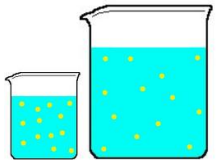
Name: _____ Class: _____ Date: _____

One in a Million – Concentration



Learner Outcomes:

- Apply and interpret measures of chemical concentration in parts per million, billion or trillion.

Key Terms:

Solute	Solution	Parts per million
Solvent	Concentration	

Background Information: The concentration of many chemicals in the environment is often very small however many environmental systems are sensitive to even the slightest changes in concentration. In order to quantify and relate small concentrations of substances, scientists often measure amounts in parts per million (PPM), or milligrams per liter (mg/L). Since 1 liter of water (the most common solvent in environmental systems) weighs 1 kilogram, we can also express parts per million in milligrams per Kilogram (mg/kg), or, 0.001 g / 1000g. This becomes 1/1000000 g, or one part in one million!

In this laboratory activity you will carry out a serial dilution which involves a series of dilution steps, each of the same size. This technique is frequently used by biologists and chemists to prepare a standard set of solutions with decreasing concentrations for an experiment.

Research Question: How can we observe parts per million?

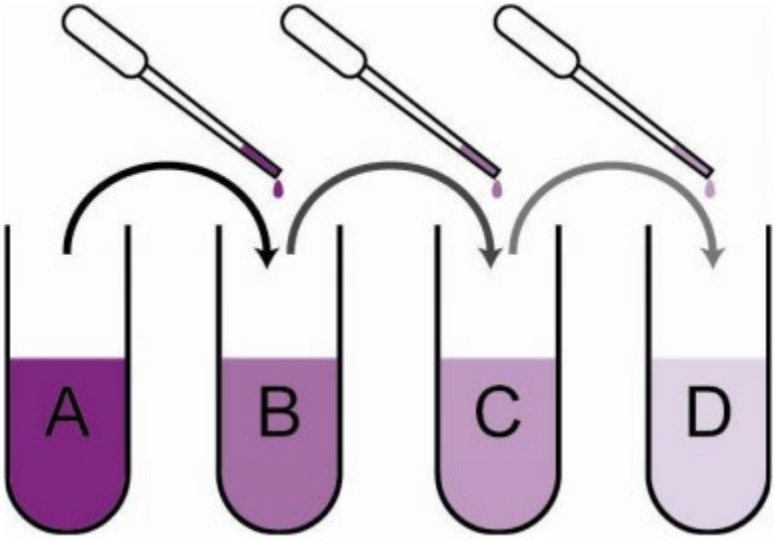
Materials:

Toothpicks	50 mL beaker	Eye dropper
Food coloring	Spot Plate	

This investigation / activity has been adapted from:
Mah K, Martha J, McClelland L, et al. *Science in Action 9.* Toronto, ON: Addison Wesley.

Procedure:

1. Decide on a system for numbering the wells from 1-10. You will have 2 wells left over.
2. Place 10 drops of food coloring into well #1. This food dye is already a 1/10 solution. The first column of the table is filled out for well #1, as an example.
3. Take one drop from well #1, transfer it to well #2, and return any extra to well. Rinse the dropper thoroughly.
4. Using a new dropper, add 9 drops of water to well #2 and stir the solution. Keep this dropper only for water.
5. This solution, in well #2, is now 1/10 of 1/10 or 1/100. Complete the table for this solution.
6. Continue the serial dilution by taking one drop from well #2 and placing it in well #3 then adding 9 drops of clean water (Don't forget to rinse the food coloring dropper).
7. Continue the serial dilution until all 10 wells are occupied and the table is complete.



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Observations:

Well	1	2	3	4	5	6	7	8	9	10
Fraction	1/10									
Decimal	0.1									
%	10%									
PPM	100,000									
Color	Dark									

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Analysis:

1. Which was the highest numbered well in which some color was visible? What is the concentration of food coloring in this well in ppm? In percent?

2. Does a lack of visible color in the remaining wells mean that no food coloring is present? Defend your answer.

3. Design a simple experiment to show that food coloring is still present in all the wells.

4. Which of the wells represents a concentration of 1 part per billion? How many times more concentrated is 5 ppm than 5 ppb?

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5. One formula for calculating parts per million is:

$$\text{Parts per million} = \frac{\text{grams of solute}}{\text{grams of solution}} \times 1\,000\,000$$

Show a correct numerical set up to demonstrate that a 4 mg/L concentration in water is equivalent to 4 ppm. You may use 1 g/mL as the density of water.

6. How many additional wells would you need to make a solution that was 1 part per trillion?

Extension:

1. An increase of one whole number on the pH scale represents a 10 times decrease in effective acid concentration. For example, an acid solution with a pH of 2 is 10 times less acidic than one with a pH of 1. How many times less acidic is an acid solution with a pH of 5 than one with a pH of 2?
2. To what total volume would you need to dilute 1 liter of a solution with a concentration of 20 ppm of a toxic substance to produce a solution with a concentration of 20 ppb?

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