particles are not problematic because they do not penetrate skin, and clothing can provide protection from beta particles, but not gamma rays. People are exposed every day to background levels of radiation in the air, mostly in the form of radon gas. Radon is an alpha particle, so it presents a low risk to skin; however, it does pose a health risk when inhaled because it can cause lung cancer.

Many building materials also emit radiation if they are made from natural rock that contains radioactive elements. For example, granite contains natural radiation and can cause low-level exposure. Grand Central Station in New York City contains so much granite that radiation levels there can be measured at levels higher than the standards for nuclear facilities.

Cosmic radiation comes from outside the Earth's atmosphere and contributes smaller amounts of radiation to the air. Exposure increases with altitude, so, for example, people who live in Denver are exposed to twice as much cosmic radiation as those who live at sea level. People also can be exposed to greater levels of cosmic radiation when flying, depending on frequency of flying, the length of the flight and flight altitude.

While the previously described exposures come from natural sources, medicine provides exposure to manmade radiation. Procedures that diagnose disease, including X-rays, CT scans and mammograms, all use radiation and result in low levels of exposure. Radiation also is used in the treatment of diseases such as cancer, and these treatments can contribute to higher levels of radiation exposure. The benefits of using radiation in medicine typically outweigh the risks associated with exposure.

Radionuclides in water and food can present a greater health risk because the radiation is actually ingested, meaning it can damage internal tissue. All plants and animals contain some level of radiation, mostly in the form of potassium-40 and radium-226. Foods that contain 3,000 picocuries per kg or more of potassium-40 include bananas, Brazil nuts, carrots, lima beans, white potatoes and red meat. Brazil nuts also contain a significant level of radium-226, so they are considered the most radioactive food.

Radionuclides also are present in water in varying amounts from natural sources within the Earth or due to releases from nuclear power plants or laboratories. Water from wells, for example, can be exposed to rock formations that can contribute radiologicals like uranium, radium and thorium. All water on Earth contains some level of radiation. In recent years, there has been increased concern over radiation levels in oceans following the Fukushima Daiichi nuclear disaster that occurred in Japan in 2011, as cesium-134 is now being found in the Pacific Ocean.

Radiation in Drinking Water

Although all water contains some level of radiation, the type and amount are dependent on a variety of factors. The most common naturally occurring alpha particles in rocks and soil are radium-226, uranium-238, radon-222, polonium-210 and lead-206. The primary beta particles typically are manmade, like strontium-90, but some are naturally occurring, like potassium-40. Some of the decay products from radon also emit beta particles. Higher levels of radiological contaminants can be found in groundwater near mining operations or areas where rock and soil have been disturbed.

Alpha particle emitters are more dangerous when inhaled or ingested, as they can expose human organs and tissues to radiation, causing biological damage that increases the risk of cancer. Beta particles can penetrate the skin and actually cause burns. They also can be detrimental when ingested, causing more damage because they are smaller and can penetrate tissues more deeply, resulting in more damage at the cellular level.

Public water supplies are tested and treated to meet U.S. Environmental Protection Agency (EPA) standards for radiologicals under the Safe Drinking Water Act. Homeowners who use private wells as their water sources may not know what level of radiation is present in their water, because most do not test for radiological contaminants. There are several reasons why people do not test their private wells—one of the foremost being that they do not even know they could be at risk. Some states require radon testing for real estate transactions and provide detailed information on the risks of radon; however, there is a lack of information about other radiological contaminants in general.

As water quality and treatment professionals, we have a responsibility to educate private well owners about the possible presence of radiologicals in their well water. One great source of information on radiological contaminants in groundwater is the U.S. Geological Survey (USGS), which has conducted several studies about radiologicals in groundwater and has a variety of resources available on its website (www.usgs.gov). State USGS educational centers also may offer more geographic-based information.

Knowing which radionuclides are present and at what levels is helpful in determining the best water treatment solution. Some treatment options, such as carbon, actually can adsorb radon and become a disposal concern if not changed out at the proper frequency, based on the level of radon. Those who do not change out carbon filters and tanks on a regular basis can increase not only their exposure to radiological contaminants, but also the exposure of workers who handle used filters and re-bed carbon tanks.

Ion exchange media also can be used to treat certain radiological contaminants. Cation exchange resin can remove radium and

Resources on Radiologicals

U.S. Geological Survey

- Web page: "Radionuclides: Radon and Other Radiochemicals," *http://water.usgs.gov/owq/topics.html#rado*
- Report: "Principal Aquifers Can Contribute Radium to Sources of Drinking Water Under Certain Geochemical Conditions," *http://pubs.usgs.gov/fs/2010/3113/*
- Web page: "Drinking Water Exposure to Chemical and Pathogenic Contaminants: Radionuclides," *http://health.usgs.gov/dw_contaminants/radionuclides.html*

U.S. Environmental Protection Agency

- Web page: "Why Are Some Atoms Radioactive?," *http://www.epa.gov/radiation/understand/radiation.html*
- Web page: "Basic Information About Radionuclides in Drinking Water," *http://water.epa.gov/drink/contaminants/basicinformation/radionuclides.cfm*

strontium, while anion resin can treat uranium. Removing radiologicals using ion exchange, however, creates waste streams that include spent resin, liquid brine and backwash that contain radiological contaminants. Disposal can become a concern, especially for spent resin that may have been used for too long and presents radiological exposure to the homeowner, as well as for the water treatment professional replacing the resin. Treating water with no idea of radiological levels can lead to higher radiation exposure for the homeowner as well as technicians who work on the water treatment equipment.

Testing for Radiologicals

There are multiple radioactive isotopes, and it is not practical or economical to test for all of them. When concerned about radiological contaminants, there are some less expensive screening tests that can be done, rather than looking for specific isotopes. A screening test looks for alpha and beta particles, and is cost-effective. If levels are elevated, additional tests to determine which contaminants are present may be done, and these tests may be more expensive. Some common additional tests might include uranium, tritium, strontium-90, radium-226 and radium-228.

We have a responsibility to educate private well owners about the possible presence of radiologicals.

Knowing which radiologicals are present in water is essential to safe and proper treatment solutions. Knowing the potential contaminants in your area can be helpful when explaining radiologicals to customers and potential customers. There are many resources for information on the presence of radiological contaminants from EPA and USGS (see "Resources on Radiologicals," page 18). If radiologicals are known to be present in your territory, educate your clients about each treatment option and the impact each has on radiologicals if present. Testing should be recommended if no testing has been done previously so that treatment systems can be properly sized and safe replacement frequency can be determined. When radiologicals are concerned, know what you are dealing with so you can protect customers and employees. WQP

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