

## Chapter 8. Acute vs. Chronic Toxicity

**Lesson 2.** Throughout the world, acid rain and acid deposition are serious threats to the health of lake and river ecosystems near industrial cities.

**Overview:** Contaminants that can affect the quality and usefulness of water are chemical, physical or biological. As students learned in a previous activity, contaminants are either primary or secondary. Primary contaminants affect the health of humans or the health of aquatic life such as fisheries, aquatic plants and insects. Secondary contaminants affect the taste, smell, color, and comfort of water. Although secondary contaminants may cause unwillingness toward use of the water, they pose no threat to the health of ourselves or aquatic ecosystems. On the contrary, primary contaminants do pose a threat to health. To avoid public and environmental health problems associated with such contaminants, we must be aware of the degree of toxicity of them. We describe the toxicity of a substance on a dose-response relationship. The length of exposure and the concentration of the contaminant may result in either acute or chronic toxicity to the organism.

**Purpose:** The purpose of this lesson is to learn about the diversity of organism response to soluble aluminum within lakes. Scientists have become particularly interested in "indicator species" - species which suffer acute toxicity, sickness or death because of chronic exposure to quite low concentrations of a contaminant. Such indicator species are key to identifying a lake or a stream, the health of which is deteriorating due to the degrading quality of water.

### **Materials Needed:**

- Colored chalk (various colors) and chalk board or colored markers and a flip chart

**Procedure:** When class begins, draw two lakes on the board. Using the colored chalk, draw in all the species that live in and around the lakes. Have the students participate if you wish, just be sure that the lakes are identical when they are finished. Do not forget the trees, willows and grasses around the lake, animals that drink out of the lake, and the aquatic insects and plants, algae and fish within the lake. Be sure to draw in some very small fish called Steriodaphnia; these will be important later in the activity. These lakes are intact ecosystems. Most often, a variety of species represents a healthy ecosystem.

Now have the students recall their previous experiment on acid rain and deposition. Ask them what acid rain is. Ask them what acid deposition is. Which of the two, acid rain or acid deposition, results in a larger immediate decrease in pH

(increase in acidity) once it reaches the lake water? Suppose acid deposits accumulate on the earth's surface for a long time. When it finally rains or the snow melts, the pH of a lake will decrease.

Now tell the students that each of these lakes lies on rocks and soils that are abundant in aluminum. Ask them if aluminum would be soluble if the lakes were not acidic. Remind them, from their alfalfa experiment, that aluminum is only soluble at low pH (high acidity). Now draw a few buildings with smoke stacks and cars in the background of the lakes. Draw smoke coming out of the smoke stacks and car exhaust pipes. Remind the students that industrial smoke and car exhaust can cause rain to become acidic if the rain passes through the smoke. Draw some clouds and rain over a lake. Tell them that this lake receives much rain throughout the year. Perhaps this lake is in Oregon. Tell them the other lake has experienced a drought for the last year. Perhaps this lake is in Arizona. Ask them what has happened to the smoke and car exhaust around this lake for the past year. Take black or brown chalk and draw many dots on the earth around the lake to show acid deposition.

Have the students imagine that a year has gone by and it has rained 60 times on the first lake. Because of this constant acid rain introduction, the pH of the lake gradually decreased to 5. In the same year, the second lake has not seen any rain, but on the last day of the year, it rained very hard for the whole day. Draw clouds with rain over this lake. Explain that because of this torrential rain, the acid deposition ran into the lake and dramatically decreased the pH of the lake to 4.3. Because of this sudden decrease of pH, all of the algae, and the smallest of fish, the Steriodaphnia, died off. Erase all the algae and the Steriodaphnia from this lake. This is a perfect example of algae and Steriodaphnia's death because of acute aluminum toxicity. Because of gradual decrease in pH of the first lake, the algae and Steriodaphnia are still alive, but their reproduction has decreased. This is a perfect example of chronic aluminum toxicity to the algae and Steriodaphnia. Erase only a small amount of the algae and Steriodaphnia.

Help the students understand why the algae and Steriodaphnia suffered acute toxicity in the second lake and only chronic toxicity in the first lake. In the first lake, the pH gradually decreased, allowing some aluminum from the rocks and minerals to go into the water. The organisms in and around the lake were exposed to constant, very low concentrations of aluminum. The concentrations were not high enough to cause death. Eventually the reproduction rate of the algae and Steriodaphnia decreased because of chronic aluminum toxicity. In the second lake, acid deposition accumulated on the earth's surface; when it rained, the deposition washed into the lake. A dramatic decrease in the pH of the lake was a result and a large concentration of soluble aluminum within the lake followed. The algae and Steriodaphnia have low tolerance to such high concentrations of aluminum; their

die-off was the consequence of acute aluminum toxicity. The aluminum concentrations were not high enough for other species to die off. Some organisms could experience chronic toxicity, however, if they were exposed to the aluminum for a long time. Remind the students that this scenario could also have happened if acid deposition had built up on snow and then the snow melted.

Explain to the students that a scientist would see this sudden die-off of algae and Steriodaphnia and he/she would know that the quality of the lake water diminished. The algae and Steriodaphnia in this case are indicator species-species which suffer acute toxicity or death as a result of chronic exposure to low concentrations of a contaminant. These indicator species suggest that the health of an aquatic ecosystem is in danger because of deteriorating water quality.

**Lessons Learned:** Throughout the world, acid rain and acid deposition are serious threats to the health of lake and river ecosystems located near industrial cities. Many lakes in the U.S. and Europe are fishless because of the chronic effects of acid rain. The problem with these lakes is not specifically the acidic water; there are many lakes around the world with equally low water pH and yet they still contain fish. These fishless lakes are located on and near rocks and soils that contain aluminum. The aluminum can easily leach from these rocks and soil when exposed to acidic water introduced from acid rain and acid deposition.

Organism response to soluble aluminum within lakes is diverse. Scientists have become particularly interested in "indicator species" - species which suffer acute toxicity, sickness or death because of chronic exposure to quite low concentrations of a contaminant. Such indicator species are key to identifying a lake or a stream, the health of which is deteriorating due to the degrading quality of water.

The lesson above was adapted from "What is Water Quality? A Resource Guide for 4-H Leaders and Teachers," 80 pages of activities and experiments related to water quality. (\$5.00) Order from the Montana 4-H Program at Montana State University-Bozeman. Phone 406-994-3501.