

Chapter 8. Acute vs. Chronic Toxicity

Lesson 1. Contaminants that can affect the quality and usefulness of water are chemical, physical or biological

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 activity is to introduce to the students the idea of toxicity and the difference between acute and chronic toxicity. This lesson takes about one to two weeks to complete.

Ideas Taught: The toxicity of a substance is its ability to affect negatively the physical, morphological, behavioral, and/or reproductive characteristics of an organism. Toxicity does not necessarily result in death to an organism. Exposure time and contaminant concentration differences can change responses of an organism to a contaminant. Toxicity is either acute or chronic. Acute toxicity is an immediate response to high concentration of a contaminant. Sickness or death occurs almost immediately. Chronic toxicity is the delayed response because of prolonged exposure to a contaminant. Chronic toxicity appears after years of continuous exposure to contaminated water. Some examples of chronic toxicity may be sickness, reproductive failure, behavioral changes, and death. The pH of the water plays an important role in governing the toxicity of some contaminants.

Materials Needed:

- $\frac{1}{2}$ cup alfalfa seeds, millet, mustard seeds, celery seeds, or bird seed—available at health food or seed stores
- Nine large mason or mayonnaise jars
- Cheesecloth
- $\frac{1}{4}$ cup aluminum sulfate (pickling salt)—available at grocery stores

- $\frac{1}{4}$ cup acetic acid (vinegar)
- $\frac{1}{4}$ cup lime—available at garden or hardware stores
- Nine 450ml plastic pop bottles
- Permanent ink pens
- pH paper
- Three teaspoons

Procedure: Two days before class, add one teaspoon of alfalfa seed (or other small seed) to each of the nine mason jars; then fill each jar with $\frac{1}{2}$ inch of water. Cover the mouth of each jar with cheese cloth and secure the cloth with the ring of the lid or a rubber band. One day before class, dump out the water from the jars without removing the cheese cloth. Tap the seeds to the bottom of the jar. Return them to a place that receives good light.

Before class you should make up aluminum solutions in the plastic pop bottles. Three pop bottles should contain a concentrated solution of aluminum sulfate and three pop bottles should contain a dilute solution of aluminum sulfate. Make the solutions by doing the following: Add one teaspoon full of pickling salt to a plastic bottle then fill the bottle with water. Shake the bottle for five minutes, then label the bottle "Concentrated Aluminum Sulfate." Add half of this solution to the other bottle, then fill the bottle with water. Shake the bottle for five minutes, then label it "Dilute Aluminum Sulfate."

Repeat this procedure until you have three bottles of each solution. Adjust the pH of a concentrated solution and a dilute solution to 4.5. To do this, add one teaspoon of vinegar, shake, and measure the pH with pH paper. Repeat this process as needed. Be sure to shake the bottles thoroughly before you measure the pH. You may need to pour out some solution so enough vinegar can be added to adjust the pH correctly.

NOTE: *The pH of the solution must not be lower than 4; if it is, you must make the solution again. When you have successfully adjusted the pH of the solutions to 4-5, label the bottles with the appropriate pH. Adjust the pH of another pair of concentrated and dilute solutions to 8-9 using lime. Follow the same procedure as with the vinegar. Note: It takes a very small amount of lime to raise the pH of these solutions to 8-9 (less than $\frac{1}{4}$ teaspoon); if the pH of the solution becomes greater than 9, you must make the solution again. The pH of the solution must not be too high or the seeds will not grow at all. When you have successfully adjusted the pH of the solutions to 8-9, label these solutions with the appropriate pH. Take the pH of the remaining pair of concentrated and dilute solutions and label them*

with the appropriate pH. Fill the last three bottles with water and label them "No Aluminum." Adjust the pH of one to 4-5 and one to 8-9 with vinegar and lime, respectively.

Be sure to shake the bottles well after each addition of vinegar and lime. Label them with the appropriate pH. Finally, take the pH of the third bottle of water and label it accordingly. You should now have the following bottles of solutions, each appropriately labeled as follows:

- 1) Concentrated Aluminum Solution - pH = 4-5
- 2) Concentrated Aluminum Solution - pH = 7 (approximately)
- 3) Concentrated Aluminum Solution - pH = 8-9
- 4) Dilute Aluminum Solution - pH = 4-5
- 5) Dilute Aluminum Solution - pH = 7 (approximately)
- 6) Dilute Aluminum Solution - pH = 8-9
- 7) No Aluminum - pH = 4-5
- 8) No Aluminum - pH = 7 (approximately)
- 9) No Aluminum - pH = 8-9

Note: *You may feel the students can mix the solutions themselves. This is fine. It is very important, however, that they adjust the pH of the solutions properly. It is also vital that they thoroughly mix the solutions after adding the aluminum sulfate and while adjusting the pH. You will find a dramatic difference between the growth of the seeds in properly made solutions.*

When class begins, ask the students what is a contaminant. They should answer quickly, since they have heard this term throughout the activities of this handbook. Remind the students that contaminants are either primary or secondary. Ask them to recall the difference between the two categories. When the students have arrived at the correct definition of these categories write on the board or overhead: "Primary Contaminant: a contaminant that can affect the health of fisheries, plants, and aquatic insects." Ask the students to give examples of some primary contaminants. Write these on the board. Below the examples of primary contaminants write on the board or overhead: "Secondary Contaminant: a contaminant that can affect the taste, smell, color, and comfort of the water." Ask the students to give examples of secondary contaminants. Write them on the board.

