Environmental Effects

Nitrate

Nitrate is an acute contaminant. It is colorless and odorless. It is found in most fertilizers, manure, liquid waste from septic tanks, and food processing waste. Rain or irrigation water can carry nitrate down through the soil into groundwater. Drinking water wells may contain nitrate if they draw from this groundwater (Ecology 2010).

The Nitrogen Cycle

The Nitrogen Cycle was adequately described in the EPA's 2012 Report, "Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley":

Nitrogen is present in many chemical forms in the environment. Nitrogen gas (N2) composes about 78 percent of the atmosphere. Nitrite (NO2-), nitrate (NO3-) and organic nitrogen, ammonium (NH4) are also present.

Nitrogen is critical to plant growth. It aids in the formation and function of cellular tissue, proteins, and reproductive structures. Nitrogen can be supplied to plants through the application of synthetic fertilizers or animal waste products or by the organic decomposition of other plants. Atmospheric nitrogen must be processed, or fixed, to be used by plants. The majority of fixation occurs by bacteria. Small quantities of nitrate may wash out of the atmosphere from aerosol salt particles from the ocean or dusts from arid regions, or from fossil fuel combustion. (EPA 2012)

Important processes in the nitrogen cycle include nitrogen fixation, mineralization, nitrification, and denitrification. The mobility of nitrogen is highly dependent on its form and the matrix through which it moves. Organic nitrogen is nearly immobile. Mineralization occurs when organic nitrogen in the soil is converted by bacteria into ammonium (NH4). Nitrification occurs as ammonium is biologically oxided to become nitrite. Nitrate is then biologically oxidized to become nitrate as it moves through the vadose zone.

Nitrate is the most mobile form of nitrogen in both the vadose and saturated zones. Nitrate moves quickly in the saturated zone, together with migrating groundwater. Its mobility is enhanced by the action of negatively charged soil particles, which repel the negatively charged nitrate ion. (USGS 2000b). In the absence of denitrification, nitrate moves with the groundwater until the groundwater is discharged to surface water, or extracted from a well. Denitrification is the conversion of nitrate back into nitrogen gas (N2) by bacteria. It occurs in poorly drained, anoxic conditions or organic soils where oxygen is depleted in the root zone. (EPA 2012).

Nitrate Leaching

"Leaching" is the process of the removal of soluble material from a substance through the percolation of water. Nitrate can "leach" from the agricultural soils to the elevation of the groundwater aquifer. "The increase in groundwater nitrate concentration measured in domestic wells, irrigation wells, and public supply wells lags significantly behind the actual time of nitrate discharge from the land surface. The lag is due, first, to travel time between the land surface, which ranges from less than one year in areas with shallow water table to several years or even decades where the water table is deep. High water recharge rates shorten travel time to a deep water table, but in irrigated areas with high irrigation efficiency and low recharge rates, the transfer to a deep water table may take many decades." (Harter 2012)

Attenuation, Soils and Climate

Attenuation of nitrogen in Lower Yakima Valley soils, or the gradual loss in intensity of the amount of nitrates in flux through the soil profile, depends upon the specific type and condition of the local soils, micro-environment and, where the overlying property is farmed, the particular horticultural variety being farmed. Attenuation is more likely in the near-surface root zone of agricultural activities than in the deeper soils or deeper geologic strata.

Health Effects to People and Animals

Exposure to excessive nitrate concentrations can reduce the ability of red blood cells to carry oxygen. (Harter 2012) In most adults and children these red blood cells rapidly return to normal. However, in infants it can take much longer. Infants who drink water with high levels of nitrate (or eat foods made with nitrate contaminated water) may develop a serious health condition due to the lack of oxygen. This condition is called methemoglobinemia or "blue baby syndrome."

> "Infants younger than 6 months may develop acquired methemoglobinemia from contaminated well water that has excess nitrates. Bacteria in a baby's digestive system mixes with the nitrates and leads to methemoglobinemia. Fully developed digestive systems keep children older than 6 months and adults from developing this nitrate poisoning." (McDowell/Biggers 2017)

While the problem is relatively well understood, there are no accurate statistics on its occurrence. Acute cases do occur, but there have been no deaths reported by medical professionals within the GWMA since it was established.

Bottled water is recommended for use in babies' foods and drinks. Although boiling water kills bacteria, it will not remove chemicals such as nitrate. In fact, boiling may actually increase the nitrate level. "Some studies have shown a positive association between long term exposure to nitrate exposure in drinking water and risk of cancer and certain reproductive outcomes." (EPA 2012, Ward 2005) Other studies have shown no association. (Ward 2005, Avery 1999). As nitrates rise in water supplies, the potential for increasing the health risk rises.

An infant with moderate to serious "blue baby syndrome" may have a brownish-blue skin tone due to lack of oxygen. This condition may be hard to detect in infants with dark skin. Infant discolorization is not required to be reported by physicians as health effects data. An infant with mild to moderate "blue baby syndrome" may have symptoms similar to a cold or other infection (fussy, tired, diarrhea or vomiting). While there is a simple blood test to see if an infant has "blue baby syndrome," doctors may not think to do this test for babies with mild to moderate symptoms.

The best way to prevent "blue baby syndrome," is to avoid giving babies water that may be contaminated with nitrate or foods that are high in nitrate. Infants less than one-year-old should not be given drinking water with nitrate levels more than 10 ppm. High-nitrate vegetables such as beets, broccoli, carrots, cauliflower, green beans, spinach, and turnips should not be offered until after six months of age. If a baby has a brownish-blue skin tone, he or she should be taken to a hospital immediately. A medication called "methylene blue" will quickly return the baby's blood to normal.

