

# Private Well Contaminant Treatment Tool Kit

Share these fact sheets with your community about the five leading private well contaminants (arsenic, nitrates and nitrites, lead, coliform bacteria, and radon), their health impact, and treatment options.

This resource was developed in collaboration with the Rural Community Assistance Partnership (RCAP).



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# Arsenic in Groundwater

Arsenic is a naturally occurring element that can be found in rocks, soils, and minerals. In soil, arsenic is found naturally at concentrations ranging from 0.1 to 40 mg/kg (Agency for Toxic Substances and Disease Registry [ATSDR], 2015). In a natural setting, arsenic typically exists in two forms, or valences, depending on the availability of oxygen in groundwater.

Arsenic usually occurs as arsenate in shallow aquifers with high oxygen levels. In contrast, arsenic exists as arsenite in deeper, anaerobic groundwater.

Common sources of arsenic in groundwater include natural geologic deposits, agricultural activities, industrial processes, and landfills and waste sites. Arsenic can leach into groundwater from:

- Mineral deposits, such as volcanic ash or sedimentary rocks that contain arsenic-bearing minerals
- Runoff from pesticides and fertilizers that contain arsenic
- Industrial processes, such as mining and smelting of arsenic-containing ores, as well as the use of arsenic-based chemicals in various industries
- Landfills and hazardous waste sites if proper containment measures are not in place. In the past, arsenic was used as a pesticide and preservative, and as a result, some groundwater sources could have been contaminated with arsenic from its application.



## Health Impacts

Arsenic is a toxic substance that is commonly found in well water in many parts of the world. Chronic exposure to arsenic in drinking water can lead to serious health problems, including:

- **Cancer:** Long-term exposure to arsenic has been linked to an increased risk of various types of cancer, such as skin, lung, bladder, liver, and kidney.
- **Cardiovascular disease:** Arsenic has been shown to increase the risk of cardiovascular disease, including heart disease and stroke.
- **Neurological effects:** Arsenic exposure has been linked to cognitive decline, memory loss, and other neurological problems. There is evidence that suggests that long-term exposure to low levels ( $\geq 0.005$  mg/L) of arsenic from drinking water might result in lower IQ scores in children.
- **Skin lesions:** Chronic arsenic exposure can lead to the development of dark patches on the skin, a condition known as arsenicosis.
- **Reproductive problems:** Arsenic has been linked to a range of reproductive problems, including decreased fertility and increased risk of miscarriage.
- **Immune system suppression:** Arsenic exposure has been shown to weaken the immune system, making people more susceptible to infections and other diseases.
- **Diabetes:** Arsenic exposure has been associated with an increased risk of type 2 diabetes.

Short-term exposure to very high levels of arsenic can cause stomach pain, nausea, vomiting, diarrhea, headaches, weakness, and even death (ATSDR, 2015). If you have concerns about health problems that could be related to arsenic in your well water, discuss them with your doctor.

## Treating Arsenic in Groundwater

It is important to regularly test well water for arsenic and to take steps to treat it if elevated levels are found. If you are concerned about arsenic in your drinking water, speak with a qualified water treatment professional or public health specialist.

For private wells contaminated with arsenic, the most common treatment options are:

- **Reverse Osmosis:** This process uses a semi-permeable membrane to remove impurities including arsenic.
- **Ion Exchange:** This method removes arsenic from water by exchanging arsenic ions with another ion in a resin bed.
- **Distillation:** This process involves boiling sample water, gathering the steam from the water and cooling it to turn it back into water. Distillation removes minerals, metals, and other contaminants, including arsenic by separating them into the boiler. It results in nearly pure water.
- **Activated Alumina System:** This method uses alumina media to absorb a wide range of contaminants from well water. This type of filter typically removes arsenic by oxidizing it with chlorine bleach or hydrogen peroxide.

