

## PARTS PER MILLION

The effects of any toxic substance are related to the amount of exposure, also known as the dose. The greater the dose the more severe the effects. Some chemicals can cause toxicity at very low doses. It is especially important to understand how low doses compare to one another.

**Parts per million (ppm), parts per billion (ppb), and parts per trillion (ppt)**, are the most commonly used terms to describe very small amounts of contaminants in our environment.

Scientists often measure very small concentrations in units called parts per million, abbreviated as **ppm**. For example, 1 ppm of a chemical in water means that, in a million units of water, there would only be one unit of the chemical. Many water pollution standards are written in these units.

They are measures of **concentration**, the amount of one material in a larger amount of another material.

They are expressed as concentrations rather than total amounts so we can easily compare a variety of different environmental situations. For example, scientists can measure the concentration of a chemical in the Great Lakes by looking at small samples. They do not have to measure the total amount of chemicals or water in all of the lakes.

By dividing a pie equally into 10 pieces, each piece would be **1 part per 10**, or, one-tenth of the total pie. Now cut this pie into 1,000,000 pieces, each piece would be **1 part per 1,000,000**, or, one millionth of the total pie.

1 kilogram (kg) = 1 million milligrams (mg)  
so: 1 mg/kg = 1 part per million

1 liter (l) of water weighs exactly 1 kg  
so: 1 mg/l = 1 part per million

The maximum level of PCBs legally allowed in fish sold is 2 ppm (parts per million). Although there are no legally established levels for PCBs in drinking water, measurements have shown that the average PCB content of the Great Lakes drinking water is about 4 ppt (parts per trillion).

1 milligram per litre	= 1 ppm
1 microlitre ( $\mu\text{L}$ ) per litre	= 1 ppm
0.001 gram per litre	= 1 ppm

### Some Interesting Comparisons

<p>A part per <b>million</b> is equal to:</p> <ul style="list-style-type: none"> <li>one penny in \$10,000</li> <li>one second in 12 days of your life</li> <li>one minute in two years</li> <li>one second in 32 years of your life</li> <li>one dime in a one-mile-high stack of pennies</li> <li>one pinch of salt on 20 pounds of potato chips!</li> <li>one inch out of a journey of 16 miles!</li> <li>one bogey in 3,500 golf matches!</li> <li>one bad apple in 2,000 barrels!</li> </ul>	<p>A part per <b>billion</b> is equal to:</p> <ul style="list-style-type: none"> <li>one penny in \$10,000,000</li> <li>one pinch of salt in 10 tons of potato chips</li> <li>one second in 32 years</li> <li>one inch out of a journey of 16,000 miles!</li> <li>one bogey in 3,500,000 golf matches!</li> <li>one bad apple in 2,000,000 barrels!</li> </ul>
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Most fish need at least 4 ppm of dissolved oxygen to survive, some species like trout need much more.

**Pre-Lab Questions**

What is **concentration**?

*The amount of substance contained in a given quantity of the solution or mixture. (If a food coloring solution has a concentration of 10%, then 100 parts of a solution will contain 10 parts of food coloring).*

What is **dilution**?

*To reduce the concentration by adding water or other liquids. (the solution in cup 4 of the parts per million activity is more dilute than the solution in cups 1, 2, and 3 because more water has been added)*

If you have 10% solution of food coloring, how many parts are water and how many parts are food coloring?

*1 part is water, 9 parts are food coloring ~ 1 part + 9 parts = 10 or 100%*

**Try This! Visualizing Activity**

You will need a sheet of 8 1/2 x 11-inch paper and a pen or pencil.

Calculate how many square centimeters are in the sheet of paper

Mark off one square centimeter. Based on your calculation above, how many of these square centimeters would fit on one sheet of paper?

How many sheets of paper would you need to make your little square be one part per million? (

*One sheet of 8 1/2 x 11-inch paper is 603.2 square centimeters. So you could fit just over 603 little squares on a single sheet. To make that little square be one part per million, you would need 1657 sheets of paper. To make that little square be one part per billion, you would need 1,657,000 sheets of paper!*

How big is a drop?

Take an eyedropper that is marked in milliliters and fill it with exactly 2 milliliters of water. Now squeeze the bulb slowly, drop by drop, counting exactly how many drops come out as you bring the level to 1 milliliter. How many did you count? Have 10 different students try this. Do they all get the same answer? If not, how far apart are the numbers? What might account for the differences? What is the average number of drops per milliliter?

20 drops/milliliter = 20,000 drops/liter = 1,000,000 drops / 50 liters.

That means one part per million is the same as one drop of a substance in a million drops, or 50 liters, of water.

A bathtub holds about 228 liters of water

7 or 8 drops of food coloring in a full bathtub of water would bring it to a concentration of one part per million.

How much toxin can destroy a population?

EPA concentrations represent mg/l. A milligram is 1/1000 of a gram, and there are 1000 ml in a liter. Since water is the solvent we are considering, and one liter of water has a mass of 1000 grams (density of water is 1 g/ml), we can calculate 1 mg/l to equal 1 ppm

**Information and Inquiry**

Lethal concentrations of common heavy metals and salt. Compiled from 1996 EPA quotations.

MERCURY	0.0005 mg/l
SILVER	0.005 mg/l
IRON	1.0 mg/l
NaCl (Salt)	200.0 mg/l

Does a dissolved toxin ever disappear? Completely?

Is dilution the solution to pollution? Be specific. If we just keep adding water to toxins, will the organisms be safe?

What are the **ppm concentrations** of the following? ( *SHOW YOUR WORK* )

0.45 ml of solute in 2 L of solvent

2 ml of solute in 1000 ml of solvent

0.0009 ml of solute in 100 ml of solvent

0.62 ml of solute in 10,000 ml of solvent

2 ml of solute in 1000 ml of solvent

0.03 ml of solute in 1000 ml of solvent

0.05 ml of solute in 1L of solvent