What's a PPM? PPB?

Purpose: To understand the meaning of the terms "parts per million" and "parts per billion".

Materials:
- 1 bottle of food coloring
- 1 well tray
- 2 eye droppers
- 1 sheet of white paper
- paper towels
- water (about 20 mL)

Background: As you read the newspaper and listen to radio, TV and internet news, you often hear that "detectable amounts" of certain substances were found in groundwater, drinking water, in soil, or in human bloodstreams. Today, "detectable amounts" are much smaller than they once were. Not more than 200 years ago, "detectable amounts" were amounts that could be seen with the unaided eye or tasted. Through advancements in technology, scientists are now able to detect very tiny amounts of substances. Most substances can be measured in parts per million (ppm) and parts ber billion (ppb). Some substances can even be measured in parts per trillion (ppt).

The ability to measure substances in such minute amounts has allowed the Environmental Protection Agency (EPA) to set advisory levels for many substances. For example, it is advised that no more than 200 ppm of calcium and magnesium salts should be in drinking water. These salts are what determines the "hardness" of water, affect taste but not health, and may require that more detergent be added to wash clothes and dishes. Calcium and magnesium salts may also leave scaly deposits on water tanks and pipes.

Other advisory levels, such as the one set for 40 ppm of NO_3 (nitrates) in drinking water, are set for safety reasons. Nitrates are natural substances that come from animal and human waste, natural soil deposits, and fertilizers. High concentrations of nitrates in drinking water can cause potentially fatal illnesses in human infants and young farm animals. Nitrates in groundwater have recently been in the spotlight. Lots of research is being done to reduce the amount of nitrates that leach into groundwater.

Pesticide residues in water are also measured for safety reasons. Parts per million of quantities of a particular herbicide can kill fish: parts per billion of a particular herbicide can be tasted by humans. The screening of pesticide residues and control standards on pesticide safety have been very successful. Generally, 99% of the food analyzed for various residues meets the required standards. This screening ensures that the food we eat is safe to eat.

What do parts per million and parts per billion actually mean? These are difficult numbers to comprehend. The following activity will help you to gain a tangible feeling for the terms ppm and ppb.

Procedure:

1. Place a piece of white paper under the tray (if it is made of clear plastic).
2. Put one drop of food coloring into cup 1 and cup 2.
3. To cup 2, add nine back drops of water. Mix the solution by drawing it up into the dropper and carefully putting it into the cup. Be sure to squeeze the bulb before putting the dropper tip into the solution. *Why? And yes, you need to write out an answer.*
4. Using the dropper, transfer one drop of the solution in cup 2 to cup 3. Return any excess back to cup 2. Then add nine drops of water to cup 3. Use the dropper to mix the solution in cup 3 and then transfer one drop to cup 4. Return excess back to cup 3. *Again, why?*
5. Continue the process through cup 9, taking a drop of the solution from the previous cup and adding nine drops of water.
6. Record the color of the solution in each cup on data table.

7. Determine the concentration of the solution for each cup and record it on the data table. Example: Cup 1 – one drop out of 10 drops is food coloring, the concentration of food coloring is 1/10 or .1 or one part per ten.

Expectations - *This prompt will not be present in future lab sheets – it's just here now as a reminder to include this step!*

Data

Title?

Cup	Color	Concentration

Questions

1. What is the number of the cup in which the solution first appears colorless?
2. What is the concentration in parts of dye per parts of solution in this first colorless cup?

Analysis

1. Do you think that there is any of the colored solution in this cup (from "Questions" above) of diluted solution even though it is colorless? Explain.
2. Describe a situation in which this technique could be used to test for the presence of a substance.
3. Look at the chart below:

<u>1 ppm is equivalent to:</u>	<u>1 ppb is equivalent to:</u>
1 second in 11 days, 13 hours, and 46 minutes	1 second in 31 years, 41 weeks, 3 days
1 inch in 15.78 miles	1 inch in 15, 782 miles
1 hole in 55,555 rounds of golf	1 hole in 55,560,000, rounds of golf
6 people in the U.S.	6 people in the entire world

Which analogy above is the most meaningful to you? Why?

Conclusion – *Address your expectations. Did you find what you expected? Give reasons why/why not.*