Parts Per Million

Adapted from: "Reaching Your Limits" in Project WET: Curriculum & Activity Guide. Bozeman: The Watercourse and the Council for Environmental Education, 1995.

Grade Level: basic

Duration: 20 minutes

Setting: classroom or laboratory

Summary: Students observe demonstrations about how much one part per million (ppm) is.

Objectives: Students will examine water quality standards, concentrations, dilution, and understand the concept of parts per million and milligrams per liter.

Related Module Resources:
- HANDBOOK for Water Quality Analysis of W.PA Waterways
- FIELD MANUAL for Water Quality Monitoring

Vocabulary: ppm (parts per million), dilution

Materials (Included in Module):
- blue or green food coloring
- 1 part per thousand (ppt) visual aid sheet
- measuring cup
- cups
- Visual aid handout of 1,000 circles and 50,000 circles (to demonstrate how much ppt and ppm is).

Additional Materials (NOT Included in Module):
- 100 or 250 ml beakers
- 10 ml graduated cylinders or pipettes

ACADEMIC STANDARDS (ENVIRONMENT AND ECOLOGY)

12th Grade
4.1.C Analyze the parameters of a watershed.
- Interpret physical, chemical and biological data as a means of assessing the environmental quality of a watershed

BACKGROUND:

Many organizations like Creek Connections monitor water quality. For example, the U.S. Environmental Protection Agency (EPA) and many state protection agencies monitor water quality to maintain safe drinking water. Water quality is also important for healthy ecosystems so that fish and frogs and blue herons can thrive. Often water quality is measured by the presence or absence of chemicals in the water.

Animals and plants that live in aquatic ecosystems can only survive under certain chemical levels. In other words, they have a range of tolerance when they are most healthy. Changes above or below the tolerance levels cause the plants and animals to move or simply die out. With this concept in mind, standards have been developed to identify water bodies that have improper chemical levels or contain dangerous levels of toxins.

Chemicals dissolved in the water are found in concentrations. A certain amount of the chemical is mixed with a certain amount of water and it can be recorded with the units milligrams per liter (mg/L). For instance, the average concentration of alkalinity in French Creek is 70 mg/L. This indicates there are 70mg of carbonate and bicarbonate in every liter of water tested.

Another popular way of recording the concentration of chemicals in the water is called **parts per million (ppm).** *Surprise, milligrams per liter (mg/L) is the same amount as ppm!* When dealing with substances that have the same density as water – the two are the same amount.

Just like mg/L, parts per million is a ratio. Using the alkalinity example, 70ppm would indicate there are 70 units of alkalinity in every million units tested. This is the same as 70 particles within one million particles. In fractional form, it would look like this:

$$\frac{70}{1{,}000{,}000}$$

To indicate even smaller concentrations, scientists use parts per billion (ppb) and parts per trillion. Parts per billion is more diluted than parts per million. **Dilution** means to lessen the concentration of a mixture (chemical perhaps) by adding more water – reducing the strength or visual evidence (color perhaps) of the mixture.

Although these amounts may seem like extremely small concentrations, the toxicity of many chemicals can cause health or habitat problems at these low amounts. People can smell petroleum products in water at concentrations as low as 10 parts per billion. A total phosphorus level of just 0.1 ppm can cause excessive algae growth to occur in a pond or lake. A total residual chlorine level of 0.06 mg/L is toxic to striped bass larva.

Many of the chemicals tested in a basic water chemistry monitoring program (total dissolved solids, dissolved oxygen, nitrates, phosphates, alkalinity, iron) are either measured in parts per million (ppm) or milligrams per liter (mg/L). The preference between ppm and mg/L is usually left up to the water testing agency or scientist. We encourage using mg/L for Creek Connection sampling.

OVERVIEW: Students observe a dilution demonstration to understand the concept of parts per million. Students may also observe a paper visual aid demonstration to reinforce the concept. Parts per million should be reviewed with Creek Connections sampling as a context. Students will also see that mg/L is interchangeable with ppm.

