CHAPTER

8

Radionuclide Contaminants (RADs)

A radionuclide is any naturally occurring or man-made radioactive element. A nuclide is a general term applicable to all atomic forms of an element. Nuclides are characterized by the number of protons and neutrons in the nucleus, as well as by the amount of energy contained within the atom. A radionuclide is an unstable form of a nuclide. They may occur naturally, but can also be artificially produced. There are 4 regulated RADs. This chapter will discuss these 4 RADs and explain the monitoring requirements.

Illinois EPA Assistance

In most cases, as a monitoring requirement approaches for a community water system (CWS), the Illinois EPA will send reminder notifications that detail the requirement and specific timeline for completion. Please remember that these are "reminder" notifications and does not relieve the CWS in meeting the monitoring schedule deadlines. If a CWS is unsure of its schedule or timeframe described in any Illinois EPA notification, it is very important that the CWS contact the Drinking Water Compliance Unit at 217/785-0561 for clarification. All RAD correspondence should be sent to:

RAD Coordinator
Illinois EPA /BOW/CAS #19
P.O. Box 19276
Springfield, IL 62794-9276
Telephone: 217-785-0561
Fax 217-557-1407

Sample Bottles

If your supply participates in the Community Water Supply Testing Fund (CWSTF), sample containers will be sent to your supply during the monitoring period. If your supply does not participate in the CWSTF, it is your responsibility to have all testing completed by a laboratory certified by the Illinois Environmental Laboratory Accreditation Program (for a list of accredited laboratories please visit the IL EPA website at http://www.epa.state.il.us/labs/combinedlist.html) and submitted on the correct reporting forms. Reporting forms must be submitted within 10 days after the end of a monitoring period. If the laboratory you choose submits data electronically, it is not necessary to submit a paper copy. However, it is the responsibility of the CWS to insure data reaches the Illinois EPA within 10 days of the end of the monitoring period.

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Certified Laboratory Result Reporting Forms can be downloaded at:

http://www.epa.state.il.us/water/forms.html#compliance-and-enforcement-drinking-water

If Internet access is unavailable, please contact the RAD Coordinator at 217-785-0561 for a copy of this form.

RAD Contaminants

Below are the 4 regulated RADs.

Beta/photon emitters	MCL = 4 mrem/yr
Decay of natural and man-made deposits. Certain minerals are radioactive and may emit forms of radiation known as photons and beta radiation. Some people who drink water containing beta and photon emitters in excess of the MCL over many years may have an increased risk of getting cancer.	
Alpha Emitters (Gross Alpha)	MCL = 15 pCi/L
Erosion of natural deposits. Certain minerals are radioactive and may emit a form of radiation known as alpha radiation. Some people who drink water containing alpha emitters in excess of the MCL over many years may have an increased risk of getting cancer.	
Combined Radium (Rad226 + Rad228)	MCL = 5 pCi/L
Erosion of natural deposits. Some people who drink water containing radium 226 or 228in excess of the MCL over many years may have an increased risk of getting cancer.	
Uranium	MCL = 30 ug/L
Erosion of natural deposits. Some people who drink water containing uranium in excess of the MCL over many years may have an increased risk of getting cancer and kidney toxicity.	

Background

RADs are considered chronic contaminants. It is important that the public understands that there are no immediate health risks from consuming drinking water containing a regulated chronic contaminant at levels below the MCL. Customers should be aware that chronic contaminant levels exceeding the MCL could cause certain health effects (see below). In addition, sensitive groups of people, such as the young, elderly, pregnant women, and cancer patients may be more susceptible to adverse health effects at any level of exposure.

Why do radionuclides occur in drinking water?

Certain rock formations contain naturally occurring radionuclides. In Illinois, they are mainly found in deep bedrock aquifers in Northern Illinois. Overtime, these radioactive elements dissolve into water from which communities pull water.

Most drinking water sources have very low levels of radioactive contaminants (“radionuclides”). These very low levels are not considered to be a public health concern. Of the small percentage of drinking water systems with radioactive contaminant levels high enough to be of concern, most of the radioactivity is naturally occurring. Some parts of the mid-West, including Illinois, have significantly higher average combined radium. While there are other radionuclides that have been known to occur in a small number of drinking water supplies, their occurrence is thought to be rare compared to radium–226 and radium–228.

