Parts per Million or Billion: A Science Activity for Grades 4-10

Judy Maben *– Water Education Foundation*

Have you ever been asked to lead a water science activity for your child's classroom? Were you stumped about what to do? Here is a quick and easy activity about water quality that you can do with your child's classmates.

How Do We Define "Bad"?

Substances dissolved in water are usually measured in parts per million (ppm) or parts per billion (ppb). But is the solution to pollution dilution? Different naturally occurring elements, toxins or poisons, and nutrients all may be considered hazardous at different concentrations. Not all man-made chemicals are toxic and not all naturally occurring chemicals are non-toxic. Almost any substance, synthetic or natural, can be considered toxic if ingested in a high enough dose. Salt is a good example. Sodium chloride is a naturally occurring chemical. A few grains sprinkled on your dinner are okay, but if you were to eat a couple of pounds per hour, you would significantly damage your body.

Water Standards and Measurement

The U.S. Environmental Protection Agency establishes standards for contaminants that are sometimes found in groundwater and in surface water. These standards usually provide a number that indicates the concentration of contaminants in ppm or ppb. These standards are enforced by individual states. Some standards relate to human safety for drinking water sources (like arsenic or mercury), and some are for aquatic ecosystems (like nitrates, which can cause too much plant growth, or dissolved oxygen, which is necessary for aquatic animals). But what do those numbers mean? And how much is too much?

Objective:

Students will:

1. perform a serial dilution using powers of 10.
2. identify the importance of standards in evaluating water quality.

Materials (per group):

- 9 clear containers or white plastic spoons
- 2 droppers
- white paper
- toothpicks
- liquid food coloring

Procedure:

1. Protect the surface (table or floor) you are going to use with sheets of white paper or toweling. Line up nine clear containers or white plastic spoons. Label them with numbers 1 through 9.
2. Put 10 drops of food coloring in #1. Assume the food coloring is already at a dilution of 1:10.
3. Put 9 drops of clear water in each of the spoon or container numbered #2 through #9.
4. Take one drop from #1 and place it in #2. Mix with a toothpick.
5. Repeat this process in each container. Example: Take one drop from #2 and add it to the nine drops of water in #3. Each dilution will be 10 times more dilute than the previous one.

Data Table:

Container	Dilution
1	1:10
2	1:100
3	
4	
5	
6	
7	
8	
9	

Discussion:

1. Which container is at a dilution of 1 ppm? (#6)
2. Which container is at a dilution of 1 ppb? (#9)
3. In which container can you no longer see the color? (usually around #5 or #6)
4. You know the color molecules of food coloring are there because you put them there. How can you demonstrate their presence? (Students could evaporate the water, or pour onto white paper and look for ring of color around the wet mark.)
5. If this were a toxic substance, which spoonful would you be willing to drink? (Depends on what it is…there are different standards for different substances.)
6. Individually or in teams, use the Internet to look up allowable total maximum contaminant levels for different substances. Indicate whether your standard is for drinking water or aquatic ecosystems. Report your findings to your classmates.

Bring a Consumer Confidence Report from your local water district to discuss the local water quality.

Further activities: Bring in a pool or spa test kit and run tests on pH and chlorine for different water samples prepared ahead of time. Suggestions: add several drops of ammonia, lemon juice, detergent, baking soda solution, etc.

Adapted from "Project Water Science," available from the Water Education Foundation, 916-444-6240, www.watereducation.org.