



## How Much Is A Part Per Million?

The health 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 and so it is important to be able to understand how these very small amounts are described. It is especially important to understand how low doses compare to one another and what they represent when compared to amounts of more familiar substances.

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. But what do these terms represent? They are measures of concentration, the amount of one material within a larger amount of another material; e.g., the weight of a toxic chemical in a certain weight of food. 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. An example might help illustrate the part per ... idea. If you divide a pie equally into 10 pieces, then each piece would be a part per ten; i.e., one-tenth of the total pie. If, instead, you cut this pie into a million pieces, then each piece would be very small and would represent a millionth of the total pie or one part per million of the original pie. If you cut each of these million minute pieces into a thousand little pieces, then each of these new pieces would be one part per billion of the original pie. To give you an idea of how little this would be, a pinch of salt in ten tons of potato chips is also one part (salt) per billion (parts chips).

In this example, the pieces of the pie were made up of the same material as the whole. However, if there was a contaminant in the pie at a level of a part per billion, one of these invisible pieces of pie would be made up of the contaminant and the other 999,999,999 pieces would be pure pie. Similarly, one part per billion of an impurity in water represents a tiny fraction of the total amount of water. One part per billion is the equivalent of one drop of impurity in 500 barrels of water.

### Comparisons and Conversions

Sometimes, instead of using the part per ... terminology, concentrations are reported in weight units; such as the weight of the impurity compared to the weight of the total. The metric system is the most convenient way to express this since metric units go by steps of ten, hundred and thousand. For example, a milligram is a thousandth of a gram and a gram is a thousandth of a kilogram. Thus, a milligram is a thousandth of a thousandth, or a millionth of a kilogram. A milligram is one part per million of a kilogram thus, one part per million (ppm) is the **same** as one milligram per kilogram. Just as part per million is abbreviated as ppm, a milligram per kilogram has its own abbreviation -- mg/kg. Using our abbreviations, one ppm equals one mg/kg.

Kilograms and milligrams are units of weight so they don't apply to volumes of liquids or gases. Instead of a kilogram, the unit of liquid volume most commonly used is the liter. A liter of water weighs one kilogram. If the contaminant is a solid, it is measured in milligrams. Thus, one part per million of a solid in a liquid can be written as a milligram per liter and abbreviated mg/l.

These are the most common units that are encountered. However, with the ability to detect even smaller amounts of contaminants, the terms, part per billion and part per trillion are becoming more common. In the metric weight system, a microgram is a thousandth of a milligram. Since a milligram is a millionth of a kilogram, and the microgram is a thousand times smaller, it is equivalent to a billionth of a kilogram. Microgram is abbreviated ug. Thus, a part per billion of solid measure is equal to a ug/kg. Similarly, a part per billion of a solid in a liquid is equal to a ug/l.

## **Part Per Million**

### **Page 2**

Before going on to discuss a real example of how these measurements are used, we can compare metric weight quantities to the quantities we are most accustomed to using. A kilogram is equal to about two pounds. Thus, a milligram is less than a millionth of a pound. Looked at another way, it would take about five thousand milligrams (5000 mg) to make up one teaspoonful of a solid (such as salt). The unit of liquid volume, the liter, is very close to a quart. Thus, a milligram per liter is about the same as a milligram per quart.

### **The Case of PCBs: An Example**

In order to appreciate how these quantities can be used in a real situation, an example is in order. In this example, we use the part per... terminology to compare the relative importance of PCBs in Great Lakes fish versus PCBs in Great Lakes drinking water; that is, which source might contribute most to PCBs exposure of humans living in the Great Lakes states. The maximum level of PCBs legally allowed in fish sold in interstate commerce 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).

Since a part per trillion is a million times less than one part per million, the maximum allowable concentration of PCBs in fish is about a million times higher than the level of PCBs in drinking water. However, we generally consume a lot more water than fish. At the extreme, people might eat as much as a pound of fish a day or as little as one pound every 100 days (1/100 lb/day). On the other hand, people generally drink about 2 liters (equivalent to about 5 pounds) of water a day. Thus, the consumption of water might range from about 5 to five hundred times the consumption of fish. However, since there are a million times more PCBs in a pound of fish compared to a pound of water, fish can be a much greater source of PCBs than drinking water. The total amount of PCBs consumed depends most on the amount of fish eaten, how contaminated it is, and how it is prepared. Thus, the best way to reduce human exposure to PCBs is to reduce the levels in fish, reduce human consumption of fish with the highest contaminant levels and prepare the consumed fish in the most appropriate manner.

### **Conclusion**

The ability to measure concentrations of chemicals in a uniform manner provides a powerful tool for the comparison of water quality from area to area, for the establishment of water quality guidelines or a comparison of doses of chemicals commonly found in reference works about pesticides. The use of the metric system provides an easy way to understand both liquid and solid measurements.

### **Metric System Quantities**

#### ***For Solids***

1 kilogram (kg) = 1 million milligrams (mg)

so: 1 mg/kg = 1 part per million

1 kilogram (kg) = 1 billion micrograms (ug)

so: 1 ug/kg = 1 part per billion

#### ***For Liquids***

1 liter (l) of water weighs exactly 1 kg

so: 1 mg/l = 1 part per million and

1 ug/l = 1 part per billion

1 kg = about 2.2 pounds

1 l = about 1 quart