Matters of Perspective (Part 1 - pH)

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For those of us who work in technical fields, such as in the applied sciences or in engineering, we often find ourselves surrounded by numbers. Over the course of months or years we grow comfortable comparing results to standards or evaluating whether these numbers fall within certain ranges, but during this time we can often lose sight of the significance of these numbers. How much, really, is a microgram? How fast is the speed of light in practical terms? Sometimes it is best to look at the scale of measurement in terms that are easier to visualize. For this article I will focus on pH.

The concentration of the hydrogen ion in a water solution is measured in powers of ten and its value is represented as a pH number. The pH scale ranges from 0 to 14, although the practical use of the scale is from 2 to 12. A pH of 7 is considered neutral. However, this does not mean that hydrogen ions are not present – they are – but in a very tiny amount. At a pH of 7, the hydrogen ions (which carry a positive charge) equal the amount of hydroxide ions (which carry a negative charge). As the pH value decreases below 7, the characteristics of the solution become governed by the acid component (hydrogen ion, H+). Conversely, as the pH increases above 7, even though hydrogen ions are present in miniscule amounts, it's the base component (hydroxide ion, OH-) that governs the solution's characteristics.

For every whole number pH decrease on the pH scale, there is a ten-fold increase in the active acid component of the solution. As mentioned before, a "neutral" pH of 7 still has a tiny acid component. At a pH of 6, the acid component concentration is ten times more than at 7. A pH of 5 has 100 times the concentration of hydrogen ions than a solution at pH 7. pH 4 is 1000 times, and a pH of 3 has 10,000 times the hydrogen ion concentration.

In this imperfect example of measuring pH in terms of distance, where you are right now is considered pH 7, neutral. A pH 6 would be ten yards away. A pH 5 would be the length of a football field away. About 0.6 miles away you'd find a pH of 4. Travel 5.7 miles and you will find the pH 3 marker. To reach a pH of 2, you would need to travel 57 miles from your "neutral" position of pH 7. By putting the pH scale in terms of distance, it is easy to visualize how acidic a solution can be.

Unpolluted precipitation has a pH of 5.65 (carbon dioxide dissolves in the water and creates a tiny amount of carbonic acid which gives a pH of 5.65). Any precipitation that has a pH lower than this is classified as acid rain. Using the distance analogy, the active acid component in normal rainwater would cover a little more than ten yards. At one place where I worked, we tested the rainwater. It was always less than pH 5.65, and several times we found to have a pH of 3. That's about six miles of an active acid component that shouldn't be longer than 10+ yards. No wonder statues and gravestones, especially marble ones, are slowly dissolving with each rainstorm. It also helps to understand why the neutralizing capacity of the land and surface water is often overtaxed, leaving many localized ecosystems sterile, especially in northeastern US and Canada.

By the way, the speed of light is 186,000 miles per second. That is equivalent to about 34 round trips from Boston to San Francisco in one second.

Reference:

Standard Methods for the Examination of Water and Wastewater 23rd edition 2017, part 4500-H^+ pH Value.

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