A very small percentage of drinking water systems are located in areas that have potential sources of man-made radioactive contamination from facilities that use, manufacture, or dispose of radioactive substances. Drinking water contamination may occur through accidental releases of radioactivity or through improper disposal practices. Water systems that are vulnerable to this type of contamination are required to perform extensive monitoring for radioactive contamination to ensure that their drinking water is safe. These radionuclides are regulated under the "beta particle and photon radioactivity" standard.

The concentration of radionuclides in your drinking water is listed in your water supply's annual Consumer Confidence Report (CCR). The CCR is an annual drinking water quality report that identifies all the contaminants found in your drinking water as well as the level found. To obtain a copy of your most recent CCR, contact your local water department. In addition, any water supply that exceeds a radionuclide standard is required by law to issue a quarterly public notice to every water customer as long as the condition exist.

What are the health effects?

Some types of radiation are more energetic. One type, non-ionizing, has enough energy to move atoms, but not enough energy to alter them chemically. Another type of radiation, ionizing, has enough energy to penetrate a human cell and may damage or change that cell over time. Changes in cells may lead to cancer.

Health effects from naturally occurring radionuclides in drinking water are attributed to ingestion. Bathing or other external contact is not a hazard. Long-term exposure to radionuclides in drinking water may cause cancer. People are diverse and respond differently to exposure due to metabolism and genetics. In addition, exposure time and levels can affect the rate of risk. Short-term exposure to naturally occurring radionuclides does not present any known health effects at levels found in Illinois potable water.

What is the risk?

USEPA has estimated that the additional lifetime risk of cancer associated with drinking water with gross alpha radiation levels of 15 pCi/L (MCL) or combined radium of 5pCi/L (MCL) is about 1 in 10,000. The analysis assumes consumption of 2 liters of water per day for 70 years. The risk doubles to 2 in 10,000 at 10 pCi/L of combined radium, and becomes 3 in 10,000 at 15pCi/L of combined radium.

Comparably and including all risks, the American Cancer Society indicates that approximately 4,400 in 10,000 Americans will develop cancer at some point in their lifetimes, and approximately 2,200 in 10,000 will die from cancer.

Can radionuclides be removed from drinking water?

Supplies that exceed a radionuclide standard are required to reduce the level below acceptable limits. This can be done in a variety of ways, such as:

- Install mechanical treatment to remove the radionuclide from the water
- Blend high-level radionuclide water with low-level radionuclide water (dilute)
- Connect to another local water supply
- Drill new radionuclide "free" wells.

All the options listed above are complex, require a lot of planning and permits, and are usually expensive. It is the responsibility of the water supply to study each option and determine which is most effective, both mechanically any financially. It is the responsibility of the Illinois EPA to ensure that when a system exceeds a radionuclide standard, the system aggressively explores treatment options and compliance is achieved in the shortest amount of time.

Certain water softeners, ion exchange, or reverse osmosis water treatment systems can also be installed in homes to reduce radium. Homeowners using these methods must be careful to maintain units according the manufacturer's instructions.

Does USEPA regulate tritium in drinking water?

Tritium is a beta particle emitter which forms in the upper atmosphere through interactions between cosmic rays (nuclear particles coming from outer space) and the gases comprising the atmosphere. Tritium can be deposited from the atmosphere onto surface waters via rain or snow and can accumulate in ground water via seepage. Tritium is also formed from human activities, including production of electricity, nuclear weapons, nuclear medicines used in therapy and diagnosis, various commercial products, as well as in various academic and government research activities. Natural tritium tends not to occur at levels of concern, but contamination from human activities can result in relatively high levels.

RAD Sample Locations

RAD samples must be collected at locations that represent each well or surface water source after all treatment but prior to entering the distribution system. If water from several sources is combined and treated at a common location, then one sample can be collected to represent all combined sources.

If a well pumps directly to the distribution system with no added treatment, then a representative sample must be collected prior to the first distribution location. This is not a common situation.

