Biology 356 – Water Testing Labs (3 and 4 in Fall 2009)

The purpose of these labs is to give you some understanding of typical water quality tests, the parameters tested and why they are biologically important, and to allow you to actually get some experience doing these types of tests. A second purpose is to make some comparisons of water from different areas of a stream (above and below a power plant for example) or from different bodies of water in the same general area (the Yellowstone River and Lake Josephine down at Riverfront Park).

The first week, we'll test two samples of Yellowstone River water collected last November near Miles City. I believe that the samples were either upstream and downstream of a power plant, or upstream and downstream of the confluence with the Tongue River (I can't really remember which it was). I'll give a brief overview of the tests you'll be doing, what they measure, why it is biologically important (or at least interesting) and a bit about how to go about it (though the actual procedure will vary from test to test).

Below is a brief list of the parameters we'll be testing:

Acidity: the quantitative capacity of water to be neutralized to a set pH by a base. Acidic solutions are determined by pH measurement. Total acidity is determined by titration. Mineral acids (strong acids) are neutralized to a pH of 3.7 – 4.5 (the methyl orange endpoint). Organic acids (the "rest" of the acidity) are determined by titration to a pH of 8.3 (the phenolphthalein endpoint). Two solutions with similar pH can have different acidities (pH is a measure of the amount of H+ ions in solution….acidity is the capacity of water to be neutralized to a set pH…this is due to other substances present that act as buffers). The pH of water can not only directly inhibit biological processes, but it can change the solubility of other substances (i.e. heavy metals) and make the water even more toxic. It is expressed as mg/L Calcium Carbonate.

Alkalinity: The quantitative capacity of a water sample to neutralize an acid to a set pH. It is a measure of how well the sample can buffer itself against pH changes. This isn't a pollutant, and it is unlikely that natural water can be so alkaline that it causes problems (indeed – generally water that is slightly alkaline is more productive than water that isn't). Alkalinity occurs as water percolates through limestone and other carbonate rocks (e.g. dolomite). Granitic rocks do not have high carbonate content, and waters in granitic regions have low alkalinity. Streams and lakes in granitic regions have lower productivity (generally) than similar streams and lakes in carbonate regions. High alkalinity prevents rapid swings in pH (acts as a buffer – this is sometimes called buffering capacity). Alkalinity is measured as Phenolphthalein alkalinity (all the hydroxide ions, but only half of the carbonate ions) at pH 8.3 and Total alkalinity (all remaining carbonate ions converted to carbonic acid) at pH 4.5. It is expressed as mg/L Calcium Carbonate.

Carbon Dioxide: naturally occurring gas produced by respiration and decay. It is generally low in aquatic systems (less than 10mg/L of carbon dioxide). Stagnant or polluted water can have high levels, which can lower the pH by forming carbonic acid. Determined in mg/L.

Conductivity/total dissolved solids (salts): capacity of a solution to conduct a current. These two measures are proportional to each other. This is essentially a measure of the ionic concentration (dissolved salts) in water. Too high, and water balance problems result. Too low, and water is not productive. Measured in milliSiemens or microSiemens.

Dissolved Oxygen: obviously necessary. Cold water has more D.O. than warm water. This changes daily with photosynthetic activity. Oxygen is removed from water during decomposition, and large amounts of decomposition can leave bodies of water devoid of oxygen (anoxic). Pollution (especially sewage runoff) can also lower oxygen concentrations as this material is decomposed. Measured in mg/L or ppm (equivalent).

Hardness: Concentration of calcium and magnesium ions in water. It is expressed as mg/L of calcium carbonate. Water with high hardness can buffer against toxic metals by forming precipitates and preventing them from being used by aquatic organisms. Calcium can be used by developing fish for bone growth, and magnesium is required by plants for photosynthesis. Hardness comes from carbonate rocks, and is generally positively correlated with alkalinity.

Nitrates: high levels promote eutrophication (excessive productivity) and thus tend to decrease dissolved oxygen and increase CO_2. Sources of nitrates are fertilizer runoff and sewage. Some nitrates exist normally in water, but they are generally converted to nitrite and taken up by plants quickly. High levels indicate biological pollution. Measured in mg/L.

Phosphates: level of phosphorus in water. Phosphate stimulates plant growth (often limiting in aquatic systems..along with nitrates). Too much causes eutrophication similar to nitrates. Sources are similar too – primarily fertilizers now. Phosphates used to be prevalent in detergents, but have been greatly reduced. High levels again represent pollutants. Measured in mg/L.

Our Procedure: We'll break into groups, and each group will test one or two different parameters. The instructions for each test vary, so everyone won't learn how to do each different type of test. However, if you'd like to try others, please feel free. There is no reason why we can't test several variables several times. It would probably help our accuracy anyway. At the end of each lab, we'll have a bit of a discussion to see what we can conclude about these water sources.