Drinking Water Quality: Nitrate Contaminant Levels

Type of EPHT Indicator	Hazard, Exposure
Measures	Level of Contaminant in Finished Water 1. Quarterly distribution of number of Community Water Systems (CWS) by mean nitrate concentration (cut-points: (0-3), (>3-5), (>5-10), (>10-20), (>20) mg/L nitrate). 2. Yearly distribution of number of CWS by maximum nitrate concentration (cut-points: (0-3), (>3-5), (>5-10), (>10-20), (>20) mg/L nitrate). 3. Yearly distribution of number of CWS by mean nitrate concentration (cut-points: (0-3), (>3-5), (>5-10), (>10-20), (>20) mg/L nitrate). 4. Average Concentration of Nitrate, by Year. Potential Population Exposure to Contaminants in Finished Water 5. Quarterly distribution of population served by Community Water Systems (CWS) by mean nitrate concentration (cut-points: (0-3), (>3-5), (>5-10), (>10-20), (>20) mg/L nitrate). 6. Yearly distribution of population served by CWS by maximum nitrate concentration (cut-points: (0-3), (>3-5), (>5-10), (>10-20), (>20) mg/L nitrate). 7. Yearly distribution of population served by CWS by mean nitrate concentration (cut-points: (0-3), (>3-5), (>5-10), (>10-20), (>20) mg/L nitrate).
Derivation of Measures	Nitrate measures will be developed from water system attribute and water quality data stored in state Safe Drinking Water Act (SDWA) databases such as the Safe Drinking Water Information System (SDWIS/State). Data will be cleaned and transformed to a standard format. Analytical results of drinking water samples (usually taken at entry points to the distribution system or representative sampling points after treatment) will be used in conjunction with information about each CWS (such as service population and latitude and longitude of representative location of the CWS service area) to generate the measures.
Units	Concentration of nitrate, mg/L
Geographic Scope	State and Community Water System
Geographic Scale	The finest detail will be approximate point location of the community water distribution system represented by water withdrawal point, water distribution extents, principal county served, or principal city served.
Time Period	2000-Most Recent Year Available
Time Scale	Calendar year
Rationale	Nitrates and Public Health Nitrate was first identified as a public health threat in drinking water in 1945 when high nitrate levels from private wells were shown to cause methemoglobinemia or "blue baby syndrome" in infants who received formula made from well water. When an individual is exposed to nitrate it can be converted to nitrite ($NO2^-$) in the body and then oxidize the ferrous iron (Fe^{+2}) in deoxyhemoglobin in the blood to form methemoglobin containing ferric iron (Fe^{+3}). Methemoglobin cannot transfer oxygen to tissues; thus nitrate or nitrite can starve the body of

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<td>oxygen and produce a clinical condition known as cyanosis, where the lips and extremities turn gray or blue. Infants younger than four months of age are more sensitive than adults, and can develop "blue baby" syndrome from intake of nitrate higher than 10 mg/L nitrate or 45 mg/L nitrate—nitrogen. Blue baby syndrome is fatal in about ten percent of the cases (ATSDR, 2007). Usually there are no outward signs of cyanosis at methemoglobin levels below 20 percent (Dabney et al, 1990).

In addition, there is some evidence to suggest that exposure to nitrate in drinking water is also associated with adverse reproductive outcomes such as spontaneous abortions, intrauterine growth retardation, and various birth defects such as anencephaly, related to fetal exposures to nitrate. However, the evidence is inconsistent (Manassaram et al, 2006).

Similarly, long term exposure to higher nitrate levels in drinking water has been suggested as a risk factor for cancer. Cancer at several sites (i.e. gsatric, colorectal, bladder, urothelial, brain, esophagus, ovarian and non-Hodgkins lymphoma have been shown to be associated with nitrate in drinking water in some studies (Sandor et al, 2001; Weyer et al, 2001; Gulis et al, 2002; De Roos et al, 2003; Volkmer et al, 2005; Ward et al, 2005b; Chiu et al, 2007;). Other studies have not found any association (Ward et al, 2003; Ward et al, 2005, 2005c; Ward et al, 2006; Zeegers et al, 2006). Significant regional differences in cancer risk may occur (Mueller et al, 2001). Occupational exposures are also of concern as nitrate fertilizer workers have shown increased risk for stomach cancer (Zandjani et al. 1994).