The most cost-effective method for removing arsenic from a private water supply is currently reverse osmosis (University of Florida, 2014). Reverse osmosis can be up to 95% effective for removal of arsenate (Massachusetts Department of Environmental Protection, 2023). Most reverse osmosis systems installed in homes are called point-of-use systems.

Consult with a water treatment professional to determine the best treatment option for your specific well. The appropriate method depends on the concentration and form of arsenic in your water, in addition to other characteristics of your well.

## Resources

- Arsenic in Well Water | Minnesota Department of Health
- Arsenic in Well Water: What You Need to Know | WellOwner.org
- Get Informed on Arsenic | Water Research Center

## Tips to Maintain a Healthy Well

- **Know** your private well and take pictures of the following to reference later if there is damage:
  - Storage or pressure tanks
  - Pump
  - Treatment system, including filters
  - Electrical components
- **Know** your well depth and pump setting if using a submersible pump.
- **Test** your water annually for coliform and nitrate, and every 3–5 years for a complete analysis to determine if there have been any changes to the water quality.
- **Check** your private well periodically for any damage or maintenance problems. Always hire a qualified professional well contractor to service your well.
- **Keep** the contact information for a licensed well contractor, local health department, university extension service, licensed electrician, and water testing laboratory handy.

- Arsenic in Your Well Water: What Homeowners Can Do if Your Well Has Too Much Arsenic | Maine Department of Health

## References

- Agency for Toxic Substances and Disease Registry. (2015). ToxFAQs for arsenic. <https://www.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=19&toxid=3>
- Massachusetts Department of Environmental Protection. (2023). *Arsenic in private well water FAQs*. <https://www.mass.gov/info-details/arsenic-in-private-well-water-faqs>
- University of Florida. (2014). Inexpensive, easy way to filter arsenic from water. *ScienceDaily*. [www.sciencedaily.com/releases/2014/11/141103142207.htm](http://www.sciencedaily.com/releases/2014/11/141103142207.htm)

# Nitrates & Nitrites in Groundwater

Nitrates and nitrites are nitrogen-containing compounds that are commonly found in groundwater. Common sources of nitrates and nitrites in groundwater include agricultural activities, septic systems, animal and human fecal waste, and industrial processes (Ward et al., 2018).

Nitrates occur naturally in groundwater, but concentrations over 3 mg/L generally indicate contamination (Madison & Brunett, 1985). A more recent study found that concentrations over 1 mg/L are a result of anthropogenic pollution (Dubrovsky et al., 2010). Microorganisms that inhabit the soil, water, and sewage cause the change from nitrate to nitrite.

Nitrates and nitrites can leach into groundwater from:

- Agricultural fields where fertilizer and manure are used
- Septic systems through leaching or runoff.
- Animal waste, such as manure from feedlots or livestock operations
- Human waste from sewage systems
- Industrial processes, such as the production of nitric acid or the manufacture of explosives.

It is important to regularly test well water for nitrates and nitrites and to take steps to treat your water if elevated levels are found.



## Health Impacts

According to Ward et al. (2018), exposure to high levels of nitrates and nitrites in drinking water can have serious public health impacts, including:

- **Infant methemoglobinemia (blue baby syndrome):** Nitrates can convert to nitrites in the body, which can interfere with the blood's ability to carry oxygen, causing this syndrome. Infants younger than 6 months are at most risk of developing serious health problems. Lack of oxygen can cause the infant to turn a bluish color. If untreated, infants can die from this condition.
- **Cancer:** Long-term exposure to nitrates and nitrites has been linked to an increased risk of certain types of cancer, such as gastric and bladder cancer.
- **Reproductive problems:** Exposure to nitrates and nitrites has been associated with decreased fertility and birth defects.
- **Endocrine disruption:** Nitrates and nitrites can interfere with the function of hormones, leading to various health problems.
- **Allergic reactions:** Some people can be sensitive to nitrates and nitrites and experience allergic reactions when they are exposed to these compounds.

