1998

G98-1369 Drinking Water: Nitrate and Methemoglobinemia *("Blue Baby" Syndrome)*

Sharon Skipton
University of Nebraska&#8211Lincoln, sskipton1@unl.edu

DeLynn Hay
University of Nebraska at Lincoln, dhay@unlnotes.unl.edu

Nebraska Cooperative Extension G98-1369

Drinking Water: Nitrate and Methemoglobinemia (*"Blue Baby" Syndrome*)

This NebGuide discusses the blood disorder methemoglobinemia, its effect on infants and prevention methods..

Sharon Skipton, Extension Educator
DeLynn Hay, Extension Water Resources Specialist

Methemoglobinemia is a blood disorder caused when nitrite interacts with the hemoglobin in red blood cells. Unlike hemoglobin, the methemoglobin formed in this interaction cannot carry sufficient oxygen to the body's cells and tissues. Although methemoglobinemia is rare among adults, cases have been reported among infants, where nitrate-contaminated well water was used to prepare formula and other baby foods. Nitrate in well water may result from point sources such as sewage disposal systems and livestock facilities, from nonpoint sources such as fertilized cropland, parks, golf courses, lawns and gardens or from naturally occurring sources of nitrogen. For additional information on nitrate in well water, read NebGuide G96-1279, *Drinking Water: Nitrate-Nitrogen*.

Methemoglobinemia

Nitrate, a relatively non-toxic substance, occurs naturally as part of the nitrogen cycle. However, bacteria can convert nitrate to nitrite in the environment, in foods and in the human body.

Until infants reach about six months of age, their digestive system secretes lower amounts of gastric acid

and the pH level in their digestive system is higher than most adults. Adults with a diminished capability to secrete gastric acid also can experience a rise in pH in their digestive system. In both situations, bacteria can proliferate, increasing the transformation of nitrate to nitrite.

Once in the blood, nitrite oxidizes iron in the hemoglobin of red blood cells to form methemoglobin, which lacks hemoglobin's oxygen-carrying ability. The nitrite can come from nitrate in drinking water or from food, some drugs or other sources. For additional information on hemoglobin oxidizing agents, read Extension Circular EC90-2502, Perspectives on Nitrates and **consult your physician**.

Although methemoglobin is continually produced in humans, an enzyme in the human body reduces methemoglobin to hemoglobin. In most individuals, methemoglobin is rapidly converted back to hemoglobin. Typically, less than 1 percent of the total circulating hemoglobin in a healthy adult is present in the form of methemoglobin. Infants, however, have a low concentration (about 60 percent of the adult concentration) of the reducing enzyme, as do some older individuals with an enzyme deficiency. In these people, methemoglobin is not converted to hemoglobin as readily.

When methemoglobin levels are elevated, the condition known as methemoglobinemia, often referred to as "blue baby syndrome", can result as the blood lacks the ability to carry sufficient oxygen to individual body cells.

Methemoglobinemia Signs and Symptoms

Infants suffering from methemoglobinemia may seem healthy but show intermittent signs of blueness around the mouth, hands and feet. They may have episodes of breathing trouble, some diarrhea and vomiting. In some cases, an infant with methemoglobinemia has a peculiar lavender color but shows little distress. Blood samples appear chocolate brown and don't turn pink when exposed to air. When the methemoglobin level is high, infants express a marked lethargy, excessive salivation and loss of consciousness. Convulsions and death can occur at extreme methemoglobin levels.

Consult your physician for additional information on methemoglobinemia signs and symptoms or for diagnosis if methemoglobinemia is suspected. Do not attempt to self-diagnose this condition.

Methemoglobinemia Treatment

If the condition is identified early and is not life-threatening, a change of drinking water to water with less than 10 milligrams per liter of nitrate-nitrogen is usually the only needed treatment. This will reduce methemoglobin to hemoglobin in two to three days. Severely affected infants may be treated with an intravenously administered solution of methylene blue.

Methemoglobinemia Prevention

The Environmental Protection Agency (EPA) has set a public water supply maximum contaminant level (MCL) of 10 milligrams per liter (mg/l) which is equal to 10 parts per million (ppm) for nitrate-nitrogen. This level provides a margin of safety against a significant risk for human health. EPA believes water containing nitrate-nitrogen at or below this level is acceptable for daily drinking over a lifetime and does not pose a methemoglobinemia health risk for infants or adults.

