



Objective: To develop an understanding of parts per million as a concept, teams of students will create successive dilutions of a solution to reach a parts-per-million concentration.

Warm Up: List what you think the atmosphere is made of.

Materials:

Each group will need the following:

- One eyedropper
- Water
- A graduated cylinder with 10-milliliter graduations
- Three 12-ounce clear plastic cups
- Masking tape
- Marking pen
- One bottle of food coloring (darker colors will work best)
- A calculator
- PPM Lab Worksheet



Background:

The atmosphere is a mixture of gases. Similarly, the world's oceans and fresh waters contain dissolved chemicals. Many substances dispersed in air or water are measured in parts per million. Some of these substances are colorless, odorless, and tasteless, yet even in small quantities they can be toxic.

Procedure: Before beginning the activity, put a piece of masking tape on each cup and label them "Sample 1," "Sample 2," and "Sample 3."

Sample 1

1. Put 99 drops of water in the graduated cylinder. Record the volume of this amount of water on your Lab Worksheet. (You will need this measurement later to avoid having to measure another 99 drops.) Pour the water from the 99 drops into the cup marked "Sample 1."

2. Add one drop of food coloring to sample 1. Stir the water. Record the color on your Lab Worksheet.
3. Answer the questions on the Lab Worksheet. You can use a calculator.

Sample 2

1. Pour an amount of water equal to 99 drops into the graduated cylinder. Pour this into the cup marked "Sample 2."
2. Add one drop of sample 1 to sample 2.
3. Stir and record the resulting color.
4. Answer the questions in the question section.

Sample 3

1. Pour an amount of water equal to 99 drops into the graduated cylinder. Pour this into the cup marked "Sample 3."
2. Add one drop of sample 2 to sample 3. Stir and record the color of the solution.

Students will then answer the Lab Worksheet Questions.

For the Teacher

Answers to the Questions in the Lesson

Sample 1: Because you have added one drop of food coloring to 99 drops of water, the concentration is one part per hundred, which can also be expressed as $1/100$ or 1 percent. A calculator can be used to visualize the answer. Divide 1 by 100. The answer is 0.01. The color should be visible.

Students might answer that filtering the water through a substance like sand or through paper might "clean" it, but filtering will not remove a chemical solution. The teacher might use this question as an opportunity to discuss the removal of CO_2 from the atmosphere. Just as no such simple process as filtering the water will remove food coloring, no simple process will remove excess CO_2 from the atmosphere. Reducing the amount of CO_2 emitted by human activity reduces the need to remove it later.

Sample 2: To 99 drops of new water, you add a drop of the solution from sample 1, which consists of .99 parts water and .01 part food coloring. Because you have now diluted the .01 drop of food coloring in a total of 100 drops of solution, divide .01 by 100 on the calculator. Your answer is .0001. This means you now have 1 part food coloring in ten thousand, or $1/10,000$. Depending on the color used, the food coloring in sample 2 should be faintly visible.

Sample 3: Again you have 99 drops of new water and one drop from the solution in sample 2. The one drop is .9999 parts water and .0001 parts food coloring. To calculate the concentration of food coloring in sample 3 divide .0001 by 100 (the total number of drops in the solution). The answer is

0.000001 or one part food coloring in one million (1/1,000,000). The food coloring will not be visible at this concentration.

Making a parts-per-billion sample: Continue the procedures described above. Begin with 99 new drops of water. Use one drop of the parts-per-million solution. You will get 0.00000001 parts food coloring or one part food coloring in one-hundred million (1/100,000,000). For the final step, take nine new drops of water and add to it one drop of the previous solution. This yields 0.000000001 or one part per billion.

Evaluation: Observation of lab work and understanding of parts-per-million in dilutions. Review of Lab Worksheet

Homework: Finish Parts-Per-Million Lab Worksheet



PPM LAB WORKSHEET

Name _____

Date _____



Record the color of Sample 1: _____



Record the color of Sample 2: _____

Record the color of Sample 3: _____

Answer the following questions:

1. What is the concentration of food coloring in sample 1? _____

2. Can you see the food coloring in sample 1? _____

3. Suppose the food coloring was a harmful substance, how would you "clean" the water? _____

4. What happened to the color of the water in sample 2? Describe and explain. _____

5. What is the concentration of food coloring in sample 2? _____

6. What is the concentration of food coloring in sample 3? _____

7. Can you see the food coloring in sample 3? _____

8. Explain why or why not. _____

9. How could a parts-per-billion solution be made? _____

