What Causes Fish Kills?
Part 2

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We originally prepared a fact sheet on fish kills. The sheet titled, "What Causes Fish Kills-Part 1", described how loss of dissolved oxygen in the water results in fish kills. This fact sheet will cover the role ammonia plays in fish kills.

How does ammonia get into the water? Ammonia is produced by the bacterial decomposition of organic matter under anaerobic (without oxygen) conditions. This takes place at the bottom of a lake. Algae, which dies over time, settles to the bottom of the lake and becomes the organic food for the bacteria. As the bacteria initially metabolize the organic matter, oxygen is consumed at an incredible rate, and drops the oxygen concentration to zero. At that time, anaerobic bacteria begin to decompose the organic matter and produce ammonia as a by-product. The more organic matter present and the warmer the water temperature, the more ammonia that is produced. Ammonia production is generally greatest in shallow, stagnant areas where organic debris accumulate or in terminal lake segments where there is no inflow and outflow.

Is all ammonia the same? In water, ammonia can exist as dissolved ammonium ion (NH_4^+) or as dissolved ammonia gas (NH_3). The ammonia in the gas form is also called un-ionized ammonia. For any given amount of ammonia in water, the proportion of ammonia gas to ammonium ion is based on (1) the water pH and (2) water temperature. Higher temperatures and higher pH favors ammonia to exist in the gas phase. The gas phase becomes highly dominant at pH values of about 9.0 SU and higher.

Why is this important? Ammonia gas is highly toxic to fish. At low concentrations (0.08 mg/L or greater) gaseous ammonia can cause acute toxicity, including loss of equilibrium, hyperexcitability, increased respiration, convulsions, coma, or death. At even lower concentrations (down to 0.002 mg/L), un-ionized ammonia can result in chronic effects such as reduced hatching success, reduced growth rate and development, and pathological changes in tissue of gills, livers, and kidneys.

How does this relate to a fish kill? When a very warm summer occurs, the lake algae become extremely productive. This provides less than ideal conditions. First, algae utilize dissolved carbon dioxide during the photosynthesis process. This causes lake pH levels to rise. Second, as the algal cells eventually die and sink to the lake bottom, they provide abundant food for the anaerobic bacteria. What results is lake pH values of 9.0 to 9.5 and un-ionized ammonia concentrations above 0.3 mg/L; in other words, acute toxicity to fish.

What can we do? (1) **Limit algae growth**. The best way to reduce gaseous ammonia toxicity is to limit algae growth, thereby limiting pH effects and bacteria's food resource. However, this is easier said than done. The lakes are filled with reclaimed water and are always high in nutrients. This stimulates algae growth and the cost of algicide treatments to achieve sufficient algae control would be staggering. (2) **Aerate the water**. The lake can

be operated to move and mix water which helps to chemically convert and physically remove (volatilize) some of the ammonia. This is being practiced by operating the aeration systems and water features. Aeration will help, but often cannot out-compete the rate of bacterial metabolism. (3) **Wait.** Algae growth is cyclic. Eventually growth will decline because of light or temperature limitations, and pH and ammonia levels will drop.