#16 Understanding the Concept of Parts per Million and Parts per Billion Student Activity

Background

Concentrations of such materials as chemical pollutants and minerals are frequently expressed in units of "parts per million" (ppm) or "parts per billion" (ppb). For example, chemical fertilizers contain nitrates, a chemical which can be dangerous to pregnant women even in quantities as small as ten (10) parts per million. Trichloroethylene (TCE), a common solvent, is an even more dangerous chemical than nitrate. In the 1970s and early 1980s, trichloroethylene in the well water of Woburn allegedly caused a higher than normal incidence of cancer among Woburn's children.

The purpose of this exercise is to demonstrate what is meant by these concepts and how chemicals may be present in concentrations which are dangerously high and yet may not be detectable by sight, taste or smell.

Materials

Solid coffee stirrers or tooth picks
Medicine dropper
Set of 9 small, clear plastic or glass containers
White paper
Clean water for rinsing the medicine dropper
Red food coloring to represent contaminant
Clean water for diluting

Procedure

1. Line up the clear containers side-by-side and place a piece of white paper under each one. From left to right, number the paper from 1 to 9.
2. Place 10 drops of food coloring into container #1. (Food dye, as it comes from the bottle, is already a dilution of about one part in ten (1:10).)
3. Place one drop of food coloring into container #2.
4. Add 9 drops of clean water to container #2 and stir the solution. Rinse the medicine dropper.
5. Use the medicine dropper to transfer 1 drop of the solution from container #2 into container #3. Add 9 drops of clean water and stir the solution. Again, rinse the dropper with clear water.
6. Transfer 1 drop of the solution in container #3 to container #4. Add 9 drops of water and stir. Rinse the dropper with clean water.
7. Continue the above process until all nine containers contain successively more dilute solutions.
8. Complete the PPM and PPB Data Sheet.

PPM or PPB Data Sheet

Name_____
Class/Section_____

Date_____

Container #	1	2	3	4	5	6	7	8	9
Color									

Questions

1. The food coloring in container #1 is a food coloring solution which is one part colorant per ten parts liquid. What is the concentration for each of the successive dilutions?

Container #	1	2	3	4	5	6	7	8	9
Concentration	1/10	1/	1/	1/	1/	1/	1/	1/	1/

2. What is the concentration of the solution when the diluted solution first appeared colorless?

3. Do you think there is any of the colored solution present in the diluted solution even though it is colorless? Explain.

4. What would remain in the containers if all the water were removed?

5. (Optional) Allow the water in the containers to evaporate and record your observations on what remains in the containers.

ACTIVITY 5-3 CONCENTRATIONS

INTRODUCTION

Contaminants in drinking water are measured in concentrations. Concentration is the measure of the amount of contaminant in the total volume of water. Some contaminants are so strong that the allowable levels are in parts per millon or parts per billion. For example, the rule for lead in drinking water is fifteen parts per billion (15 ppb). The Safe Drinking Water Act (passed in 1974) requires water suppliers to limit contaminants in water supplies to certain levels.

PROCEDURE

In this game you will imagine you are monitoring a water supply. We will use levels in parts per thousand (because we can't fit a million dots on one page.) Contamination is represented by four different colored dots. The objective of the game is to keep your water supply with the lowest possible levels of contaminants (the fewest dots colored in).

Each player will have a piece of paper with one thousand dots on it and four different colored pencils, markers, or pens. On your paper each dot represents one part per thousand. Each color represents a different contaminant.

The first player should roll the dice and then follow the **Dice Directions** to determine how many dots to color in. For example, if you rolled a 3, you would follow the directions for number 3, and color 2 dots blue. The second player will then take a turn by rolling the dice and following the dice directions. Go around the group twelve times. The objective is to end up with as few dots colored in as possible.
The regulations for the maximum contaminant levels are as follows:

- contaminant blue 10 parts per thousand
- contaminant red 8 parts per thousand
- contaminant purple 7 parts per thousand
- contaminant green 12 parts per thousand

DICE DIRECTIONS

After you roll the dice, follow the directions for the number.

2. Erosion control on the logging roads has been improved. Don't color any dots.
3. A town in your watershed decided to lift restrictions on development. Color 2 dots blue.
4. Your hazardous waste collection day was very successful! Don't color any dots.
5. The local middle school collected several thousand used batteries and brought them to the proper disposal site. Don't color in any dots.
6. Outdated Septic systems found to be leaking during rainy weather. Color 3 dots green.
7. Your town's planning board voted to allow development of a new shopping area near a wetland. Color 2 dots purple.
8. A factory in your watershed did not pretreat its wastewater. Color 2 dots red.
9. New and improved street sweepers that vacuum particles were purchased by your town. Don't color any dots.
10. A plan to reduce the use of road salt was accepted by your town council. Don't color any dots.
11. A farm in your watershed has decided to increase their use of pesticides. Color 3 dots purple.
12. The local sewer line was leaking for several hours. Color 3 dots green.

THOUSAND DOTS PAGE