On occasion the Illinois EPA will require a RAD sample to be collected directly from a well prior to treatment. If the case, the sample collector will receive specific sample collection instructions.

Initial and Reduced Monitoring Requirements

New systems, and systems that begin using a new source of supply, must conduct initial monitoring for gross alpha, radium-226/228, and uranium during the calendar quarter that follows the quarter in which they begin using the new source of supply.

Initially, RAD samples are collected quarterly for a minimum of four consecutive quarters per sample location (or entry point). A RAD sample consists of a **gross alpha, radium-226, radium-228, and uranium** analysis. However, the **uranium** analysis will NOT be required if the gross alpha result is below 15 pCi/L. Most RAD certified laboratories will evaluate the gross alpha level at the time of analyses and determine whether or not the uranium analysis is needed (gross alpha > 15 pCi/L); but, please note, it is the responsibility of the water system to ensure all analyses are performed as required. If you are uncertain that the laboratory understands that they only need to run the uranium analysis if gross alpha level is over 15 pCi/L it is recommended that the water system discuss the uranium analysis with the laboratory prior to collecting samples.

After one year (or 4 quarters) and base line data is established for a sample location, monitoring many times can be reduced. The chart below describes the reduced monitoring requirements if the average of the four quarters at each sample location is……

< detection limit	1 sample every 9 years
≥ detection limit and ≤ one-half MCL	1 sample every 6 years
> one-half MCL ≤ the MCL	1 sample every 3 years
> MCL	1 sample per quarter until results from 4 consecutive quarters ≤ MCL

Required Laboratory Detection Levels (pCi/L)

Gross Alpha	3
Gross Beta	4
Radium-226	1
Radium-228	1

Upon a request from the water system, the Illinois EPA may waive the third and fourth quarter of initial monitoring and place the system on reduced monitoring. One qualification, however, is that the first and second quarter results indication no detection for all RADs. Again, the request must come from the water system after the first two quarters with no detections.

Once on a reduced monitoring frequency, sample frequency is re-evaluated after each routine sampling event. The results of the each entry point sample will dictate the future monitoring frequency (as specified in the above chart).

Please also remember that several other factors may influence monitoring requirements; such as, violation of regulations, new regulations, and/or elevated detections. It is recommended that each CWS water operator and/or sample collector periodically (at least quarterly) download a new schedule since monitoring schedules change frequently. A CWS can download their most current monitoring schedule at:

http://www.epa.state.il.us/water/compliance/drinking-water/sdwis/index.html

Composite Monitoring

In the past, composite monitoring, which is allowing a water system to collect up to four consecutive quarterly samples from a single entry point and have the laboratory composite them temporally and then running one set analyses on the composite sample, was allowed. However, composite monitoring is no longer allowed. Every routine sample must be analyzed for each RAD parameter. Please contact the Radiological Coordinator if you would like to discuss composite monitoring in more detail.

Monitoring Requirements for Emergency Wells

All wells that are active and are either on back-up or emergency status must be monitored every three years. If the CWS purchases its primary source of water from another CWS, the purchasing system must collect annual samples from each well. There is no exception to this requirement. A RAD sample consists of a **gross alpha, radium-226, radium-228, and uranium** analysis. However, the **uranium** analysis will NOT be required if the gross alpha result is below 15 pCi/L.

If there is detection below the MCL, the CWS may be required to locate the source of the contamination and remediate.

If there is detection above the MCL, the CWS will be required to locate the source of the contamination and remediate in an established amount of time or properly abandon the well (or make treatment adjustment at the water treatment plant if applicable).

Monitoring Requirements for Beta Particle and Photon Emitters

The vast majority of systems will not be required to monitor for beta particle and photon emitters (man-made radionuclide contaminants). Beta particle and photon radioactivity monitoring is only required if:

- The system is designated by the State as vulnerable to man-made radionuclides. Vulnerable systems must collect quarterly samples for beta emitters and annual samples for tritium and strontium-90 at each entry point. Sampling must begin the quarter after the system is notified

by the Illinois EPA. The Illinois EPA most likely will require a system to speciate the sample for the most likely emitters associated with the nearby source.

