

# 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 watch a demonstration about how much one part per million is.

**Objectives:** Students will understand the concept of parts per million.

**Related Module Resources:**

- Books, for students to research water quality amounts permissible

**Vocabulary:** ppm (parts per million), dilution

**Materials (Included in Module):**

- Visual aid handout of 1,000 circles and 50,000 circles (to demonstrate how much ppt and ppm is).
- blue or green food coloring [B-3]
- 1 – 25mL graduated cylinder [B-3]
- 1 part per thousand (ppt) visual aid sheet [enclosed]

**Additional Materials (NOT Included in Module):**

- 100 or 250 ml beakers
- additional 10 ml graduated cylinder or pipette

**ACADEMIC STANDARDS:**

12<sup>th</sup> 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:** Scientist measure and report water chemicals and contaminants in **parts per million (ppm)**, parts per billion (ppb), and parts per trillion (ppt). Parts per million is how many particles, pieces, or whatever you are looking at out of a total of one million particles, pieces, or whatever you are looking at. Although these may seem extremely small concentrations, the toxicity of many chemicals can cause health problems at these low amounts. People can smell petroleum products in water at concentrations as low as 10 parts per billion.

Parts per billion is more diluted than parts per million. **Dilution** means to lesson the concentration of a mixture (chemical perhaps) by adding more water – reducing the strength or visual evidence (color perhaps) of the mixture.

Many of the chemicals tested in a basic water chemistry monitoring program (total dissolved solids, dissolved oxygen, nitrate, phosphorus, alkalinity, sulfate and ferrous iron) are either measured in parts per million (ppm) or milligrams per liter (mg/L). *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.

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 demonstration of a dilution to understand the concept of parts per million.

**PROCEDURE** – For Dilution Demonstration

1. Show students a glass of water. Ask how they know the water is safe to drink. Have students list things they would like to know about the water before they drink it. Why would they drink water from a faucet, but probably not from a mountain 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? What if they were thirsty?
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? What if they were in the desert?
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 amount of many of the chemical parameters that we test our creeks for. 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 On 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.

**EXTENSIONS AND MODIFICATIONS:**

- Have the students explain how to make a solution with 1 part per billion of the pollutant chemical.
- 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):**

## Visual Aid for PARTS PER MILLION ACTIVITY

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.



1 ppt (part per thousand)



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