Acute exposure to nitrates through consuming elevated levels of nitrite in drinking water can compromise the process of cellular respiration, impacting overall well-being.

If you are concerned about nitrates or nitrites in your drinking water, speak with a qualified water treatment professional or public health specialist.

If you have concerns about health problems that could be related to nitrates or nitrites in your well water, discuss them with your doctor.

## Treating Nitrates and Nitrites in Groundwater

There are several methods that can be used to treat nitrates and nitrites in groundwater:

- **Ion exchange:** Removes nitrates and nitrites from the water by exchanging them with ions of another substance, typically sodium, through an ion exchange resin.
- **Reverse osmosis:** This is a physical filtration process that removes nitrates and nitrites by forcing the water through a semipermeable membrane.
- **Electrodialysis:** Uses an electric field to separate nitrates and nitrites from the water and is typically used in conjunction with reverse osmosis.
- **Chemical precipitation:** In this process, chemicals are added to the water to cause the nitrates and nitrites to precipitate out and be removed.
- **Denitrification:** This process uses bacteria to convert nitrates and nitrites into nitrogen gas, which is harmless and released into the atmosphere. This process can be achieved through various methods such as bioreactors, constructed wetlands, or deep-bed filters.

It is important to note that the most effective method of treatment will depend on the specific groundwater conditions, including the concentration of nitrates and nitrites, the presence of other contaminants, and the desired outcome. It is best to consult with a water treatment specialist to determine the best course of action.

## Recommended Resources

- ToxFAQs for Nitrate and Nitrite | Agency for Toxic Substances and Disease Registry
- Nitrate in Drinking Water | Minnesota Department of Health
- Nitrate in Wells | Penn State University Extension

## References

- Dubrovsky, N. M., Burow, K. R., Clark, G. M., Gronberg, J. M., Hamilton, P. A., Hitt, K. J., Mueller, D.K., Munn, M.D., Nolan, B.T., Puckett, L.J., Rupert, M.G., Short, T.M., Spahr, N.E., Sprague, L.A., &

## Tips to Maintain a Healthy Well

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  - Storage or pressure tanks
  - Pump
  - Treatment system, including filters
  - Electrical components
- **Know** your well depth and pump setting if using a submersible pump.
- **Test** your water annually for coliform and nitrate, and every 3–5 years for a complete analysis to determine if there have been any changes to the water quality.
- **Check** your private well periodically for any damage or maintenance problems. Always hire a qualified professional well contractor to service your well.
- **Keep** the contact information for a licensed well contractor, local health department, university extension service, licensed electrician, and water testing laboratory handy.

Wilber, W. G. (2010). *The quality of our nation's waters—Nutrients in the nation's streams and groundwater, 1992–2004*. [Circular, 1350]. U.S. Geological Survey. <https://doi.org/10.3133/cir1350>

- Madison, R. J., & Brunett, J. O. (1985). Overview of the occurrence of nitrate in groundwater of the United States. US Geological Survey water supply paper, 2275, 93-105.
- Ward, M. H., Jones, R. R., Brender, J. D., De Kok, T. M., Weyer, P. J., Nolan, B. T., Villanueva, C.M., & Van Breda, S. G. (2018). Drinking water nitrate and human health: An updated review. *International Journal of Environmental Research and Public Health*, 15(7), Article 1557. <https://doi.org/10.3390/ijerph15071557>

# Lead in Groundwater

Lead is a naturally occurring element that can be found in natural deposits in some areas and can leach into the groundwater. Lead can also combine with groundwater from private wells due to lead pipes, lead-based paint, lead soldering, and industrial contamination (Matta & Gjyli, 2016).

Lead was once a common material used in pipes for carrying water. Lead can contaminate groundwater:

- In older homes with plumbing systems that still have lead pipes
- Through runoff water from chipping or peeling paint in homes built before 1978, before lead was banned in paint
- From lead soldered corroded join pipes in plumbing systems
- From leaks or spills from industries that use lead in their processes

Lead can also be toxic to wildlife and can accumulate in the food chain, leading to toxic concentrations in animals at the top of the food chain.



