Ammonia in the Distribution System: First in a Series

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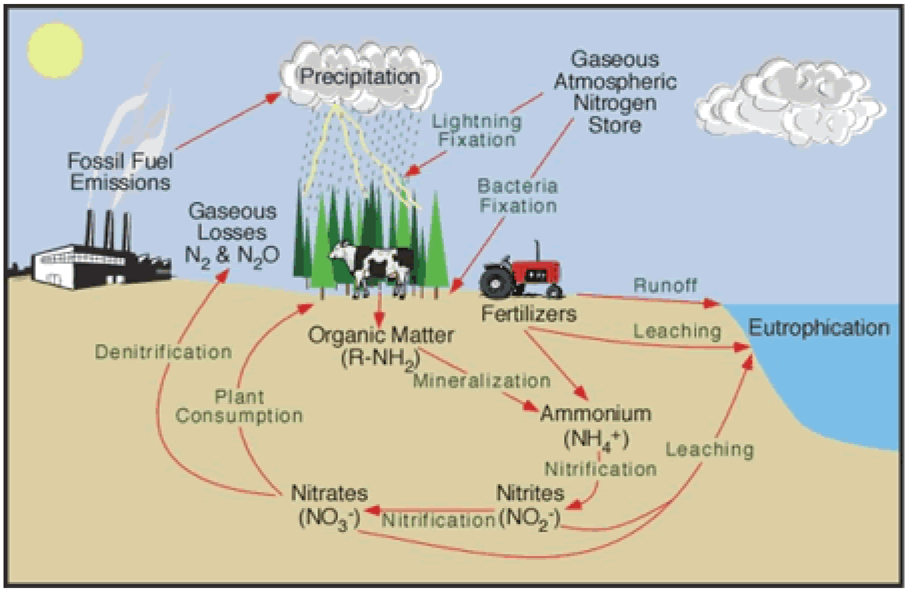

This is the first in a series of articles that will bring a practical approach to understanding ammonia and the problems it can cause in our water distribution systems.

Many water systems in Minnesota already have ammonia in their water or add ammonia during their treatment process. Excess free ammonia in water distribution systems promotes biological growth and nitrification. If your system experiences isolated areas of water quality degradation that affect the aesthetic quality of the water (and generate customer complaints due to taste, odor, and particles in the water), or if your system has areas where it's difficult to keep acceptable chlorine levels, this might be a direct result of biological growth and nitrification.

This first in the ammonia series, which will focus on understanding ammonia and nitrification, will help systems determine if the problems they are experiencing are associated with ammonia in their water.

Nitrogen Cycle
Nitrogen is essential to all living systems, which makes it one of Earth's most important nutrient cycles. Eighty percent of Earth's atmosphere is made up of nitrogen in its gaseous form.

Nitrogen is removed from the atmosphere by lightning. During electrical storms, large amounts of nitrogen are oxidized and united with water carried to the earth in rain-producing nitrates. Nitrates are taken up by plants and are converted to proteins. The nitrogen then passes through the food chain from plants to animals. When they eventually die, the nitrogen compounds are broken down, producing ammonia. Some of the ammonia is taken up by the plants; some is dissolved in water or held in the soil where bacteria convert it to nitrates (nitrification).

Human activities cause increased nitrogen deposits in a variety of ways, including:

- Burning of both fossil fuels and forests, which releases nitrogen into the atmosphere.
- Fertilizing of crops with nitrogen-based fertilizers, which then enter the soil and water.
- Ranching, during which livestock waste releases ammonia into the soil and water.
- Leaching of sewage and septic tanks into streams, rivers, and groundwater.

Chlorination

Free chlorine and chloramines, disinfectants used in water systems, each has its advantages and disadvantages. Free chlorine provides a strong disinfectant residual but reacts with organic matter to form disinfection by-products (DBPs). Chloramines, produced when ammonia is combined with chlorine, have lower disinfection power than free chlorine but they provide a more stable residual and halt the formation of DBPs such as trihalomethanes and haloacetic acids.

Heterotrophic Plate Count (HPC)

Heterotrophs are broadly defined as microorganisms that require carbon for growth. They include bacteria, yeasts, and molds. The HPC analysis gives an indication of microbiological activity in drinking water supplies.

