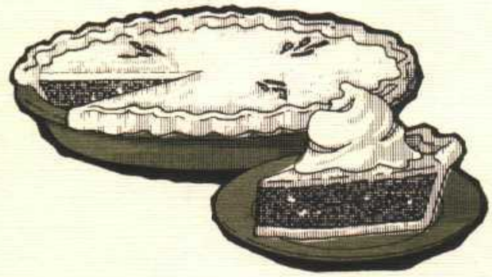
HOW MUCH IS A PART PER MILLION?

Michael Kamrin
Center for Environmental Toxicology
Michigan State University

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. Since some chemicals can cause toxicity at very low doses, it is important to be able to understand how these very small amounts are described. It is especially important to understand how these very low levels compare to one another and what they represent when compared to amounts of more familiar substances.

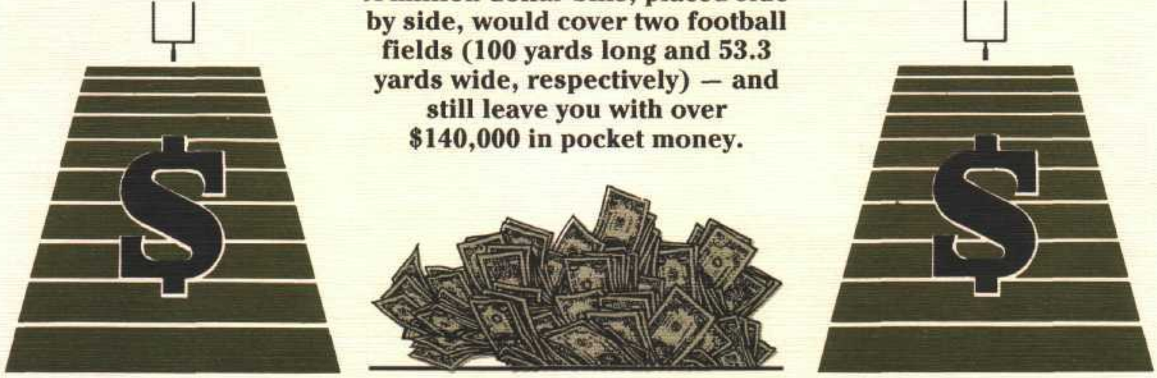
Part per million (ppm), part per billion (ppb), and part per trillion (ppt) are the most commonly used terms to describe very small amounts of contaminants in our environment. What do these terms represent? They are measures of concentration the amount of one material in a larger amount of another material, ex., the weight of a toxic chemical in a large weight of food.

They are expressed as concentrations rather than 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 you to understand the "part per . . . " idea. If you divide a pie equally into 10 pieces, each piece would be a part-per-ten; i.e., one-tenth of the total pie. If you cut this pie into a million pieces, each piece would be very small and would represent a millionth, or part per million, of the original pie. If you cut each of the million minute pieces into a thousand little pieces, each of these new pieces would be a part per billion of the original pie. To give you an idea of how little this

A million dollar bills, placed side by side, would cover two football fields (100 yards long and 53.3 yards wide, respectively) — and still leave you with over $140,000 in pocket money.



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would be, a pinch of salt in 10 tons of potato chips is also a part per billion. Thus, a part per billion of the pie would be invisible to you.

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 final 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.

Since a trillion is 1,000 times larger than a billion, a part per trillion (ppt) is 1,000 times smaller (one drop of impurity in 500,000 barrels of water).

In order to appreciate how these quantities can be used in a real situation, look at the following example.

We'll use the "part per . . . " terminology to compare the relative importance of PCBs in Great Lakes fish vs. PCBs in Great Lakes drinking water; i.e., which source might contribute most to PCB exposure of humans living in the Great Lakes region.

The maximum level of PCBs legally allowed in fish sold in interstate commerce is 2 ppm. 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 4 ppt.

Since we know that a part per trillion is a million times less than a part per million, we can see that the maximum allowable concentration of PCBs in fish is about a million times higher than the level of PCBs in drinking water. However, people generally consume a lot more water than fish about 100 times as much water as fish, on the average.

By comparing amounts of fish and water consumed and PCB level in each, it is clear that fish can be a much greater source of PCBs than drinking water. We can also see that the total amount of PCBs consumed is most dependent on the amount of fish eaten and how contaminated it is. Thus, the best way to reduce human exposure to PCBs is to reduce the levels in fish and reduce human consumption of fish with the highest contaminant levels.

PPM AND THE METRIC SYSTEM

Sometimes, instead of using the "part per . . . " terminology, concentrations are reported in weight units 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 10, 100 and 1,000. For example, a kilogram is 1,000 grams and a gram is 1,000 milligrams. Thus, a milligram is a thousandth of a thousandth, or a millionth of a kilogram. It follows, then, that a milligram is a part per million of a kilogram; i.e., 1 part per million is the same as 1 milligram per kilogram. Just as part per million is abbreviated as ppm, milligram per kilogram has its own abbreviation – mg/kg. Using these abbreviations, 1 ppm equals 1 mg/kg (see Table 1).

These are the most common units that you will encounter. However, with our increasing ability to detect even smaller amounts of contaminants, you may encounter the terms "part per billion" and "part per trillion" more often. In the metric weight measure systems, a microgram is a thousandth of a milligram. Since a milligram is a millionth of a kilogram and the microgram is 1,000 times smaller, it is equivalent to a billionth of a kilogram. The abbreviation for microgram is 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.

TABLE 1

Common concentration units for environmental contaminants.

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

LIQUIDS

1 liter (l) of water weighs 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

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