## Health Impacts

Lead is a toxic metal. Lead in groundwater can contaminate drinking water, which can lead to profound negative health outcomes (Levallois et al., 2018).

Ingesting even small amounts of lead over a long period of time can result in lead toxicity. Chronic exposure to lead can result in developmental and behavioral problems, and high levels can cause damage to the brain, kidneys, and reproductive system:

- **Neurological effects:** Lead can damage the brain and nervous system, especially in young children and pregnant individuals. Chronic exposure to lead can result in developmental and behavioral problems, as well as reduced IQ and learning difficulties.
- **Cardiovascular disease:** Long-term exposure to lead has been linked to an increased risk of cardiovascular disease, including high blood pressure and heart attacks.
- **Kidney damage:** Lead can accumulate in the kidneys and cause damage over time, leading to reduced function and, in severe cases, kidney failure.
- **Reproductive effects:** Lead can harm the reproductive system, reducing fertility and increasing the risk of miscarriage and stillbirth.
- **Anemia:** Lead can interfere with the body's ability to produce red blood cells, leading to anemia.

It is important to be aware of the potential for lead contamination in groundwater and to have your water tested if you have concerns. If lead is found, a water treatment specialist can advise you on the best course of action to remove it and ensure the safety of your drinking water.

## Treating Lead in Groundwater

There are several methods that can be used to treat lead in groundwater:

- **Reverse osmosis:** This process uses physical filtration to remove lead from water by forcing it through a semipermeable membrane. Reverse osmosis is very effective at removing lead, but it can also remove beneficial minerals and should be used in conjunction with a mineral recovery system.
- **Activated carbon filtration:** Uses a filter filled with activated carbon to absorb lead and other contaminants from the water. Activated carbon filtration is a highly effective method of removing lead, but filters must be replaced regularly to maintain effectiveness.
- **Ion exchange:** This process uses an ion exchange resin to remove lead from water by exchanging it with ions of another substance, typically sodium. Ion exchange is a highly effective method of removing lead, but it can be expensive and requires regular maintenance.
- **Distillation:** This method removes lead by heating water to its boiling point, causing it to evaporate and leaving the lead and other contaminants behind. Distillation is effective at removing lead, but it can be expensive and requires a significant amount of energy.

It is important to note that the most effective method of treatment will depend on the specific groundwater conditions, including the concentration of lead, the presence of other contaminants, and the desired outcome. It is best to consult with a water treatment specialist to determine the best course of action.

## Recommended Resources

- Basic Information About Lead in Drinking Water | U.S. Environmental Protection Agency
- Lead in Drinking Water | Centers for Disease Control and Prevention
- Lead in Private Well Water | Virginia Department of Health

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## References

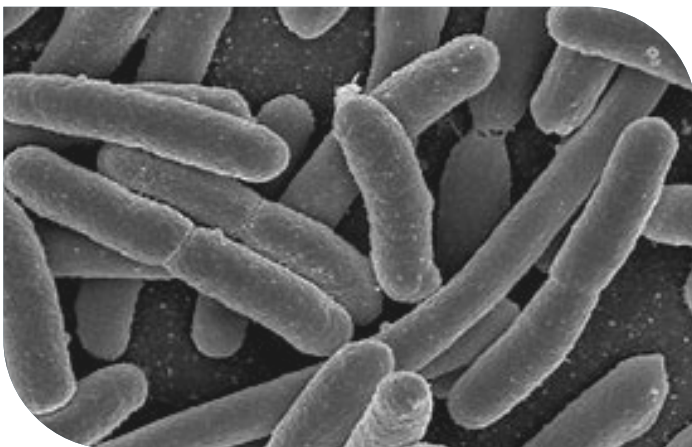
- Levallois P, Barn P, Valcke M, Gauvin D, Kosatsky T. Public Health Consequences of Lead in Drinking Water. *Curr Environ Health Rep.* 2018 Jun;5(2):255-262. doi: 10.1007/s40572-018-0193-0. PMID: 29556976.
- Matta, G., & Gjyli, L. (2016). Mercury, lead, and arsenic: impact on environment and human health. *Journal of Chemical and Pharmaceutical Sciences*, 9(2), 718–725.

