Extension
University of Missouri

Nitrate and Water

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Nitrates in water can affect livestock production and human health. "Blue-baby syndrome" can be caused by high nitrate concentrations in the drinking water of infants under six months of age. Sudden deaths, lowered reproductive performance and loss of milk production in warm animals have been associated with water supplies containing high amounts of nitrate.

Why is nitrate present in some water?

Nitrate is a naturally occurring chemical form of nitrogen found in most soils. Nitrate may be formed when plant residues, animal manures and human wastes decompose. It may be added to soil directly as a nitrogen fertilizer.

A small amount of nitrogen (N), about five to ten pounds per acre annually, is carried from the atmosphere to the soil in precipitation. Nitrate in soils is necessary for plant growth. Nitrate is not held by soil particles and not chemically fixed in the soil. Nitrate is water-soluble and can move with water on and through the soil, porous rock and sand layers to underground water supplies.

Multiple causes may be responsible for contaminating water, and the source of contamination may be a considerable distance from the water supply. In a state-wide survey of nitrate levels in well water, MU agronomists found that in the 6,000 water supplies analyzed, the major sources of nitrate were animal manures, inadequate human waste treatment systems and soil organic matter.

High nitrate content of many water supplies in north Missouri appears to be associated with long-time livestock production where shallow water supplies are found at the junction of the pervious wind blown soil (loess) and tight, glacial clays (Figure 1).

Contaminated wells may be located on high ground with good drainage, but the underground water supply contains nitrate originating from a considerable distance by its leaching through pervious soil or porous, fissured rock. The data in Table 1 shows how nitrate can accumulate and move downward toward the underground water under feedlot conditions.

Table 1.
Soils of feedlot areas high in nitrate.

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Depth	Clinton County* pounds NO_3-N per acre	Macon County** pounds NO_3-N per acre
0 to 18 inches	53	235
18 to 36 inches	146	413
36 to 52 inches	96	392
52 to 68 inches	402	340
68 to 84 inches	269	730
84 to 120 inches	550	1,226
120 to 144 inches	301	
144 to 156 inches	120	
156 to 168 inches	85	
Total	2,022 (14 feet)	3,336 (10 feet)

***Has been a feedlot for more than 75 years. Nearby drilled well more than 100 feet deep, 15-20 ppm NO_3-N (Marshall silt loam).**
****Near old barn lot, but no livestock near for 10 years. Nearby well dug 30 feet deep, contains 150-170 ppm NO_3-N (Mexico silt loam).**

Nitrates in surface drainage may enter wells through faulty well tops or walls. Surface drainage also contains high bacterial populations. Bacteria complicate the problem as they convert nitrate to the more toxic nitrite.

Much of south Missouri is underlain by highly weathered limestone formations. Many soils have a high stone content and are pervious to water (Figure 2). Sinkholes, collecting sites for surface drainage, and human and/or animal wastes contribute to underground water contamination in this area.

Nitrogen from legumes and fertilizers

Nitrogen from legumes, especially old alfalfa stands, and from heavy manure applications can contribute nitrate to underground water supplies of nearby shallow wells. During droughts some soils may crack, and later rainfall can move some of the naturally produced nitrate into lower depths before renewed plant growth can absorb it.

Increasing use of nitrogen fertilizers has been considered a source of nitrate in water. Possibly, in very sandy or bottomland soils, nitrogen fertilizer applied in excess of crop needs or when there is no crop actually growing contributes to nitrate in shallow water supplies. Avoid indiscriminate, heavy use of nitrogen fertilizer, manures or sewage effluent in excess of crop removals. Realistic rates of nitrogen applied to silt loam or clay soils will not likely contribute significant nitrogen to water supplies.

Soil from plots used 20 consecutive years for continuous corn production at MU were found to contain 222 pounds of nitrate-nitrogen per acre in the surface 10 feet of soil where 120 pounds of fertilizer nitrogen were used per acre annually. Soil of the non-nitrogen fertilized plots contained 42 pounds at the

same depth. The average annual corn yield was 82 bushels per acre with nitrogen fertilization and 43 bushels without added nitrogen.

Growing crops reduce movements of nitrates

Nitrate accumulation and losses by leaching and/or denitrification (return of nitrogen to the air) relate to soil texture, rainfall and the growth of plants. Nitrates move with soil water, but growing roots of most crops penetrate deeply during the growing season to intercept and use these nitrates in the soil profile.

The rate of downward movement of nitrates and water is restricted in fine- and medium-textured soils, thereby permitting the roots to use substantial amounts of nitrogen that would otherwise accumulate.

Figure 3 illustrates the depth at which nitrate accumulated with different rates of fertilizer nitrogen. Nitrates move more freely and deeply in coarse-textured, sandy soils, limiting the amount that can be recovered by growing crops.

Application of nitrogen fertilizers near the time of crop needs is more important with sandy soils. Maintaining a soil cover with growing crops minimizes nitrate accumulation and movement into the soil profile.

Nitrate in runoff water

Nitrate in runoff water from agricultural soils is minimized when an optimum fertilizer program produces vigorous crop growth. Plant growth intercepts the force of raindrops and decreases movement of soil sediment to streams and water impoundments.