- The system is designated by the State as utilizing waters contaminated by effluents from nuclear facilities. These systems must collect quarterly samples for beta emitters and iodine-131, and annual samples for tritium and strontium-90 at each entry point. More frequent monitoring is required if iodine-131 is found in finished water. Sampling must begin the quarter after the system is notified by the State. For the quarterly monitoring requirements for gross beta particle activity, samples must be collected and analyzed monthly or the composite of three monthly samples must be collected and analyzed. For the quarterly monitoring requirements for iodine-131, samples must be collected for five consecutive days, composited, and analyzed.

  For the annual monitoring requirements for tritium and strontium-90, samples must be collected quarterly and analyzed or composited and analyzed. In all cases, laboratories should be responsible for compositing the samples prior to analysis.

- The Illinois EPA, at its own discretion, requires the system to collect samples.

Compliance with the RAD Maximum Contaminant Levels (MCL)

Compliance is based on the running annual average of quarterly samples. This is calculated for entry point to the distribution system. If one sample location is out of compliance, the entire system is out of compliance unless that part of the system is entirely separate (no inter-connections) from the rest of the system.

If any single sampling result is high enough to cause the annual average to be exceeded, the supply is out of compliance immediately (for example, the analytical result is greater than four times the MCL or two analytical results are greater than twice the MCL, etc.).

Systems on reduced monitoring whose sample result exceeds the MCL, must revert to quarterly sampling for that contaminant the next quarter. A single exceedance is not necessarily a violation. Systems triggered into increased monitoring will not be considered in violation of the MCL until they have completed one year of quarterly sampling unless any sample collected during quarterly monitoring would result in the annual average exceeding the MCL.

If a system does not collect all required quarterly samples, compliance will be based on the running annual average of the samples collected. If a system has a result that is more than four times the MCL, even if the next three quarters results are non-detect, the system mathematically will have an average of greater than the MCL. The water system will also commit a monitoring and reporting violation for the missed quarterly sample.

Water systems may choose to monitor more frequently than what is required of their system. Samples must be clearly marked as “compliance/routine samples” prior to being submitted to the laboratory (and not after the results are known). If the case, all samples must be used when

determining compliance (the system cannot pick and choose results). Samples marked as "special" samples will not be used for compliance and cannot later be changed to routine samples. There are no exceptions to this rule.

The Illinois EPA has the flexibility to require confirmation samples for positive or negative results. The Illinois EPA may require more than one confirmation sample to determine the average exposure. If confirmation samples are required by the Illinois EPA, the average of the analytical result and the confirmation sample will be used for compliance determinations.

Below are examples of calculating compliance:

Example 1				
Sample Location	**Date Collected**	**Combined Radium (pCi/L)**	***Quarterly Average**	**Running Annual Average**
TP01 Well 1	10/18/07	5.6	5.6	5.6 / 4 = **1.4 (no MCL)**
TP01 Well 1	01/05/08	5.9	5.9	5.6 + 5.9 / 4 = **2.8 (no MCL)**
TP01 Well 1	04/20/08	6.3	6.3	5.6 + 5.9 + 6.3 / 4 = **4.4 (no MCL)**
TP01 Well 1	07/08/08	6.2	6.2	5.6 + 5.9 + 6.3 + 6.2 / 4 = **6 (MCL Violation)**
TP01 Well 1	10/02/08	5.4	5.4	5.9 + 6.3 + 6.2 + 5.4 / 4 = **5.9 (MCL Violation)**
TP01 Well 1	01/05/09	2.4	2.4	6.3 + 6.2 + 5.4 + 2.4 / 4 = **5.0 (no MCL)**
** Only one sample (Radium-226 and Radium-228) was collected per quarter. Combined radium equals the sum of Radium-226 plus Radium-228.* The water supply had 2 quarters in which the running annual average exceeded the MCL; therefore, the water supply was in violation. Public notice is required for these two quarters (see Chapter 1 Public Notification for requirements).				