Nitrification and the Safe Drinking Water Act

The maximum contaminant levels (MCLs) are 1 milligram per liter (mg/L) for nitrite and 10 mg/L for nitrate at the entry to the distribution system. There are currently no MCLs for nitrite or nitrate within the distribution system. If these MCLs were to be applied to locations in the distribution system, it is possible that the MCL for nitrite could be exceeded due to the conversion of ammonia to nitrite during nitrification.

Free Ammonia

The term "free ammonia" is used when naturally occurring ammonia is present in water and/or when chloramines are used to disinfect water. During chloramination, chlorine and ammonia are added to water to form monochloramine. The portion of ammonia that has not combined with chlorine is called free ammonia, and exists as either NH4+ or NH3 depending on the pH and temperature of the water. At typical water pH of 7.0 to 7.8 and temperature of 12 to 24 degrees Celsius, more than 96 percent of ammonia is in the ionized form of ammonium (NH4+). As the pH and temperature increase, the amount of NH3 increases and the amount of NH4+ decreases.

Ammonia in Your Water System?

The only accurate way to determine if your water contains ammonia is to perform an ammonia analysis. We recommend that a system check its source water at each entry point for total ammonia. If ammonia is detected, additional sampling on the distribution system for free ammonia should be explored. We have detected ammonia levels of over 7 mg/L in groundwater in Minnesota. Many ground water systems in this state have ammonia levels ranging between 0.2 to 2.0 mg/L. Since ammonia is an unregulated compound, the U. S. Environmental Protection Agency (EPA) has not required a system to sample for it. Because of this, we have very little historical data on ammonia levels in ground waters in Minnesota.

Indicators of Ammonia and Nitrification

1) If your system uses chlorine as the disinfectant, the best indicator of whether your water contains ammonia is the difference between free-chlorine and total-chlorine residual levels. If you observe an increased difference between free and total chlorine, you may have ammonia in your water. For example, many systems that were tested that have ammonia in their water typically have total chlorine levels in the range of 1.2 to 1.5 mg/L and free chlorine levels in the range of 0.1 to 0.3 mg/L. The differences between the two results are significant as they indicate that something is combining with the chlorine; in most cases, it is ammonia. Beware of free chlorine level readings below 0.3 mg/L. Is it really a low reading? If free ammonia is present, this means breakpoint chlorination has not occurred. Therefore, only the combined chlorine is present, and there will be 0 mg/L of free chlorine. (MDH has contacted chlorine test equipment manufacturers, who acknowledge that there is an interference with the free chlorine test that will give you false readings if "free ammonia" is present. The manufacturers recommend using total

chlorine, monochloramine, and free ammonia test kits when free ammonia is present. This will give a better understanding of where you are in the breakpoint chlorination curve.)

2) Low total chlorine levels may appear in isolated areas in the distribution system. Does your system have areas where it is difficult to maintain total chlorine residuals? Is this an area of your system that generates consumer complaints due to taste, odor, and particles in the water? Do you get complaints from a home on one side of the street but not homes on the other side? If so, you might have nitrification and microbiological growth in this area. Nitrification occurs more often in areas of low water usage. This may explain why certain residences may experience nitrification and others do not.

3) A pH drop may occur in isolated areas in the distribution system. Often a decrease in pH and alkalinity will happen during a nitrification episode. This reaction may affect U.S. EPA Lead and Copper Rule compliance resulting in increased lead and copper solubility.

4) An increase in HPC bacteria counts is an indicator of a nitrification episode. If ammonia is detected in your source water, additional testing should be conducted at point of entry and on the distribution system. Monochloramine, “free ammonia,” total chlorine, pH, HPC, nitrite, and nitrate are some of the basic tests used to verify a nitrification episode. There are operator-friendly nitrification and denitrification specific tests available through manufacturers or nitrification tests can be requested from a private lab.

Conclusion

There have been many unexplained customer complaints due to taste, odor, and particles in the water. In many cases, we cannot explain why customers are experiencing these problems, and the remedy has been to flush a local hydrant to appease the customer, only to have the complaints come back over time. Are many of these unexplained complaints due to excess ammonia and nitrification in the distribution system? This article provides some basic understanding of ammonia and nitrification and lists some indicators to help you determine if the problems you are experiencing are due to excess ammonia in your water.
Many systems in Minnesota have ammonia in their source water; some have tested for it but many have not. The purpose of this article is to help identify ammonia issues in your distribution system and understand that excess free ammonia is a food source for nitrifying bacteria.

The second part of this series will address the importance of understanding breakpoint chlorination and examine low-cost options of dealing with ammonia and nitrification control.