NITRATE/ NITRITE FACT SHEET

Contaminant	In Water As	Maximum Contaminant Level

Nitrate	NO_3^{-1}	**US EPA:**
		
		    MCL* = 10.0 mg/L (as N)
		
		    MCLG** (goal) = 10.0 mg/L (as N)
		
		Health Canada MAC*** = 10 mg/L (as N)
		
		WHO† Guideline:
		
		    11.3 mg/L (as N)
		
		    50 mg/L (as NO_3^{-1})

Nitrite	NO_2^{-1}	**US EPA:**
		
		    MCL* = 1.0 mg/L (as N)
		
		    MCLG** (goal) = 1.0 mg/L (as N)
		
		Health Canada MAC*** = 1 mg/L (as N)
		
		WHO† Guideline = 1 mg/L (as N)

Sources of Contaminant	Human sewage and livestock manure Fertilizers Erosion of natural deposits	
Potential Health Effects	Methemoglobinemia (blue baby syndrome) Most potential health effects are seen in infants under the age of 6 months	

Treatment Methods
    Point-of-Entry
    Point-of-Use
	Reverse Osmosis with thin film composite membrane
	
	Anion Exchange (Type I and II, Cl⁻ form, subject to competing sulfates)
	
	Nitrate "Selective" Anion Exchange resins
	
	Distillation
	
	Electrodialysis	

*Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

**Maximum Contaminant Level Goal (MCLG) - The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

***MAC - Maximum Acceptable Concentration

WHO† - World Health Organization

Most nitrogenous materials in natural waters tend to be converted to nitrate, so all sources of combined nitrogen, particularly organic nitrogen and ammonia, should be considered as potential nitrate sources. Primary sources of organic nitrates include human sewage and livestock manure, especially from feedlots.

The primary inorganic nitrates which may contaminate drinking water are potassium nitrate and ammonium nitrate both of which are widely used as fertilizers. According to the Toxics Release Inventory, releases to water and land totaled over 253 million pounds in 2012. The US EPA conducted a 6-year review for selected drinking water contaminants, and from 1998-2005 the largest releases of nitrates occurred in California by far. In 2005 alone, of the data collected for the review, California had 320 systems above the MCL.

The principle sources of nitrate contamination in water are thus fertilizers, animal waste, and septic tank wastes. The water supplies most vulnerable to nitrate contamination are in agricultural areas and in well waters having a close or hydraulic relationship to septic tanks. In 2005, the US EPA found 1,062 public water systems were in violation of the MCL. A more recent intensive study of 19,000 wells in two counties in California showed median levels of 20 to 23 mg/L of NO_3^{-1} with 1 in 10 wells showing higher than regulated values. An analysis of these numbers over three decades indicated that nitrate levels increased about 2.5 mg/L NO_3^{-1} per each decade due to ongoing agricultural activities.