Table 2 illustrates the influence of fertilizer nitrogen and growing crops on loss of nitrate-nitrogen in runoff water resulting from two rains in June totaling 4.5 inches. Only a small amount of nitrogen applied as fertilizer to well managed soils is lost in runoff.

Table 2
Nitrate-nitrogen in runoff*** water from corn.****

Cropping system	Nitrogen pounds applied per acre	Nitrate-nitrogen pounds lost per acre
Fallow-tilled	0	0.8
Corn-oats	0	0.3
Continuous corn	9	0.09
Continuous corn	177	0.01

***Runoff resulting from 2 rains in June totaling 4.5 inches precipitation.
****Source: Midwest Claypan Experimental Farm, McCredie, Missouri.

Animal manures and chemical nitrogen fertilizers applied on frozen soils of sloping fields may result in some loss of nitrogen in surface runoff water in case of heavy rainfall or rapid snow melt. Disposal of animal manures during winter by spreading on unfrozen soils or fields with nearly level topography will minimize possible enrichment of streams and ponds with nitrogen and phosphorus.

Determining nutrient content of animal wastes, effluents and sewage sludge by chemical analysis is suggested before large amounts are applied to soils. Realistic application rates to supply needed essential elements (N, P and K) for soil improvement and crop production will greatly reduce any nitrate lost from cropped fields. Avoid excessive applications.

Tile drains

Varying amounts of nitrate may be contained in tile drainage. Concentration will likely be greater in late fall and early spring when there is little crop growth. During the crop growing season, plants use the nitrates derived from decomposition and nitrification of plant residues, organic matter and supplemental nitrogen fertilizer applications. Limited studies in some Midwest states have found seven to 16 pounds of nitrate-nitrogen per acre annually collected in tile drainage. The amount is greater with highly fertile soils and in years of high rainfall.

Ponds have low nitrate levels

Seldom has more than a trace of nitrate been found in ponds unless barn lot, feedlot or silo drainage enters the reservoir. High levels of nitrate have been found during warm weather where large amounts of organic materials enter ponds.

Eutrophication is the natural aging process of ponds and lakes in which nitrate and phosphate, as well as other essential elements for plant life, permit vigorous growth of algae and aquatic plants. Some algae growths accumulate in great quantities and color large areas of water. Such growths are known as "water blooms."

Some algae may give unpleasant odors and taste to water. Other species can fix atmospheric nitrogen. Algae and aquatic plant life effectively use nitrate-nitrogen, thereby minimizing the concentration in the impounded water.

The concentration of phosphorus in fresh water that will limit the growth of aquatic plants is about 0.02 parts per million (ppm), while the limiting amount of nitrate-nitrogen is 0.05 to 1.0 ppm.

Spring water

Water of some springs contains nitrate that is thought to originate from natural soil leachings and bat guano deposits in nearby caves.

Annual flow of some large springs may contain more nitrate-nitrogen than the total fertilizer nitrogen used annually in Missouri. However, the concentration is generally low and therefore safe to drink from a nitrate point of view. Springs flowing intermittently are more likely to have seasonal variation in nitrate

concentration.

Caves often contain deposits of nitrate salts. Such caves provided gunpowder ingredients during the Civil War. Nitrate salts found as crystals on the walls and in crevices of caves are believed to originate from evaporation of soil leachates.

Suggestions for safer water supplies

Human health is most important. Nitrate contaminated water can pose a particular health hazard to infants. Safe water is essential for infants and may be important to other members of the family.

Removing nitrate from water is difficult and costly. Nitrate can't be removed from water by boiling or allowing to stand. It can't be removed with filters or water softeners or by adding chemical compounds. Preventing possible sources of nitrate contamination or developing a new source of water may be more practical.

Anion exchange resins offer the only possibility for removing nitrate from water. Water softeners should be used ahead of an anion resin exchanger.

Livestock may be affected by nitrates, depending upon nitrate intake from water, forage or other feeds, or a combination of sources.

Ponds or reservoirs properly located, constructed and protected from drainage of feedlots and sewage disposal systems may provide the most practical source of water in areas where deep wells are not feasible.

Old wells may be repaired if surface drainage is a factor. Recasing deep wells may ease the problem. Diverting surface drainage may help.

Locate new wells some distance from livestock concentration areas. Test drilling accompanied with soil and water analysis should be helpful in locating new wells.

Chlorination of water will convert nitrite to nitrate and kill bacteria that might otherwise increase the nitrate to nitrite conversion. Chlorination neither removes nitrate nor prevents its conversion to nitrite in the intestine of an animal. Chlorination is recommended for surface water and shallow well supplies for human consumption.

Water standards

The Public Health Service suggests 10 ppm or 10 milligrams per liter of nitrate-nitrogen as the maximum for safe human drinking water. This is equivalent to 45 ppm or 45 milligrams per liter of nitrate.

Excessive nitrate intake may be converted to nitrite in the digestive tract and react with the blood to reduce it's oxygen carrying capacity. The resulting disease is known as "Methemoglobinemia." Infants are more susceptible than adults. Severe symptoms in infants is called "blue baby" disease.

Detect nitrate with chemical tests

Chemical tests are available to detect nitrate in water. Nitrate concentration from a single source may reflect seasonal changes in moisture to plant growth. Therefore, samples taken in January to March and in October are most likely to be the high values. Information about testing is available from your local MU Extension center.

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