Sources of Nitrate

Nitrate is the most commonly found contaminant in groundwater aquifers worldwide (Ward, 2005 from: Spalding and Exner 1993). Nitrate (NO3$^-$) originates in drinking water from nitrate-containing fertilizers, sewage and septic tanks, and decaying natural material such as animal waste. Nitrate is very soluble in water, can easily migrate, and does not evaporate (EPA Consumer Fact Sheet). Anthropogenic sources of nitrates are increasing resulting in increased nitrate levels in water resources. Surface water and shallow wells in both rural and urban areas can be affected. Consequently, private wells are especially vulnerable to excess levels of nitrates. Excess levels of nitrate and nitrite can occur in community water supplies. A U.S. Geological Survey (USGS) study found nitrate levels exceeded regulatory monitoring standards in 2% of a sample of 242 public drinking water wells between 1992 and 1999 (Squillace et al, 2002). Levels of nitrates in private wells are less well known; private wells are not regularly monitored and are often more vulnerable to higher levels of nitrates because they draw water from shallower groundwater aquifers. The USGS estimates approximately 22% of domestic wells in agricultural areas of the U.S. exceed the MCL (Ward, 2007).

Nitrate Regulation and Monitoring

Congress established the Safe Drinking Water Act in 1974, which set enforceable Maximum Contaminant Levels (MCLs) and non-enforceable Maximum Contaminant Level Goals (MCLGs) for certain specified contaminants. In the case of nitrate in drinking water, the MCLG of 10 mg/L (ppm) was established from human data from studies of methemoglobinemia in young children. (Johnson and Kross 1990; Walton, 1950). The MCL is also set at 10 ppm, and any exceedance of the MCL is potentially serious as there is no additional margin of safety between the MCLG and the MCL. 2002). The MCLG and MCL for nitrite are 1 mg/L. While evidence to suggest MCL exposures for chronic health endpoints remains inconclusive, there is some evidence to suggest that chronic exposure to nitrate levels below the MCL may be of concern (Ward, 2005).</td>
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<td>Use of Measure</td>
<td>These measures assist by providing data that can be used for surveillance purposes.

• Distribution measures provide information on the number of CWS and the number of people potentially exposed to nitrate at different concentrations.
• Maximum concentrations provide information on the peak potential exposure to nitrate at the state level.
• Mean concentrations at the CWS level provide information on potential exposure at a</td>
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	smaller geographic scale.
Limitations of the Measure	The current measures are derived for CWS only. Private wells are another important source of population exposure to nitrate. Transient non-community water systems, which are regulated by EPA, may also be an important source of nitrate exposure. Measures do not account for the variability in sampling, numbers of sampling repeats, and variability within systems. Concentrations in drinking water cannot be directly converted to exposure, because water consumption varies by climate, level of physical activity, and between people (EPA 2004). Due to errors in estimating populations, the measures may overestimate or underestimate the number of affected people.
Data Sources	State grantee
Limitations of Data Sources	Nitrate levels can vary substantially in groundwater; thus high levels may not be captured by even quarterly sampling. Estimates of the number of people potentially exposed may be unreliable as they are based on estimates made by the water system operator. Concentrations in drinking water cannot be directly converted to exposure because overall water consumption, and the proportion of water consumed that comes from the tap is quite variable (EPA 2004). In systems that have more than one Entry point to the Distribution system, the actual nitrate level at any given house is a mixture of the levels from all contributing sources. Compliance samples are taken at each entry point to the distribution system. In systems with separate wells serving some branches or sections of the distribution system, the system mean would tend to underestimate the nitrate concentration of people served by wells with higher nitrate concentrations. Exposure may be higher or lower than estimated if data from multiple entry points for water with different nitrate levels are averaged to estimate levels for the PWS.
Related Indicators	Public Water Use
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