The US Geological Survey (USGS) released results of studies on about 2,100 private wells (2009) and 932 public wells (2010). The report on private wells states: "*Nitrate was the most common inorganic contaminant derived from man-made sources – such as from fertilizer applications and septic tanks – that was found at concentrations greater than the Federal drinking water standard for public water supplies (10 mg/L).* A 2006 USGS study suggests more than 1 million private well owners are located in areas with groundwater risk above the 10 mg/l MCL (see Figure 1 for occurrence map). Factors that contribute to the risk of nitrate groundwater contamination include fertilizers, population density, soil drainage, and woodland to cropland ratio, depth to the seasonally high water table, and presence of sand or gravel aquifers. For more information on how the risk analysis study was conducted, review the report on the USGS website: http://water.usgs.gov/nawqa/nutrients/pubs/est_v36_no10/.
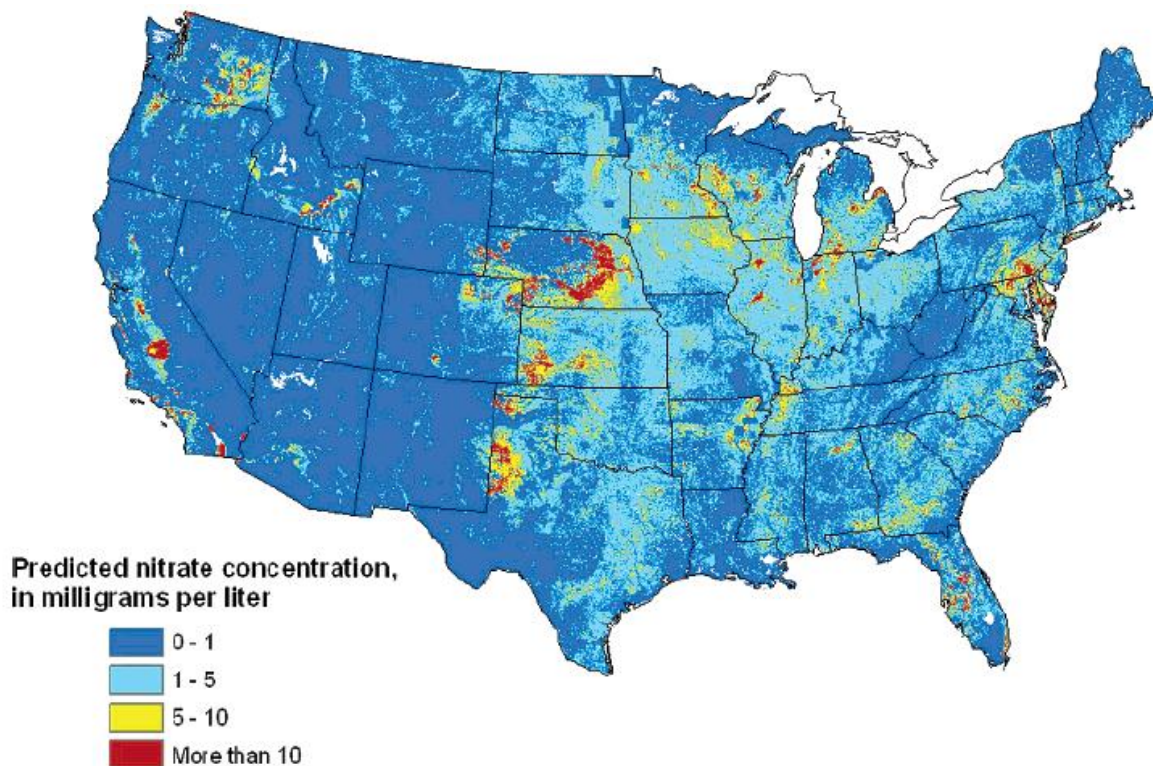
FIGURE 1: NITRATE CONCENTRATION US GROUNDWATER AS PREDICTED BY THE USGS RISK MODEL (2006).

HEALTH EFFECTS

Nitrate in drinking water can be responsible for a temporary blood disorder in infants called methemoglobinemia (blue baby syndrome). In infants less than six months old, a condition exists in their digestive systems which allows for the chemical reduction of nitrate to nitrite. The nitrite absorbs through the stomach and reacts with hemoglobin to form methemoglobin, which does not have the oxygen carrying capacity of hemoglobin. Thus, the oxygen deficiency in the infant's blood results in the "blue baby" syndrome. When the nitrate-contaminating source is removed, the effects are reversible. Since ingestion of water containing high nitrate concentrations can be fatal to infants and livestock, the U.S. EPA has established a level of 10 mg/L total nitrate (measured as nitrogen) as the Maximum Contaminant Level Goal (MCLG) and Maximum Contaminant Level (MCL) in drinking water. This is equivalent to 44.2 mg/L when measured as nitrate ion, NO_3^{-1}. The Agency has also established an MCLG and an MCL of 1 mg/L for nitrite (measured as nitrogen) as well as the 10 mg/L MCL for total nitrate plus nitrite (measured as nitrogen). Although extreme levels of nitrate can be associated with central nervous disorders in adults, it should be noted that nitrates and nitrites are rarely a problem in drinking water for humans older than six months of age.

TREATMENT METHODS

Residential **Point-of-Entry (POE)** **Point-of-Use (POU)**	Reverse Osmosis with thin film composite (TFC) membrane
	Anion Exchange (Type I and II, Cl⁻ form, subject to sulfates competitive ion exchange)
	Nitrate "Selective" Anion Exchange resins
	Distillation
Municipal	Blending
	Disinfection with chlorine, chloramine and ozone will oxidize nitrite to less hazardous nitrate
	Anion Exchange
Visit WQA.org or NSF.org to search for products certified to NSF/ANSI 58, 53, and WQA S-300 for nitrate/nitrite reduction.	

Current technology suggests that several techniques may be used for removing nitrate from drinking water including chemical reduction, ion exchange, reverse osmosis, electrodialysis, and distillation. At the present time, it appears that three methods, ion exchange, distillation, and reverse osmosis, are considered to be practical and economically feasible for nitrate removal when considering POU or POE devices. It must be recognized that devices that remove nitrates may have varying effectiveness based on the amount of nitrate in the water supply and the balance of other ions in the water. The ion exchange process, for example, is sensitive to waters containing high TDS, high sulfate, and high hardness levels **(**which can cause hardness precipitation during regeneration)**.** Effective anion exchange removal of inorganic nitrate requires softening pretreatment ahead of the anion exchanger. Care must be taken in the choice of anion resin to avoid "dumping" of nitrates—a condition where effluent nitrate levels can exceed influent levels due to selectivity of sulfates over nitrates. Nitrate dumping can result in effluent concentrations of nitrate equaling the equivalent sum of nitrates plus sulfates and other preferred anions in the incoming water supply. The use of nitrate "selective" resins can avoid this and is recommended in systems that are unmonitored or for POU cartridge applications. Brine reclaim should be avoided because excess nitrates in the recycled brine can lead to excessive nitrate leakage in the subsequent run. Anion resins are lower in density than softener resins and are backwashed at lower rates.