PROCEDURE – For Dilution Demonstration

1. Show students a glass of water. Ask how they know the water is safe to drink. Have the students list things they would like to know about the water before they drink it. Why would they drink water from a faucet, but not from a local stream?

NOTE: For simplicity, only metric measurements are used in the following directions.

2. In a beaker, carefully measure out 100ml of water mixed with blue or green food coloring. Tell students that this represents a chemical or pollutant. Ask them if they would like to drink it.

3. Take 10 ml of the chemical/pollutant and put it into 90 ml of clear water. Calculate the concentration *(1 part per 10*). Would they drink it?

4. Take 10 ml of this diluted solution and put it in 90 ml of clear water. What is the concentration of the chemical/pollutant? *(1 part per 100).* Is a shade of color even detectable? Would they drink the water now?

5. Dilute the chemical/pollutant one more time, 10ml to 90 ml of clear water. What is the concentration now? *(1 part per 1,000).* Tell them this measurement is known as parts per thousand (ppt). Any color shade?

6. Repeat three more time until you reach parts per million (ppm). Would they drink the water with the chemical/pollutant now? Parts per million (ppm) is often used to describe the concentration chemical parameters in waterways. Remember, milligrams per liter (mg/L) is used interchangeably with ppm.

7. Have students review the enclosed fact sheet on Water Quality Standards for Drinking Water. These indicate how much (usually in ppm) of a contaminant is allowed in our drinking water. Have students notice that in some cases, there is to be less than 1 mg/L of contaminant in the water.

8. Remind students that although dilution is a method of reducing the concentration of a chemical/pollutant within a sample, to ensure water is safe to drink, other forms of treatment are necessary.

PROCEDURE – For Paper Visual Aid Demonstration

1. Find the visual aids sheets with many circles on them at the end of this activity. There is a visual aid sheet with 1,000 circles on it that can allow you to demonstrate parts per thousand (ppt). There is also a visual aid sheet with approximately 50,000 circles on it (very small circles). Making 20 copies of this latter sheet will give you 1 million circles, thus allowing you to demonstrate parts per million (ppm).

2. To demonstrate to the class how much 1 ppt is, use a colored pen to color in one circle on the 1,000 circle sheet.

3. To demonstrate to the class how much 1 ppm is, use a colored pen to color in **one** circle of the 1,000,000 circles (20 sheets). Remember, milligrams per liter (mg/L) is used interchangeably with ppm.

4. Have students review the enclosed fact sheet on Water Quality Standards for Drinking Water. These indicate how much (usually in ppm) of a contaminant is allowed in our drinking water. Have students notice that in some cases, there is to be less than 1 mg/L of contaminant in the water.

DISCUSSION:

Discuss with the students how their concept of parts per million has changed. Does it seem bigger or smaller than they imagined? Did they know that such small amounts are detectable? Did they realize that the food coloring (possibly representing a toxic chemical) may be allowed in their drinking water – but only after much dilution (which creates the parts per million amounts).

EVALUATION:

- Explain the concept of parts per million.
- Why is mg/L and ppm the same?
- Have students conduct the demonstration as a peer presentation.

EXTENSIONS AND MODIFICATIONS:

- Have the students explain how to make a solution with 1 part per billion of the pollutant chemical.
- Continue the demonstration until ppb is reached.
- Have students research the environmental standards for the amounts certain pollutants are allowed to be in drinking water (most are in the ppm and ppb ranges).

NOTES (TEACHERS, PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):

