Parts per Million (ppm) and Parts per Billion (ppb)

Definition

Parts per million (ppm) and parts per billion (ppb) show a relationship between two quantities that use the same units. A part per million could be one drop per one million drops, one gram per one million grams, etc. By definition, one ppm = 1,000 ppb.

Ppm/ppb can be measured by *weight* (ppmw/ppbw) or by *volume* (ppmv/ppbv), depending on what's being measured. Some documents will tell you if it's weight or volume, other times you will need to figure it out yourself.

Uses

Ppm and ppb are often used like a percent, but for very small amounts. The word percent literally means "part per hundred". So, 1% = 10,000 ppm = 10,000,000 ppb.

For soil, mg/kg = ppm and µg/kg = ppb. This is always by weight.

For water, mg/L = ppm and µg/L = ppb, if comparing by weight. These equations are *not* true in the rare cases where measuring ppm/ppb by liquid volume.

For air, ppm and ppb are always by volume. There is no direct conversion between ppm/ppb and mg/m^3 or $\mu g/m^3$; it will depend on the density of the contaminant in the air, and on air temperature and pressure.

Examples

Part per Million

Other ways of thinking about parts per million:

- 1 drop of ink in a large kitchen sink (about 13 gallons).
- One drop in the fuel tank of a mid-sized car
- One inch in 16 miles
- One minute in two years
- One car in a line of traffic from Cleveland to San Fransisco
- One penny in $10,000

Part per Billion

Other ways of thinking about parts per billion:

- one drop of ink in a large tanker truck (about 13,000 gallons)
- 1 car in a line of cars that goes around the Earth 100 times
- Three seconds out of a century
- One penny in $10,000,000
- One grain of sand in a sand box

Parts per million (ppm) and parts per billion (ppb)

Launch the Discussion

Remind or tell the group why you're covering this topic (it came up at a previous meeting, it's a key to understanding something the group has identified as a priority, etc.) Ask the group:

ppm**: Has anyone heard of a part per million before? What's an example of a part per million?** Which do you think is closest to a part per million? (Read the list and have participants vote, but don't give an answer until they have had a chance to guess.) Is it like one drop of ink in:

- A cup of water? (1 part in 4,730, or 211 ppm)
- A gallon of water? (1 part in 75,700, or 13 ppm)
- A large kitchen sink? (about 1 ppm)
- An olympic-sized swimming pool? (1 part in 5,000,000,000, or 0.005 ppm, or 5 ppb)

ppb**: Has anyone heard of a part per billion before? What's an example of a part per billion?**

Which do you think is closest to a part per billion? (Read the list and have participants vote, but don't give an answer until they have had a chance to guess.) Is it like one drop of ink in:

- A large kitchen sink? (about 1 ppm, or 1,000 ppb)
- A bathtub? (1 part in 3,180,000, or 315 ppb)
- An olympic-sized swimming pool? (about 5 ppb. This is the closest answer, but the most accurate would be one drop spread across five olympic swimming pools)
- Lake Erie? (1 part in $1x10^{18}$, or one billionth of a part per billion)

Fact Sheet

Pass out the Fact Sheet. Review key points. Discuss with the group how it connects to their work.

Activities

In the *SfA* activity *Converting Between Units*, participants practice converting parts per million or parts per billion to either mg/kg and µg/kg (for soil) or mg/L and µg/L (for water).