Commercially available line pressure and pump driven reverse osmosis membranes systems reduce nitrates from water by 60-95%, even at nominal 50 pounds per square inch (psi) pressure and at 45° to 70° F. Cellulosic membranes should not be used for nitrate reduction in line pressure applications. Thin film composite (TFC) membranes are more effective for nitrate reduction especially in household line pressure applications where feed pressure to the RO membrane may fall below 60 psi. For effective reduction of nitrates with RO treatment using a line pressure unit, the RO feed pressure should be always maintained above 40 psi and maximum nitrate influent concentration should not exceed 30 mg/L measured as nitrogen. For back up on POU systems, nitrate selective ion exchange cartridges can be used as polishers.

The treatment methods listed herein are generally recognized as techniques that can effectively reduce the listed contaminants sufficiently to meet or exceed the relevant MCL. However, this list does not reflect the fact that point-of-use/point-of-entry (POU/POE) devices and systems currently on the market may differ widely in their effectiveness in treating specific contaminants, and performance may vary from application to application. Therefore, selection of a particular device or system for health contaminant reduction should be made only after careful investigation of its performance capabilities based on results from competent equipment validation testing for the specific contaminant to be reduced.

As part of point-of-entry treatment system installation procedures, system performance characteristics should be verified by tests conducted under established test procedures and water analysis. Thereafter, the resulting water should be monitored periodically to verify continued performance. The application of the water treatment equipment must be controlled diligently to ensure that acceptable feed water conditions and equipment capacity are not exceeded.

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REGULATIONS

In the United States the EPA, under the authority of the Safe Drinking Water Act (SDWA), has set the Maximum Contaminant Level Goal (MCLG) for total nitrate/nitrite at 10.0 mg/L and for nitrite at 1.0 mg/L (measured as nitrogen, N). This is the health-based goal at which no known or anticipated adverse effects on human health occur and for which an adequate margin of safety exists. The US EPA has set these levels of protection based on the best available science to prevent potential health problems. Based on the MCLG, EPA has set an enforceable regulation for total nitrate/nitrite, the Maximum Contaminant Level (MCL), at 10 mg/L (10 ppm)(as N) and for nitrite at 1 mg/L (1 ppm)(as N). MCLs are set as close to the MCLG as possible, considering cost, benefits and the ability of public water systems to detect and remove contaminants using suitable treatment technologies.

REFERENCES/SOURCES

Boyle, D., King, A., Kourakos, G., Lockhart, K., Mayzelle, M., Fogg, G.E. & Harter, T. (2012) Groundwater Nitrate Occurrence. Technical Report 4 in: Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater. Report for the State Water Resources Control Board Report to the Legislature. Center for Watershed Sciences, University of California, Davis. http://groundwaternitrate.ucdavis.edu/files/139106.pdf

Doudrick, Kyle and Pauli Westerhoff. "Nitrates in Groundwater: Treatment Technologies for Today and

Tomorrow." Dept. of Civil, Environmental, and Sustainable Engineering, Arizona State University. Retrieved from: http://www.swhydro.arizona.edu/archive/V8_N4/feature6.pdf

Nolan, Bernard and Kerie Hitt (2006). "Vulnerability of Shallow Groundwater and Drinking-Water Wells to Nitrate in the United States".

US EPA, "Basic Information on Nitrate in Drinking Water,"
http://water.epa.gov/drink/contaminants/basicinformation/nitrate.cfm
US EPA, "Basic Information on Nitrite in Drinking Water,"
http://water.epa.gov/drink/contaminants/basicinformation/nitrite.cfm

US Geological Survey, 2009, "Water Quality of Potential Concern in US Private Wells"
http://water.usgs.gov/nawqa/studies/domestic_wells/

US Geological Survey, 2010, "Quality of Water from Public Supply Wells in the United States"
http://water.usgs.gov/nawqa/studies/public_wells/

US Geological Survey, 1998, "A National Look at Nitrate Contamination in Groundwater."
http://water.usgs.gov/nawqa/nutrients/pubs/wcp_v39_no12/

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