Red blood cells in older children and adults quickly return to normal. However, some health conditions make people susceptible to health problems from nitrate. They include individuals who don't have enough stomach acids and individuals with an inherited lack of the enzyme that converts affected red blood cells back to normal (methemoglobin reductase).

The *Preliminary Assessment* concluded that over 2,000 people in the area are exposed to nitrate over the maximum contaminant level (MCL) through their drinking water. (EPA 2010) But it also found that not all water supplies in the area have been affected, particularly including public water system supply. Public water systems are regularly monitored for suspected contaminants. They must meet national and state drinking water standards, and public systems that use contaminated water are required by law to treat the water, thus maintaining a safe supply of drinking water to their customers. Until treatment has been installed, or if the treatment isn't working, public water systems must notify their users if nitrate levels exceed the standard.

The *Preliminary Assessment* found that many families of the Lower Yakima Valley are served by private wells and do not have access to public water systems. Regular testing of drinking water is not required for private water wells. The *Preliminary Assessment* concluded that "There is sufficient data to suggest that many of these well water supplies are at risk, even if they do not currently exceed a drinking water standard." (EPA 2012). The Valley Institute for Research and Education collected data from the wells of low income households in 2001 and 2002. In some areas, up to 40 percent of the wells sampled were above 5 mg/L nitrate, a level below the 10 mg/L Drinking Water Standard., but nevertheless recognized in the *Preliminary Assessment* as a concern. The LYVGWMA has caused testing of private groundwater wells to occur since it was organized. The data collected from that testing is set forth below under the section entitled "Investigation and Analysis"

Owners of private wells who are unsure about their water quality may have their water tested for coliform bacteria and nitrate. The Yakima Health District (YHD) can advise where to get water tested and has specific recommendations for testing. Many certified labs in Washington charge $20 to $40 per test. If nitrate test results are over 8 mg/L, annual testing is recommended. If results are less than 8 mg/L, testing every three years is recommended.

The *Preliminary Assessment* expressed the concern that those who rely on private well water may not know the quality of the drinking water within their homes. They may not use tested wells, and if so, they may not know how to interpret the test results. Many residents are renters and are not the property or well owners. The well owner of record may not be the current property owner. Current property owners may not live on the property. Property owners may fear or question the implications of owning a contaminated well (in terms of liability, responsibility, property values, and access to safe and affordable housing) (EPA 2012).

Nitrates in groundwater may impact both domestic animals and wildlife. This can be either directly by ingestion, or indirectly through impacts to habitats, where groundwater discharging to surface water contributes to nutrient loading of streams, lakes, and wetlands.

The *Preliminary Assessment* found that nitrate-nitrogen concentrations are greatest in shallow groundwater. Shallow wells, poorly sealed or constructed wells, and wells that draw from shallow aquifers are at greatest risk of nitrate contamination. Manure and septic-tank waste may also contain disease-causing bacteria and viruses. Nitrate levels in well water can vary throughout the year. A significant decrease in nitrate-nitrogen concentrations was found in groundwater samples collected from depths below 300 feet. The highest percentage of samples exceeding State Drinking Water Standards (l0 mg/l nitrate-nitrogen) was obtained from shallow wells (less than 300 feet deep), a well depth typical of most private domestic drinking water wells. (EPA 2012)

Yakima River Surface Water Quality

The USGS' Hydrogeologic Framework the Yakima River Basin Aquifer System (USGS 2009a) posited an hydrologic connection between the surface water within the Yakima River and the groundwater beneath lands adjacent to the river. However, no direct correlation has been established between nitrogen in groundwater and nitrogen in the Yakima River.

Section 303(d) of the CWA, 33 U.S.C., § 1313(d), requires states to identify waters where current pollution control technologies alone cannot meet the water quality standards set for that waterbody. Every two years, states are required to submit a list of impaired waters plus any that may soon become impaired to EPA for approval. The impaired waters are prioritized based on the severity of the pollution and the designated use of the waterbody (e.g., fish propagation or human recreation). States must establish the "total maximum daily load(s)" of the pollutant(s) in the waterbody for impaired waters on their list.

A "total maximum daily load" or "TMDL" is the amount of a specific pollutant that a waterbody can receive and still meet water quality standards. A TMDL is made up of the sum of all the point source loads ("wasteload allocation") and load associated with nonpoint sources and background sources ("load allocation"). TMDLs must include a margin of safety (explicit or implicit) and consider seasonal variations. Potential wasteload allocations include background, groundwater inflow, diffuse runoff, irrigated agriculture return flow, agricultural stormwater, atmospheric deposition, nonpoint sources, stormwater point sources, and non-stormwater point sources.

Numerous water quality assessments of the Yakima River are contained within Washington State's 303(d) list. Primary Yakima River surface water quality problems of concern are temperature, dissolved oxygen (DO) and acidity (pH). Nitrogen is an aquatic nutrient in surface water, which contributes to algae growth, but not included in the Yakima River's surface water quality problems..

Ecology has proposed three TMDL projects within the Lower Yakima River area. Two have been approved by the EPA. The third is in development. They are: Lower Yakima River Suspended Sediment and DDT TMDL—project approved for DDT and TSS parameters. See: http://www.ecy.wa.gov/programs/wq/tmdl/yakima_wq/LowerYakTMDL.html; https://fortress.wa.gov/ecy/publications/documents/97321.pdf; Granger Drain Bacteria TMDL—project approved for fecal coliform bacteria parameter. See: http://www.ecy.wa.gov/programs/wq/tmdl/GrangerTMDL.html;