Parts Per What?

Norm Meck

We hear a lot of talk about Parts per Million (PPM), Parts per Thousand (PPT), and Percent concentrations of stuff. What is really being talked about? They all refer to exactly the same thing since 1 Percent is 1 Part per Hundred, which is 10 Parts per Thousand , which is 10,000 Parts Per Million. Similarly, 1 Part per Million is 0.001 Parts per Thousand or 0.0001 Percent (or Parts per Hundred). One just selects the units to make it easier to write down the value.

Technically, these measures of concentration have to do with the amounts of the two substances being mixed together based on their relative molecular weights. We can usually get by with just using the weights of each substance that we determine by using a scale or balance beam.

So for our definition, One Part per Million is One <u>WEIGHT</u> measure of the first substance mixed with enough of a second substance to give a total of one million <u>WEIGHT</u> measures. The important part of this definition is that the weight measures must be of the same type. For example if we add one Pound of salt to 99 pounds of water we would end up with 100 pounds of a mixture that has concentrations of 1 percent (1 part per hundred) salt and 99 percent (99 parts per hundred) water. The concentrations would be the same if we mixed one gram of salt with 99 grams of water, or one ounce of salt to 99 ounces of water, or one ton of salt to 99 tons of water. But NOT one POUND of salt to 99 GALLONS of water. Gallons are not a unit of weight and the resulting mixtures units are meaningless.

Note that we will usually just mix one part of the first substance with 1000 parts of the second substance and call it a one Part per Thousand concentration although it truly is one part per thousand-and-one parts. For our applications, this small amount of error is not important.

We are normally concerned with mixing something with water to obtain a given concentration and we normally don't measure the amount of our water by weight. Here is where problems often arise, we have to make a conversion from the volume of our water to the weight of our water.

I prefer to work in metric units for this task because it makes the math much easier. In metric units, 1 cubic centimeter (cc) of water is one milliliter (ml) and weighs one gram. This makes things work out nicely in that 1 gram of a substance mixed with 1 liter (1000 grams) of water is 1 part per thousand or 1000 parts per million. For some reason, in US units, one fluid ounce of water weighs 1.0425 ounces (avoirdupois). Therefore, in US units, to get our 1 part per thousand mixture, we would have to use 0.03336 ounces of the substance in a quart of water (32 fluid ounces, which is 33.36 ounces by weight). A US Gallon of water weighs 8.33 pounds. If we would add 8.33 pounds of a substance to 1000 gallons of water we would have a 1 part per thousand mixture. To confuse the whole thing even more, the British use the Imperial gallon, which is 1.2 US gallons and therefore weighs 10 pounds (maybe they used some logic in this selection). We would have to add 10 pounds of a substance to 10000 Imperial gallons to achieve the 1 part per thousand mixture. Don't ask why, just go metric.

It is suggested that as you read through the calculations below, that you do the computations yourself to make sure you understand where each number comes from (and why).

Let's take a look at an example:

A US gallon of water is 3.79 liters and therefore weighs 3790 grams. So one gram of a substance in one US gallon of water will produce a concentration of 1/3790=0.000264 or 264 parts per million. Or one gram in 100 US gallons will give a concentration of 2.64 parts per million. If we have a 5000 gallon pond (50 hundred gallons) and desire a 2.0 PPM concentration (of Potassium Permanganate perhaps), we should add 2/2.64= 0.76 grams per hundred gallons or 50 x 0.76 = 38 grams for our 5000 gallon pond.

That one wasn't too bad, let's try another one:

Another number of interest is that one hundred US gallons of water weighs 833 pounds. If we add one pound of a substance to that, we end up with a concentration of 1/833 = 0.0012. This is the same as 0.12 percent, 1.2 parts per thousand, or 1200 parts per million. Knowing this relationship makes it easy to calculate how much salt to add to our 5000 pond for a given concentration. Assuming we want to make an initial dosage of salt at a 3 part per thousand (0.3%) concentration. 3/1.2 = 2.5 pounds per hundred gallons. We should add 2.5 x 50 or 125 total pounds of salt. What if we measure the salinity of our pond and find that it is 1.0 PPT (0.10%) and we want to increase it to 3 Parts per Thousand? Since we need to increase the concentration by 3.0-1.0=2.0 PPT, we should add 2/1.2=1.67 pounds of salt per hundred gallons or 83.5 pounds to our 5000 gallon pond.

Here is an example where interpretation problems can occur:

We are told that a 25 PPM dosage of Formalin is appropriate for handling most parasites. (Formalin is a mixture that consists of 37% Formaldehyde, 10% Methanol, and 53% water). The Formaldehyde is the active ingredient so the question must be asked what the dosage refers to. Does it mean 25 ppm of Formaldehyde or does it mean 25 ppm of Formalin? Since the Formalin is 37% Formaldehyde, a 25 ppm Formalin concentration is a 25 * 0.37 = 9.25 ppm Formaldehyde concentration. We are also told that we should dose at 1 milliliter (ML) of Formalin per 10 gallons of water. This makes it easy, we just have to add 500 ML of Formalin to our 5000 gallon pond. Let's check to see what this dosage really gives us. If we assume that the Formalin mixture weighs about the same as pure water, 1 milliliter would weigh 1 gram and 10 gallons of water weighs 37900 grams so the dosage level would be about 1/37900 = 26 PPM (of Formalin). Obviously, it was intended that the dosage refered to the Formalin mixture, not the actual Formaldehyde concentration (9.75 ppm). If we dosed at a 25 PPM of Formaldehyde, we would be at about 2 1/2 times the recommended dosage and probably be killing our fish (as well as the parasites).

Some products come pre-mixed at various concentrations. It is important to read the label carefully to determine how much to actually use. Suppose we have a bottle of Malachite Green solution. The manufacturer recommends a dosage of 1 teaspoon (5 milliliters) per 100 gallons. The next time, we didn't get the same product, we got pure, dry Malachite Green instead. We want to dose at the same level as the liquid product we had been using so we find the old empty bottle and it states that it is contained 1% Malachite Green. Each 5 milliliters of the solution would have weighed approximately 5 grams, so we must have been dosing with 5/100 = 0.05 grams of Malachite Green per 100 gallons. This means we should use 0.05 x 50 = 2.5 grams of the pure, dry Malachite Green as the proper pond dosage. Note that since 100 gallons of water weighs 379,000 grams, the actual dosage for both cases was 0.05/379000 = 0.13 Parts per Million.

In any of these computations it is necessary to know the amount of water in your pond as accurately as possible. I consider it a good idea to compute the amount of a substance to add to your pond to give a one Part per Million concentration and a one Part per Thousand concentration. Double and triple check your math, then write these numbers down and save them to help make your treatments easy in the future. Be sure and measure your dosages as accurately as possible (and don't forget to use the proper units).

Here is a set of numbers that might make your computations easier:
1 Part per Million = 0.379 grams per 100 US Gallons = 1 gram per 1000 liters.
1 Part per Thousand = 0.833 pounds per 100 US Gallons = 1 gram per liter.
1 Part per Hundred (1%) = 1.33 ounces (avoirdupois) per US Gallon = 10 grams per liter.

My large pond is 8500 gallons (including the water in the filter system). For a 1 PPM dosage, I would use 32.2 grams; and for a 1 PPT dosage, 70.8 pounds. Check my math to see if you agree.