Now ask the students what is toxicity. Which contaminant is toxic-primary or secondary? Explain that just because a contaminant is toxic, it does not mean that

the contaminant causes death to the organism exposed to it. Toxicity is the ability of a contaminant to affect negatively the physical, morphological, behavioral, and/or reproductive characteristics of an organism. Have the students think of examples of each of these changes. It might be useful to have them give examples of these adverse effects toward humans, to fisheries and to aquatic insects and plants. Sometime during the discussion, the students should remember the terms acute and chronic toxicity. We introduced these terms in Chapter 1 of this handbook. When they have arrived at the correct definitions of acute and chronic toxicity, write on the board or overhead: "Acute Toxicity: a sudden or immediate response of sickness or death resulting from exposure to a contaminant." Then write on the board or overhead: "Chronic Toxicity: a response of sickness, death, physical, morphological, reproductive, and/or behavioral changes that result from prolonged exposure to a contaminant."

By now many students should recall part 5 of Chapter 1 of this handbook. The first example illustrated acute vs. chronic toxicity using goldfish and salt. Have the students recall the effects of adding salt to the goldfish bowl. You may want them to repeat the experiment if it is necessary. Did they observe acute toxicity when salt was added to the water? What types of chronic responses might we observe in fish exposed to a low concentration of salty water every day for a long time? The second example in part 5 of Chapter 1 illustrated acute vs. chronic toxicity using brine shrimp and bleach. Did they observe acute toxicity when they added bleach to the water? What type of chronic response might we observe in brine shrimp exposed to a low concentration of bleach in the water every day for a long time?

The students are going to set up an experiment that will illustrate acute and chronic toxicity using aluminum and alfalfa seeds. (For simplicity, alfalfa seed is the example throughout this activity. Any of the other seeds listed in the materials section work well, also.) Explain to the students that aluminum is the most abundant metal on earth. Aluminum is also quite toxic in its aqueous form. Aluminum sometimes gets into lakes, rivers, soil porewater or groundwater. When it does, fish, aquatic and terrestrial plants, insects, animals and humans may experience toxic effects. Aluminum is usually bound up in rocks and soils. Aluminum seldom occurs in water with which the rocks and soils come in contact. The pH (acidity) of the water, however, will dictate whether the aluminum will go from its solid phase (rocks and soils) to its aqueous phase (water). Aluminum is soluble in water at low pH (acid conditions) and at higher pH's aluminum is completely insoluble. A common source of aluminum is from mine tailing sites.

Have the students get into four groups. Give three of the groups two mason jars with alfalfa seeds that have been soaking and have begun to germinate. Give each of the three groups one concentrated and one dilute solution. Each group should receive solutions with the same pH. The fourth group should receive the solutions with no aluminum at pH 4-5, 7, and 8-9. Now tell the students that the mason jars contain alfalfa seeds that have been soaking for a few days. Do not remove the cheese cloth from the jars. Have students label each jar with the solution with which they will be rinsing their seeds. It is important that they never mix the jars up. Use one solution with the same jar throughout the experiment. Students rinse one jar of seeds three times with 1/2 inch of the labeled solution. After the solution has been added and the seeds rinsed around, pour the solution out of the jar without removing the cheese cloth. Tap the seeds back down into the jar. It is better if most of the seeds are in the bottom of the jar without solution when they are done. Place the labeled jars in a light place and leave them over night. For the next 2-3 days follow the same procedure, rinsing the sprouts only once each day with the appropriate solution. Do not mix them up! As alfalfa seeds grow, discuss the effects of aluminum on their growth. Is there a difference between the concentrated aluminum solution and the dilute solution? What effect does pH have on the sprout growth? What effect does pH have on aluminum toxicity? Do they see acute toxicity? What types of chronic toxicity can they see? What other chronic effects might they observe if the experiment were prolonged? You may wish to make up a table, such as below, and have the students observe, evaluate, and record observations each day for their solutions. I suggest you make up the entire table, in the same order as you would give to the teams. Photocopy the table, then cut the copy into parts, each containing only one group's solutions. This way the students can record their own data on their part of the table, then you can combine the results into the original table at the end.

- Observations - Describe What You See					
Treatment Solution	Day 1	Day 2	Day 3	Day 4	Day 5
Concentrated Aluminum pH =4					

Lessons Learned: Contaminants that can affect the quality and usefulness of water are chemical, physical or biological. 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.

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.