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Virginia Household Water Quality Program: Nitrate in Household Water

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Private water sources, such as wells and springs, are not regulated by the U.S. Environmental Protection Agency (EPA). Although private well construction regulations exist in Virginia, private water supply owners are responsible for the maintenance of their water systems, for monitoring the quality of their drinking water, and for taking appropriate steps to address problems should they arise.

The EPA public drinking water standards are good guidelines for assessing your water quality. *Primary drinking water standards* apply to contaminants that can adversely affect health and are legally enforceable for public water systems. *Secondary drinking water standards* are non-regulatory guidelines for contaminants that may cause nuisance problems such as bad taste, foul odor, or staining.

Testing your water annually and routinely inspecting and maintaining your water supply system will help keep your water safe. For more information, visit the Virginia Household Water Quality Program website at www.wellwater.bse.vt.edu.

Introduction

Nitrogen is an essential nutrient for all living things. Nitrogen present in the soil can be converted to nitrate (NO_3^-), which is water–soluble. Once nitrate is in solution it moves easily through the soil and into groundwater. The amount or concentration of nitrate in water is typically reported as either nitrate-nitrogen or nitrate-N (NO_3^--N), or as nitrate (NO_3^-). For public water systems, the U.S. Environmental Protection Agency (EPA) has set a primary drinking water standard of 10 milligrams per liter (mg/L) for nitrogen when reported in the nitrate-N form (NO_3^--N) and 45 mg/L when reported in the nitrate form (NO_3^-).

Although most groundwater contains less than 1 mg/L of nitrate-N, a national study completed in 2009 by the United States Geological Survey (USGS) reported finding nitrate-N concentrations above 1 mg/L in about 40% of sampled domestic water wells. Elevated nitrate levels in groundwater are usually caused by excess fertilizer applications to crops, lawns, gardens, parks, or golf courses; improperly handled livestock manures or intensive livestock production facilities; failing septic systems; decaying vegetation; or wastewater treatment plant discharge. Although wastewater treatment plants typically discharge to surface water, some surface water infiltrates to become groundwater. The risk of nitrate contamination from these sources increases in areas where the water table is near the soil surface and/or soils are sandy.

Problems Associated With Nitrate in Drinking Water

Nitrate-N levels in drinking water of 10 mg/L or greater have been linked to *methemoglobinemia,* or "blue baby" syndrome in infants under six months old. Infants are at risk for methemoglobinemia because they often have intestinal bacteria that convert nitrate in water into nitrite (NO_2^-). Nitrite converts hemoglobin to methemoglobin in the blood, limiting the oxygen-carrying capacity of the infant's blood. The baby may develop a blue-gray color because of oxygen deprivation, and require emergency medical treatment. The EPA public water system primary drinking water standard or Maximum Contaminant Level (MCL) of 10

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mg/L for nitrogen in the nitrate-N (NO_3^--N) form or 45 mg/L in the nitrate (NO_3^-) form is designed to protect infants. Because approximately 10 percent of ingested nitrate (NO_3^-) is converted to nitrite (NO_2^-) by infants, the MCL for nitrite has been set at 1 mg/L by the EPA.

If test results show that your water supply has a nitrate-N level approaching 3-5 mg/L, it is recommended that it not be used for mixing baby formula or for drinking water for infants younger than six months old. Alternatives include breastfeeding, using premixed baby formula, or using bottled water. Pregnant women should avoid water with nitrate-N levels above 10 mg/L.

After about six months of age, the digestive system has developed sufficiently so that methemoglobinemia is no longer a serious threat for most infants. However, nitrate in drinking water may also be associated with adverse health effects in some older children and adults. These health effects are thought to be caused by the conversion of nitrate to nitrite in the body and the reaction of nitrite with amino compounds (proteins) to form *nitrosamines*, which are potentially carcinogenic. Some studies have shown that high nitrate levels in drinking water may be a factor in some types of cancer, non-Hodgkins lymphoma, certain birth defects, and other chronic health issues. To date, these studies have not been conclusive because variables such as diet, heredity, and environment are also factors. Please consult your physician if you think you or your family may be at risk.

Testing for Nitrate

Nitrate in drinking water is odorless, tasteless, and colorless, so water testing for nitrate is most accurately done by a certified laboratory. When collecting any water sample, follow the instructions for proper sample collection carefully. A list of certified water testing laboratories may be accessed at www.wellwater.bse.vt.edu/resources.php.

The EPA recommends that those using private water supplies test for nitrate annually. Testing is especially important if there is a young infant, pregnant woman, or elderly person in the home. Note that elevated nitrate levels may be an indicator of other water quality problems, such as contamination by bacteria or pesticides, so consider testing for these contaminants as well. Nitrate levels in a well can vary seasonally. Testing during the spring months can give an indication of nitrate levels at their highest annual concentration in your area.