Example 2				
Sample Location	**Date Collected**	**Combined Radium (pCi/L)**	***Quarterly Average**	**Running Annual Average**
TP01 Well 1	10/18/07	5.6	5.6	5.6 / 4 = **1.4 (no MCL)**
TP01 Well 1	01/05/08	5.9	5.9	5.6 + 5.9 / 4 = **2.8 (no MCL)**
TP01 Well 1	04/20/08	6.3	6.3	5.6 + 5.9 + 6.3 / 4 = **4.4 (no MCL)**
TP01 Well 1	07/08/08	6.2	6.2	5.6 + 5.9 + 6.3 + 6.2 / 4 = **6 (MCL Violation)**
TP01 Well 1	10/02/08	5.4	5.4	5.9 + 6.3 + 6.2 + 5.4 / 4 = **5.9 (MCL Violation)**
TP01 Well 1	01/05/09	Fail to Sample	Mon Violation	6.3 + 6.2 + 5.4+ Viol/ 3 = **5.9 (MCL Violation)**
** Only one sample (Radium-226 and Radium-228) was collected per quarter. Combined radium equals the sum of Radium-226 plus Radium-228.* The water supply had 2 quarters in which the running annual average exceeded the MCL; therefore, the water supply was in violation. Public notice is required for these two quarters.				

If more than one sample is collected during the quarter from the same sample location, the samples are averaged to calculate a quarterly average. See example below.

Example 3				
Sample Location	**Date Collected**	**Combined Radium (pCi/L)**	**Quarterly Average**	**Running Annual Average**
TP02 Well 2	10/18/07	23.3	23.3 + 27.2 / 2 = 25.2	25.2 / 4 = **6.3 (MCL violation)**
TP02 Well 2	11/12/07	27.2		
TP02 Well 2	2/12/08	6	6	25.2 + 6 / 4 = **7.8 (MCL Violation)**
TP02 Well 2	04/20/08	4	4	25.2 + 6 + 4 / 4 = **8.8 (MCL Violation)**
TP02 Well 2	07/08/08	18	18 + 2 / 2 = 10	25.2 + 6 + 4 +10 / 4 = **11.3 (MCL Violation)**
TP02 Well 2	8/2/08	2		
TP02 Well 2	10/02/08	No detect	0	6+ 4 + 10 + 0 / 4 = **5 (no MCL)**
TP02 Well 2	01/05/09	No detect	0	4 + 10 + 0 + 0 / 4 = **3.5 (no MCL)**
The water supply had 4 quarters in which the running annual average exceeded the MCL; therefore, the water supply was in violation. Public notice is required for these four quarters (see Chapter 1 Public Notification for requirements).				

Exceeding the MCL

If your water system triggers a RAD MCL violation, in addition to public notification (as described in Chapter 1 of this Handbook), a Violation Notice (VN) will be issued. The VN will require that you submit a written response within 45 days of receipt. In the written response, you will need to propose a Compliance Commitment Agreement (CCA). A RAD CCA is an agreement between a water supply and the Illinois EPA that identifies activities needed to achieve compliance with the radionuclide rule, and establishes a tentative schedule for completing these activities.

One activity that you will need to commit to is hiring an engineer to research treatment options and submitting a compliance report to Illinois EPA. Once an option is selected, the preparation of plans and specifications, obtaining funding and right-of-ways, preparing and submitting construction permits, overseeing construction, obtaining operating permits must be completed and treatment/facility operational within a “reasonable” time period.

Any supply that fails to submit an acceptable RAD CCA within the allowed time constraints will invoke enforcement follow-up under Section 31 of the Act and an enforceable schedule may be developed in a judicial order. Furthermore, the relative risk of incurring sanctions would tend to increase commensurately with the length of delayed compliance.

Monitoring after the Installation of RAD Treatment

Once treatment is installed, quarterly monitoring will be required for a minimum of one year. After a year, future monitoring requirements will be dependent on the type of RAD treatment that was installed. In some cases, reduced monitoring will be granted following the rule guidelines specified on Page 7. In other cases, more frequent monitoring will be required to ensure that treatment is always optimal. In some extreme cases, surrogate monitoring in lieu of frequent radium testing will be allowed (e.g. after the installation of home water softeners).