

What is the Significance of a Part Per Million?¹

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The health effects of toxic substances are related to their doses—the amount of exposure to the toxic substance. The greater the dose, the more likely it is to affect our health, but some chemicals can cause toxicity even at very small doses. Therefore, it's very important to understand how doses are described, how they relate to one another, and what these doses represent when compared to other substances were exposed to every day.

Most of the toxic substances that people are exposed to don't appear in their pure forms, but are suspended in some other (usually larger) substance—air, water, food, etc. The amount of a toxin contained in a given substance is known as its concentration, which is most often measured in parts per million (ppm), parts per billion (ppb), or parts per trillion (ppt). Think of these concentration measures as being like a percentage—just as 1 percent is one part of a hundred, 1 ppm is one part of one million. Concentrations are expressed in this manner so that consistent comparisons can be made among the many substances that undergo toxicity testing. For example, a scientist who wants to evaluate the concentration of a chemical in Lake Okeechobee can do so using small samples, rather than draining the entire lake. To put the concentration of the chemical that he finds in his small sample into a relative term that can be

compared with the lake's total volume, he may use ppm. If he detects 1 ppm, then this would be equal to one ounce of the chemical per 1 million ounces (7,812.5 gallons) of Lake Okeechobee's water.

In most laboratory animal toxicity studies, these concentrations are measured in metric units, because metric units are in increments of 10, and so are easier to express. For example, a milligram (mg) is 1/1,000 of a gram and a gram is a 1/1,000 of a kilogram (kg); it takes a million milligrams to make up a kilogram, therefore one ppm is equivalent to one mg/kg. A common toxicological measurement, LD₅₀, is most often measured in mg/kg of body weight. Furthermore, regulatory measures for levels of certain substances require measurements made in the ppb or ppt range of concentrations. For example, the element silver is acutely toxic to aquatic organisms at extremely low concentrations. Because of these concerns, the Florida Department of Environmental Protection has set a class III water quality criterion of <0.07 ppb for silver. If it is desired to report in ppb, then the microgram, or µg, is used, since there are 1,000 µg in one mg and 1,000 mg in one g. In expressing ppt the nanogram, ng, is used, as there are 1,000,000 ng in one mg. Table 1 provides a summary of these measurements with their units and ratios.

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The liter (L) is the common unit used with liquids and gases, since 1 liter of water weighs 1 kg. Therefore 1 ppm is equivalent to 1 mg/L; 1 ppb would equal 1 µg/L, and 1 ppt is 1 ng/L. As an example, one kg (2.2 lbs) of material in 1,000 metric tons (2.2 million lbs.) would be equivalent to 1 ppm., since there are 1,000 kg in one metric ton.

In discussing doses in terms of ppm, ppb and ppt, we are of course talking about very small amounts compared with substances in which they're suspended. It might be easier to put these miniscule amounts into perspective by using analogies to more common measurements (Table 2).

A Real Case Using a Pesticide

A real case will demonstrate how these quantities can be used to compare the relative importance of substances found on raw food products and drinking water. This example will use chlordane, the former commonly-applied insecticide, in drinking water. Because of environmental concerns, chlordane was banned for use during the 1980s, but because of its long half-life and the patterns in which it was used, it is still detected on occasion. The maximum level of chlordane allowed in drinking water is 0.002 mg/L (0.002 ppm or 2 ppb) – a set standard that is considered safe for drinking on a regular basis. A variety of organic pesticides and other substances are carefully monitored throughout the state's sources of drinking water and these substances each have their own standard allowable concentrations.

Allowable contaminant concentrations are determined through a process called *risk assessment*. In this process, models are used to determine lifetime exposures to the contaminants, mostly through ingestion. Laboratory tests that examine the effects of the contaminant are used to determine endpoints, such as the concentration which does not affect the test subject in any manner. After often adding a 100-fold safety factor to the concentration which causes no concern, the amount of material that can be safely consumed is back-calculated. In the majority of instances, the amount of contaminant that is ingested over a lifetime is much less than the concentration known to cause effects. When this is not the case, regulatory actions serve to control the release of the

materials and/or reduce the chance of exposure to them if they are released.

Measuring substances consistently provides a means by which comparisons may be made with any food commodity and allows for establishment of safe consumption standards. The vast majority of the states carefully monitored drinking water sources have no pesticide detections and are safe for consumption.

Additional Information

American Water Works Association. 2005. Parts Per million? <http://www.awwa.org/index.cfm>. Visited: October 2005.

Extension Toxicology Network (EXTOXNET). 1993. How much is a part per million? Oregon State University. <http://extoxnet.orst.edu/tibs/partperm.htm>. Visited: October 2005.

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Table 1. Summary of measurements.

Unit	Measurement	Ratio
1 mg/kg	1 P.P.M. (part per million)	1/1,000,000
1 µg/kg	1 P.P.B. (part per billion)	1/1,000,000,000
1 ng/kg	1 P.P.T. (part per trillion)	1/1,000,000,000,000

Table 2. Analogies demonstrating small amounts.

1 P.P.M.	1 P.P.B.	1 P.P.T.
1 second in 11.5 days	1 second in 31.7 years	1 second in 317.1 centuries
1 penny out of \$10,000	1 penny of \$10,000,000	1 penny of \$10,000,000,000
1 inch of 15.8 miles	1 inch of 15,782.8 miles	1 inch of 657.6 trips around the equator
1 minute in 1.9 years	1 minute in 19 centuries	1 minute in 1,900 millenniums
1 ounce in 62,500 pounds	1 ounce in 31,250 tons	1 ounce in 31,250,000 tons