Methemoglobinemia prevention is especially important for infants under six months of age, although preventative measures are also encouraged for pregnant women, women who are breast feeding and other high-risk individuals. Use water from a source containing nitrate-nitrogen at or below 10 mg/l. If

the drinking water source contains nitrate-nitrogen above 10 mg/l, use bottled water or treat the water with a distiller, ion exchange unit or reverse osmosis unit to reduce the nitrate-nitrogen level. Boiling water containing nitrate-nitrogen does not reduce nitrate-nitrogen levels. In fact, boiling can concentrate nitrate-nitrogen levels in water as some water evaporates as steam.

Methemoglobinemia Case Histories

Cases of infant methemoglobinemia have been reported in the United States. The majority of reported cases were in infants under the age of four months and who were fed milk formulas prepared with contaminated well water. A Nebraska survey of physicians reported in the Nebraska Medical Journal in 1981 indicated at least eight cases of infant methemoglobinemia were treated in Nebraska between 1973 and 1978. More recently, two infants with methemoglobinemia were identified by the South Dakota Department of Health. The private well water was found to have a nitrate-nitrogen concentration of 150 mg/l in one instance and 54 mg/l in the other. In Colorado, a case of methemoglobinemia involved an infant ingesting water containing 13.3 mg/l nitrate-nitrogen. No cases have been identified with water at or below the MCL of 10 mg/l nitrate-nitrogen.

Additional Information

Not only does consuming drinking water contaminated with nitrate-nitrogen above 10 mg/l have the potential to result in methemoglobinemia, but newer studies also have indicated a possible risk of cancer, as well as the potential to be a contributing factor in spontaneous abortions. For additional information on drinking water and nitrates, read NebGuide G96-1279, *Drinking Water: Nitrate-Nitrogen* and Extension Circular EC90-2502, Perspectives on Nitrates. This publication does not provide or substitute for professional medical advice. If you have any questions or concerns related to nitrate consumption and health effects or the condition known as methemoglobinemia consult your physician.

Summary

The methemoglobinemia hazard from drinking water with nitrate-nitrogen occurs when bacteria in the digestive system transform nitrate to nitrite and the nitrite oxidizes iron in hemoglobin of red blood cells to form methemoglobin. Methemoglobin lacks oxygen-carrying capacity and the condition known as methemoglobinemia occurs. Because infants under six months of age have a higher concentration of the digestive system bacteria known to transform nitrate to nitrite, and a lower than normal concentration of the enzyme known to reduce methemoglobin back to hemoglobin, they are at higher risk for methemoglobinemia. Consuming water from a source containing 10 or less mg/l nitrate-nitrogen provides assurance that methemoglobinemia should not result from drinking water. Consult your physician for information on methemoglobinemia or for professional diagnosis if methemoglobinemia is suspected.

Other Related Publications

- EC94-135, *Understanding Pesticides and Water Quality in Nebraska*
- EC98-765, *Improving Drinking Well Condition*
- EC98-766, *Drinking Water Well Condition*
- EC90-2502, *Perspectives on Nitrates*
- G89-946, *Water Treatment Equipment: Water Softeners*
- G90-976, *Water Treatment Equipment: A Buyer's Guide*
- G90-989, *Drinking Water: Bacteria*
- G92-1079, *Home Water Treatment Equipment: An Overview*

- G95-1255, *Shock Chlorination of Domestic Water Supplies*
- G96-1274, *Drinking Water: Hard Water*
- G96-1275, *Drinking Water: Sulfates and Hydrogen Sulfide*
- G96-1279, *Drinking Water: Nitrate-Nitrogen*
- G96-1280, *Drinking Water: Iron and Manganese*
- G96-1282, *Drinking Water: Man-made Chemicals*
- G97-1333, *Drinking Water: Lead*
- G98-1360, *Drinking Water: Copper*

Adapted in part from:

Ziebarth A. (1991), NF91-49, Well Water, Nitrates and the "Blue Baby" Syndrome Methemoglobinemia; Lincoln, NE; University of Nebraska Cooperative Extension.

Davis, R. (1990), EC 90-2502, Perspectives on Nitrates, Chapter 4 - Nitrates, Nitrites and Methemoglobinemia; Lincoln, NE; University of Nebraska Cooperative Extension.

File: G1369 under: WATER RESOURCE MANAGEMENT
A-25, Water Quality, 5,000 printed
Issued December 1998

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert C. Dickey, Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.