Different laboratories may report nitrate analysis results differently. Nitrate concentrations may be reported either in terms of nitrate-nitrogen (NO_3^- -N) or simply as nitrate (NO_3^-). Ten (10) mg/L of nitrate-nitrogen (NO_3^--N) is equivalent to 45 mg/L of nitrate (NO_3^-). If you are unclear about how to interpret the report, contact the laboratory that performed the analysis, your local Virginia Cooperative Extension office (www.ext.vt.edu/offices/index.html), or the Virginia Department of Health (www.vdh.state.va.us).

Protecting Groundwater Resources and Your Private Water Supply from Nitrate Contamination

Responsible use of nitrogen sources, such as manure and fertilizers, and good design and maintenance of private water systems can help prevent nitrate from contaminating water supplies. Proper nitrogen management is the only long-term solution for reducing nitrate contamination of groundwater. Nitrogen application to soils exceeding that required for healthy plant growth will generally result in nitrate leaching and possibly lead to high nitrate levels in groundwater. Take care not to overapply fertilizers and manure on the farm or the home lawn and garden, and conduct soil testing to determine appropriate application levels. Consider fertilizing in the fall, rather than the spring months, for increased root growth and food storage in grass through the winter. Avoiding fertilization during the rainy spring months will decrease leaching and runoff of nitrogen to ground and surface waters. Fertilizers and manures should be stored in areas where potential leaching will be minimized.

The potential for nitrate contamination of wells can be reduced by protecting wells from possible sources of contamination (such as septic drainfields, areas where

The Virginia Household Water Quality Program, offered through Virginia Cooperative Extension (VCE), periodically conducts county-based household water sampling clinics where you can learn about the quality of your water supply, proper water supply system maintenance, and, if needed, possible water treatment options. Please contact your local Extension office or visit www.wellwater.bse.vt.edu for more information.

fertilizer or manure are applied, or areas where livestock gather) and by keeping them in good repair. This includes locating the well at least 100 feet away and up slope from potential contaminant sources, grading the ground surface around the well so that water drains away from the wellhead, ensuring the well casing extends at least 12 inches above the ground surface, and fitting the well with an approved sanitary well cap. Additionally, contract a licensed well driller to seal all abandoned wells and take steps to isolate sinkholes to prevent contamination of groundwater supplies. Abandoned wells and sinkholes are direct conduits to groundwater.

Treatment Options

Taking steps to prevent nitrate contamination of your private water supply should be a priority. However, if nitrate concentrations continue to be problematic, there are several treatment options by which nitrate may be removed from water: distillation, reverse osmosis, or ion exchange. Note that boiling water will actually INCREASE the concentration of dissolved substances, like nitrate, in water, and that other common treatment approaches, such as chlorination or mechanical filters, will NOT remove nitrate.

Treatment methods to remove nitrate from drinking water include distillation, reverse osmosis, and ion exchange. Because the distillation and reverse osmosis treatment options treat a relatively small volume of water at any one time, they can be costly and storage space for treated water may be required. As a result, these devices are typically considered point-of-use treatment options and may only be practical for installation at one faucet. Ion exchange treatment systems can be either point-of-use or they can be installed where the water enters the house (point-of-entry). It is not necessary to remove nitrate from all water in your household; only water to be used for drinking and cooking needs to be treated.

Distillation involves boiling water in a special unit that collects the resulting steam and cools it in a separate chamber. One of the benefits of distillation is that is uses no chemicals. Distillation, however, takes longer to produce the processed water than other methods, units can be expensive to operate, and the length of time distilled water is stored may affect its quality. In addition, distilled water has a very "flat" taste, because minerals naturally present in water that help to impart taste are removed during treatment.

Reverse osmosis (RO) involves forcing water molecules through a semi-permeable membrane. Water passes through the membrane but most contaminants are trapped by the membrane. Ten to twenty percent of the water entering the RO system exits as treated water, and the other 80 to 90 percent is wastewater and is diverted to a drain. These systems work best with higher water pressure and often require pretreatment and post-treatment systems to work properly. They have an average lifetime of 3-5 years at which point the membrane must be replaced. These devices can be expensive to purchase and maintain.

Ion exchange devices exchange unwanted constituents in water with less objectionable ones. To remove nitrate, anion exchange units contain resin beads that are covered with chloride, and, as water passes through the device, the resin adsorbs the nitrate and releases chloride into the water. Removal of nitrate may be influenced by other contaminants in a water supply, as resins adsorb anions preferentially. Ion exchange system maintenance involves periodically regenerating the resin with a brine solution, which replaces the adsorbed contaminants with chloride ions. The contaminants are discarded with the recharge wastewater. Ion exchange treatment may result in lower pH, and therefore slightly more corrosive water.

A complete water analysis for other contaminants and/or the advice of a certified water treatment professional will help in selecting a specific treatment method. Consumers should verify manufacturer claims before purchasing any water treatment device by contacting the National Sanitation Foundation (http://www.nsf.org), or the Water Quality Association (http://www.wqa.org/).

Additional Information

For more information on household water quality, see the Virginia Cooperative Extension publications available here:

Virginia Household Water Quality Program website: http://www.wellwater.bse.vt.edu/resources.php

Virginia Cooperative Extension website: http://pubs.ext.vt.edu/category/home-water-quality.html

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