

*(The following layperson's summary on ammonia-ammonium measurement was compiled from information provided by John Sawyer, Department of Agronomy, and Tom Isenhardt, Department of Natural Resource Ecology and Management, and edited by Brian Meyer, Agriculture and Life Sciences Communications, Iowa State University.)*

## **A General Summary on Ammonia-plus-Ammonium Measurements of Iowa Waters May 2008**

### Impact on aquatic life

Measurements of nitrogen reported as ammonia in Iowa waters really are measuring a combination of two different nitrogen forms: one that's toxic to aquatic life (ammonia) and one that isn't (ammonium).

Ammonium ( $\text{NH}_4^+$ ) is an ionized form of nitrogen; it's nontoxic. Ammonia ( $\text{NH}_3$ ) is a form of nitrogen that isn't ionized; it's toxic to fish and other aquatic life.

In water, ammonium and ammonia exist in equilibrium. When conditions favor one, the other is reduced. The equilibrium is very dependent on pH. (It also depends to a lesser extent on temperature.) The equilibrium shifts to ammonia when the pH is high (9.0 and higher). It shifts to ammonium when pH is neutral or low. Examples:

- At pH less than 6.0, the proportion of ammonia is very low.
- At pH around 8.0, ammonia is 10 percent or less.
- At pH slightly above 9.0, ammonia grows to 50 percent.

Most Iowa surface waters have a neutral to slightly basic pH, around 7.0 or 8.0. In that range of pH, most of the nitrogen measured is in the form of ammonium and of little consequence to aquatic life.

When water samples are taken, the resulting measurement is the sum of ammonium plus ammonia concentrations. Since the risk to aquatic life depends on water's pH and temperature, the Iowa Administrative Code (Chapter 61) spells out water-quality criteria in tables indexed for those two conditions. In this way, the tabled values factor in the conditions necessary to determine whether ammonia-plus-ammonium concentrations put aquatic life at risk. The Iowa Administrative Code also provides a distinction between criteria for chronic (long-term) conditions and for acute (short-term) conditions.

A recent newspaper article reporting on ammonia measurements taken in January, February and March stated the following:

- *“An ammonia reading of more than 0.1 parts per million is considered damaging to fish and the tiny creatures and plants on which they feed”*
- *“Readings of 0.1 parts per million or higher can put fish and plants at risk”*
- *“Readings of 0.1 parts per million or higher are considered potentially damaging to fish and other aquatic life, depending on the temperature and the pH of the water.”*

An ammonia-plus-ammonium level of 0.1 parts per million is a concern to aquatic life — but only with pH of 9.0 and at 30 degrees C (86 degrees Fahrenheit), which are the chronic conditions outlined in Iowa Code. Those conditions normally occur in the middle of summer in streams actively producing algae as the equilibrium shifts to ammonia (NH<sub>3</sub>).

Stream conditions in February and March (the time of the Iowa Department of Natural Resources sample collections cited in the article) were in the range of pH of 7.5 to 8.0 and a temperature of less than 5 degrees C (less than 41 degrees Fahrenheit). Under these pH and temperature chronic criteria, the level for concern to aquatic life would be 2.5 parts per million. Under acute criteria, the level would be in the range of 8.4 parts per million.

Using those accurate criteria, none of the concentrations reported in the newspaper story exceeded the chronic level.

Values reported in the newspaper article are samples collected by the Iowa DNR ambient monitoring program. The data are publicly available within the Iowa DNR STORET database. A review of the past eight years (2000-2008) of Iowa DNR data from statewide ambient water samples taken during January, February and March shows that measured levels tend to be higher in the late winter months and can be quite variable. While levels found in 2008 were among the higher ones recorded over this time, the range and variation was consistent with several past years, likely under similar hydrologic conditions. Other entities, such as the Des Moines Waterworks and the Des Moines River Water Quality Network, observed similar patterns in ammonia levels during 2008.

### Impact on drinking water

Misperceptions on how ammonia in water is measured and how it impacts aquatic life may affect concerns — also reported in the newspaper article — on drinking water for urban areas. The state has criteria for impact of ammonia on the health of aquatic life. There are no additional criteria for waters used for drinking water. The impact of ammonia and ammonium on drinking water is a separate issue — it is about treatment of water. Municipal water works add chlorine to their water supplies to kill bacteria. High levels of ammonia impede chlorine's effectiveness. Water treatment plants add more chlorine to ensure that ammonia doesn't overcome its bacteria-reducing ability.

In its relating of city actions to address ammonia concerns, the newspaper focuses much attention on a single management practice, the wintertime spreading of manure on snow-covered, frozen ground. Aqueous nitrogen is complex, as is the sourcing of nitrogen and its effect on aquatic life, as reflected by the acute and chronic levels outlined in Iowa Code. The annual and seasonal patterns of ammonia are highly variable and are driven primarily by climate and hydrology. As with all such complex relationships, it is difficult to separate the overriding impacts of climate and hydrology with short-term land management.