

Chapter 6. How Much is a Lot?

Lesson 2. Contaminant Concentration Measurements

Overview: We have seen in past lessons that water quality is really a matter of perspective. It is just how we look at the water and its intended use. The water quality issue is sometimes quite subjective. At those times, it is unclear, a matter of perspective and not easily expressed to others.

There are ways to describe and discuss water quality objectively. In those cases, the term, value or description is clear and definable to all observers. In this lesson, we will examine some objective ways to measure and talk about water quality.

Every human being, whether he or she knows it or not, has a concern for water quality. Occasionally, we need to speak with others about it. To ensure understanding when we do, we use standard terms, definitions and methods of measurements. Understanding these special terms makes water quality issues easier for us to understand.

Purpose: The objective of this activity is to help students understand the idea of concentration when it is expressed in the commonly used dimensions or units such as milligrams per liter (mg/L) or parts per million (ppm).

Ideas Taught: The concentration of a contaminant or constituent can be expressed in a variety of ways, most of which are in metric units and most of which are easy to understand and comprehend; the most common unit is either milligrams per liter (mg/L) or parts per million (ppm).

Materials Needed:

- 1 teaspoon measuring spoon
- 1 cup of sugar or a supply of sugar cubes
- Several clear plastic 2 liter pop bottles
- A supply of small drinking cups
- A supply of waterproof markers or tape and pens

Procedure:

Note: *One objective is to help students understand the idea of concentration when it is expressed in the commonly used dimensions or units (parts per million, parts per billion, and parts per trillion). Although these seem like very small values, most contaminants measure in only a few parts per million or parts per billion. There are*

many different ways to teach the idea of parts per million. Only one example appears here.

When the class begins, ask the students if they are familiar with the concentration or level at which many contaminants are found and measured in water. Although you might get many different answers, you are looking for answers like parts per million, parts per billion, milligrams per liter, and micrograms per liter. Ask the students if they can give you an example of something that would help illustrate a concentration of 10 parts per million. Give the students a couple minutes to work out some examples.

Here is one example you might use. Ask the students how much pop would you have if you had one million cans of pop. One can of pop equals 12 oz., so one million cans equal 12 million oz. A gallon is 128 oz. So, one million cans of pop would be equal to 93,750 gallons of pop, which would be equal to 1,705 55-gallon drums. That much pop would fill a swimming pool 30' wide x 40' long x 10' deep. Imagine having a swimming pool full of orange pop. Mentally take out a volume equal to 24 cans of pop. Add one case (24 cans) of ginger ale. Would you be able to taste, smell, or see the ginger ale? That is an example of 24 parts per million. You would have 24 cans of ginger ale in one million cans of orange pop.

Listen to and list on the board other examples the students might work out. Explain that concentrations of only a few parts per million or only a few parts per billion of some contaminants make water unsafe to drink. For instance, the acceptable limits for some commonly found contaminants are (you might want to list these on the board):

| | |
|------------------|-----------------------|
| Nitrate-nitrogen | 10 parts per million |
| Lead | 15 parts per billion |
| Arsenic | 15 parts per billion |
| Sodium | 250 parts per million |

Explain that it is generally more convenient to talk about concentration in metric units (such as milligrams per liter) than in English units. Tell the class that:

- 1 part per million is equal to one milligram per liter

Ask the class if anyone knows why this is true and if they can explain it. The answer is like this:

- 1 liter of water is equal to 1000 milliliters
- 1 milliliter of water is equal to 1 gram of water
- 1 gram of water is equal to 1,000 milligrams of water

Therefore, $1,000 \text{ milligrams/gram} \times 1,000 \text{ grams per liter} = 1 \text{ million milligrams per liter}$. One milligram in 1 liter of water is the same as 1 milligram in 1 million milligrams of water. This makes 1 milligram per liter the same as 1 milligram per 1 million milligrams, or 1 part per million. Therefore, if you have 20 parts per million of sodium in water, you also have 20 milligrams of sodium per liter of water.

Illustrate this idea with some sugar and water. Provide each team a 2-liter pop bottle and several sugar cubes. (If you do not have sugar cubes, one level teaspoon is "the same as one sugar cube.") Tell them that a single sugar cube weighs about 3 grams, which is about the same as one level teaspoon. Therefore, one sugar cube (or one teaspoon of sugar) is equal to about 3,000 milligrams. Have the students dissolve five sugar cubes or five teaspoons of sugar in two liters of water. Ask them what they think the concentration of sugar is in the bottle and whether they can taste it, but do not let them taste it. The concentration will be about 15,000 milligrams per two liters or about 7,500 milligrams per liter (7,500 parts per million). Have them pour a small amount of the water into a couple plastic drinking cups and mark each cup as 7,500 ppm. Now have them pour half the bottle of water down the drain and refill the half full bottle with water. The concentration in the bottle will now be about 3,750 parts per million. Have them pour a small amount of this water into a couple plastic cups and mark each cup as 3,750 parts per million. Again pour half the bottle down the drain and refill the bottle. The concentration will now be about 1,900 parts per million. Have them pour a small amount of this water into a couple plastic cups and mark each cup as 1,900 parts per million. Repeat this process three more times, marking the cups as 940 parts per million, 470 parts per million, and 230 parts per million. When they finish, they should have cups marked as 230, 470, 940, 1,900, 3,750 and 7,500 parts per million. Fill a couple of the remaining cups with plain water.

Now the fun begins. Tell the class that they are going to take a taste test. They will see how well and at what concentration they can detect the sugar in water. Have all team members but one close their eyes. The member with his/her eyes open provides the taste samples to the others. They can provide them in any order. Have the tasters tell when they can taste the sugar, or guess at the concentrations. Have the teams keep track of their results. When everyone has had a chance to take the test, compare results. Ask them if they now understand parts per million and milligrams per liter. At what level of concentration of sugar can we begin to taste the sugar?

Lessons Learned: Concentration of a contaminant or constituent can be expressed in a variety of ways, most of which are in metric units and most of which are easy

to understand and comprehend; the most common unit is either milligrams per liter (mg/L) or parts per million (ppm).

The lesson above was adapted from "What is Water Quality? A Resource Guide for 4-H Leaders and Teachers," 80 pages of activities and experiments related to water quality. (\$5.00) Order from the Montana 4-H Program at Montana State University-Bozeman. Phone 406-994-3501.