# Coliform Bacteria in Groundwater

Coliform bacteria are microorganisms that are commonly found in the digestive tract of warm-blooded animals, including humans, and are used as an indicator of potential contamination in water supplies. In groundwater, the presence of coliform bacteria can indicate that the water has been contaminated with human or animal waste, which can contain harmful pathogens.

It is important to note that not all coliform bacteria are harmful, but their presence in groundwater can indicate the potential presence of harmful pathogens. Further testing is typically needed to determine the exact cause of contamination and the level of risk to public health.

Regular monitoring and testing of groundwater for coliform bacteria is essential to ensure it is safe for human consumption and use (Colford et al., 2006). In the event of contamination, treatment and remediation processes can be implemented to reduce the levels of coliform bacteria and other harmful pathogens in the water.



## Health Impacts

The presence of coliform bacteria in groundwater is a significant public health concern since contaminated water can cause serious illnesses if consumed or used for hygiene purposes.

The presence of coliform bacteria in groundwater can indicate the presence of more harmful pathogens, such as *E. coli* and *Salmonella*. These pathogens in groundwater can cause:

- Gastrointestinal illness with symptoms of nausea, vomiting, and diarrhea. These illnesses can be life-threatening, especially for vulnerable populations such as older adults, young children, and people with compromised immune systems.
- Bacterial infections of the skin and soft tissue, urinary tract, and lungs (pneumonia)
- Increased risk to people with compromised immune systems and individuals who are pregnant
- Waterborne diseases such as cholera, typhoid fever, and dysentery

Monitor groundwater for the presence of coliform bacteria and take steps to reduce exposure if levels are high. Options include:

- Treating the water
- Finding alternative water sources
- Taking other protective measures as recommended by public health officials

Determining the source of the fecal coliform contamination in water systems is important since repairs and/or modifications might be needed to prevent recontamination after water treatment.



## Treating Coliform Bacteria in Groundwater

Coliform bacteria in groundwater can be treated through:

- **Disinfection:** The most common method used to treat groundwater contaminated with coliform bacteria. This method can be done using chemicals such as chlorine, chloramines, or ozone. The water is treated with a specific dose of the chemical and then left to stand for a certain amount of time to allow for adequate disinfection.
- **Ultrafiltration:** A method that uses a membrane to filter out bacteria and other impurities from the water. This method is effective for reducing coliform bacteria levels in groundwater and is commonly used in conjunction with other treatment methods.
- **Reverse osmosis:** Uses a semipermeable membrane to filter out impurities, including bacteria, from the water. This method is effective for reducing coliform bacteria levels in groundwater, but can be expensive and might require a significant amount of water to be wasted during the filtration process.
- **UV light:** Used to treat water to reduce coliform bacteria levels. This method involves running the water through a UV light treatment unit, which uses UV light to kill the bacteria.
- **Boiling:** Boiling water is an effective method for reducing coliform bacteria levels. The water should be brought to a rolling boil for at least 1 minute to ensure that all bacteria are killed.
- **System Maintenance:** Repairs or maintenance of system components might eliminate the source of contamination.

The most effective method will depend on the specific situation, including the coliform bacteria level, the groundwater chemistry, and the needs and preferences of the homeowner (California State Water Resources Control Board, 2018).

A water treatment professional can help determine the best treatment option for a specific private well.