Activity Version: November,2021

Visual Aid: Parts Per Million

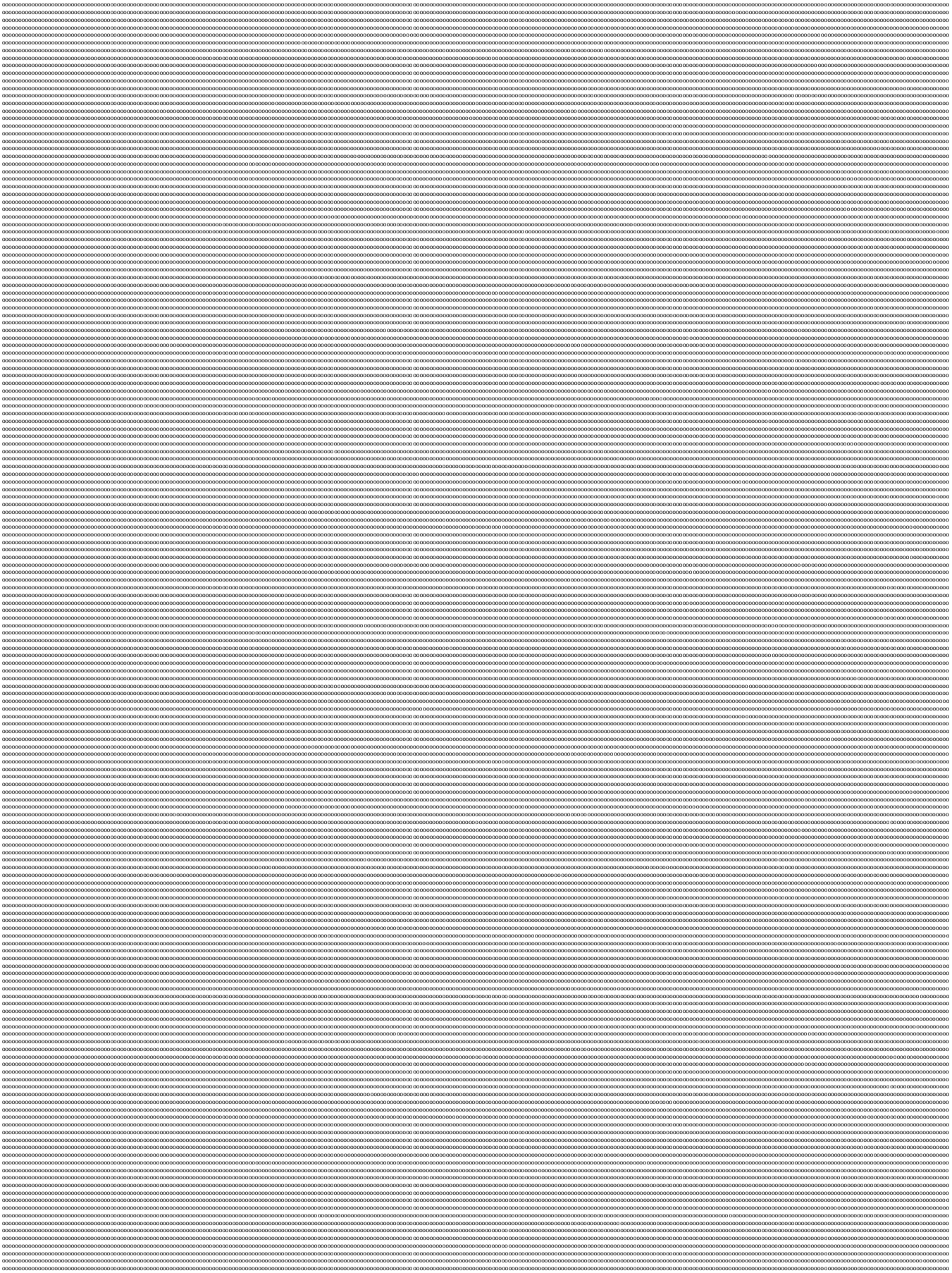
The other side of this sheet contains almost **50,000 circles**.

It would take **20** copies of this sheet to have **1,000,000** (one million) circles.

You could then demonstrate how much
1 ppm (parts per million) or 1 mg/L is by coloring in just 1 circle of the 1,000,000.

ALSO include for this activity:

Sheet of 1,000 circles
Sheet of ~50,000 circles
Drinking Water Facts – Water Quality Standards Fact Sheet



1 ppt (part per thousand)

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The box above contains 1,000 circles.
To have 1,000,000 (one million) circles, you would need 1,000 copies of this sheet.
Then you could demonstrate 1 ppm (part per million) or 1 mg/L