

Chapter 8. Acute vs. Chronic Toxicity

Lesson 3. All contaminants behave chemically differently once they reach a water supply and contact an organism.

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 aquatic ecosystems or us. 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 that all contaminants behave chemically differently once they reach a water supply and contact an organism. Many contaminants are quite toxic, even at low concentrations. Other contaminants must exist in large concentrations before an organism shows any toxic response. Organisms can also respond differently to the same concentration of a contaminant within their water supply.

Materials Needed:

- 60 petri dishes (tops and bottoms) or ziplock plastic bags
- Nine 60cc disposable plastic syringes (available from a local vet)
- 60 - 8oz plastic cups
- Paper towels
- Permanent markers
- Teaspoons
- Index cards
- Forceps or tweezers
- 1-2 gallons distilled water
- Tap water
- Contaminants: bleach, liquid soap, salt, sugar, fertilizer, ammonia, hydrogen peroxide, mouthwash, baking soda
- Seeds (1/2 cups each): raw sunflower (unsalted), mustard, celery, alfalfa

Procedure: Before class begins, fill one 8 oz plastic cup half-full with one liquid contaminant. Make sure you label the cup with the appropriate contaminant using a permanent marker. Repeat this procedure for each liquid contaminant. Add three teaspoons of each of the dry contaminants to separate cups. Fill them half-full with distilled water and mix them thoroughly, then label them with the appropriate contaminant. You should now have nine cups, each with a different contaminant.

When class begins, have the students get into nine groups. Give each group a solution, nine plastic cups, a syringe, seven petri dishes (or ziplock bags), seven pieces of paper towel, a permanent pen, and a teaspoon of one kind of seeds. Have each group work with a different kind of seed. Tell the students they will be doing a semi-quantitative analysis of responses of different seeds to five different concentrations of a contaminant. Each of your labeled plastic cups contains concentrated solutions that would inhibit germination (growth) of all their seeds, and that inhibition of growth is an example of acute toxicity. Explain that the purpose of this activity is to do a series of serial dilutions of each of the concentrated solutions until a concentration is reached in which the plants will grow. Explain that serial dilutions are done to obtain a group of solutions ranging from dilute to concentrated.

Have the students transfer 15ml (15 ce) of their concentrated contaminant solution to plastic cups using their syringes. They should then fill the cup almost full with water, stir it thoroughly, then label it "5000x." This is a hypothetical concentration, as will all of the concentrations be; however, we want to show that serial dilutions are usually on a log scale. Explain to the students that they have learned about the log scale in the activity on pH in this handbook. Tell them pH is not the only parameter that can be on a log scale. If they have forgotten what a log scale is, they will remember after they do the dilution. It is important that they rinse their syringe with tap water after they have successfully transferred the solution into a new cup. Have them label an empty cup "rinse" and fill it with distilled water. Label another cup "waste." To rinse their syringes, they should take approximately 20ml of distilled water from the "rinse" cup and deliver it into the "waste" cup. Repeat twice. Next, using their rinsed syringe, have them take 15ml of their 5000x solution and put it in a new plastic cup. They should then fill the cup almost full with water, stir it thoroughly, then label this new solution "500x." Explain that they have just diluted their solution by a factor of 10, or one unit on the log scale. Have them repeat this dilution procedure, making solutions of 50x, 5x, and .5x, remembering to stir each solution thoroughly before they take out 15ml to make the next solution. It is also very important that they rinse their syringe before they take 15ml of the new solution. When they are done, have the students arrange their solutions in order from concentrated to dilute. As they

look at the concentrations, they should recall that the solutions are each log unit (or a factor of 10) from the one next to it.

Now have the students place one petri dish (or ziplock bag) in front of each of their solutions. Label the tops and the bottoms of the dishes or the zip lock bag with the appropriate concentration using a permanent marker. They should label the dishes in small writing and they should write toward the side of the dish. This is so they can view the growth of the seeds without removing the top of the dish. Label no two petri dishes with the same concentration! Label a remaining dish "distilled water." Label the other "tap water." Have them place 4-5 seeds into the tops of each dish or into the zip lock bags. At this point, they should not lift the petri dishes from the table. Next, using their rinsed syringe, they should put 20ml of each solution into the respective petri dish or ziplock bag. If they start with the most dilute solution (0.5x), and end with the most concentrated solution (5000x), they will not have to rinse out their syringe every time. After they have rinsed their syringe, they can then deliver 20 ml of the distilled water and tap water to the appropriate petri dishes. Put the bottoms of the dishes in place and allow the seeds to soak overnight.

The next day, have the students fold their paper towels into squares small enough to fit into a petri dish. Open a petri dish, and place a towel flat inside. After the towel has soaked up all the water, turn the dish over, so the seeds are showing. Repeat the procedure for all dishes. Write the contaminant on an index card, and place it near the dish. The students will observe the seed growth. Have students make tables like the one below, to write their daily observations on seed growth. Note: If the towel goes completely dry, add 20ml more of the solution.

Each day, observe and compare what is happening with the seed growth in the different solutions. Do students observe a dilution effect on growth of the seeds? There will be a dilution effect exhibiting minimal growth in the more concentrated solutions. As the solutions become more dilute, growth increases. Which seeds grow better in the more concentrated solutions? Do the seeds grow more in one type of contaminant compared to the others? If there is no growth or if it is delayed, acute toxicity has occurred. Continue talking about and writing observations each day until you feel the seeds have grown (or not grown) enough to give satisfactory results.

Contaminant Daily Observations							
Treatment	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Distilled							
Tap							

5000x							
500x							
50x							
5x							
.5x							

Lessons Learned: In the first two parts of this activity, we explored the idea of acute versus chronic toxicity using aluminum and pH. Aluminum is abundant in rock and soils. It can pose a significant threat to insects, plants, animals and fisheries if acid water leaches it from rocks and soils. Acid rain and mining operations can decrease the pH of lake and stream waters, allowing potentially large concentrations of aluminum from rocks and soils into the water. Certain species may not tolerate such concentrations of aluminum. Acute toxicity, or immediate sickness or death, is the result.

Most organisms tolerate lower concentrations of aluminum in lakes and streams. Some organisms may experience chronic toxicity (or delayed sickness or death) from prolonged exposure to aluminum. Indicator species are the first to suffer acute or chronic toxicity. These species are important in identifying a stream or lake, the health of which is deteriorating because of degrading water quality.

In the third part of this activity, we learned that the type and concentration of the contaminant play important roles in contaminant toxicity. Some contaminants are toxic at the acute level, even in very low concentrations. Some contaminants require large concentrations to be acutely toxic.

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.