### Recommended Resources

- Well Testing | Centers for Disease Control and Prevention

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- Protect Your Home's Water | U.S. Environmental Protection Agency
- Bacterial Indicators | California State Water Resources Control Board

### References

- California State Water Resources Control Board. (2018). Title 22, California Code of Regulations, Regulations Related to Drinking Water.
- Colford, J. M., Jr, Roy, S., Beach, M. J., Hightower, A., Shaw, S. E., & Wade, T. J. (2006). A review of household drinking water intervention trials and an approach to the estimation of endemic waterborne gastroenteritis in the United States. *Journal of Water and Health*, 4 Suppl 2, 71–88. <https://doi.org/10.2166/wh.2006.018>

# Radon in Groundwater

Radon is a naturally occurring, radioactive gas that can be found in the soil and rock beneath homes, buildings, and private wells.

The U.S. Environmental Protection Agency (U.S. EPA) estimates that about 1 in 15 homes in the country have elevated radon levels. No level of radon gas exposure is considered safe.

The significance of radon in private wells lies in the potential health risks associated with long-term exposure to the gas. Radon can enter homes and buildings through cracks in the foundation, sump pumps, floor-wall joints, and other openings, and can accumulate to levels that are hazardous to human health.



## Health Impacts

Radon is the second leading cause of lung cancer U.S. after smoking. It is estimated to cause more than 20,000 deaths in the country every year (U.S. EPA, 2023).

Exposure to radon through drinking water can have significant health impacts, although the risk is generally lower than from inhaling radon gas (Otahal et al., 2014).

When radon is ingested through drinking water, it is absorbed into the bloodstream, potentially increasing the risk of developing certain types of cancer, including lung, stomach, and intestinal.

People who are exposed to radon through both drinking water and indoor air can face an increased risk of health problems compared with people exposed through only one source. While the risk of health problems from drinking water is lower than from inhaling radon gas, exposure to high levels of radon in drinking water can still have significant health impacts.

Individuals relying on private wells for drinking water are particularly at risk of exposure to high levels of radon in drinking water, as these wells are not subject to the same regulations as public water supplies (Chen, 2019).

It is important for homeowners with private wells to have their water tested for radon on an annual basis to determine if levels are high enough to pose a risk. If high levels are found, there are mitigation techniques that can be used to reduce exposure, such as installing a radon removal system in the water supply.

## Treating Radon in Groundwater

U.S. EPA recommends testing radionuclides in private wells every 3 years. If high levels of radon are found in a private well, there are several methods that can be used to treat the water and reduce exposure. Some of the most common methods include:

- **Aeration:** This process involves bubbling the water through a tank of air to remove radon gas. This method is simple and can be effective for reducing radon levels in drinking water.
- **Granulated activated carbon (GAC):** This type of carbon is highly effective at removing radon from water. This method involves running the water through a tank filled with GAC, where the radon is adsorbed onto the carbon. GAC can be used only if radon gas levels in groundwater are very low. The use of GAC can create a radiation source and expose residents to radiation that cannot be disposed of as household waste.

The most effective method will depend on the specific situation, including the radon level, the well water chemistry, and the needs and preferences of the homeowner. A water treatment professional can help determine the best treatment option for a specific private well.

## Recommended Resources

- Basic Information on Radon in Drinking Water | U.S. EPA
- Natural Radionuclides in Private Wells | U.S. EPA
- Radon in Private Drinking Wells | University of Massachusetts Outreach Extension

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- Chen, J. (2019). A discussion on issues with radon in drinking water. *Radiation Protection Dosimetry*, 185(4), 526-531. <https://doi.org/10.1093/rpd/ncz035>
- Otahal, P., Merta, J., & Burian, I. (2014). Radon in private drinking water wells. *Radiation Protection Dosimetry*, 160(1-3), 235-238. <https://doi.org/10.1093/rpd/ncu095>
- U.S. Environmental Protection Agency. Health Risks of Radon. <https://www.epa.gov/radon/health-risk-radon>