Experiment Modules

Water Quality

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1 pH

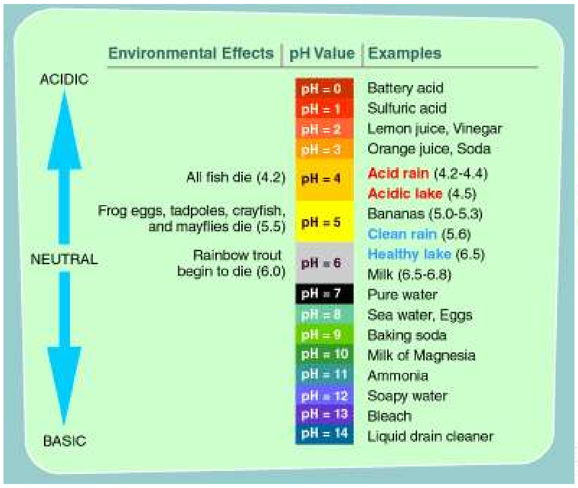
pH is a measure of the acidity or basicity of water or any liquid solution. The range goes from 0 - 14, with 7 being neutral. pHs of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. pH is reported in "logarithmic units". Each number represents a 10-fold change in the acidity/basicness of the water. Water with a pH of five is ten times more acidic than water having a pH of six.

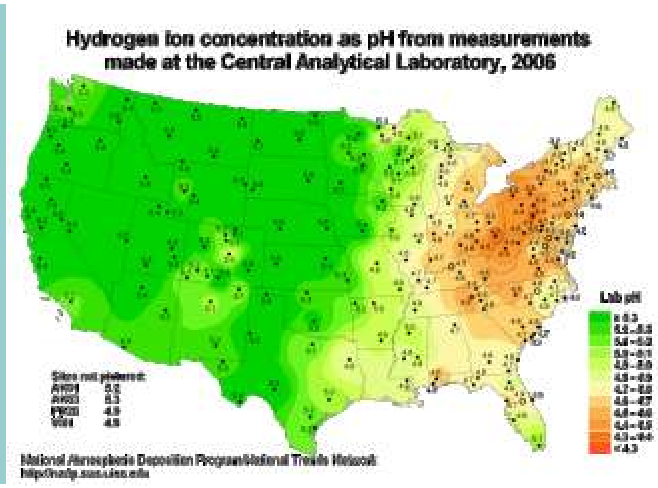
Importance of pH

The pH of water determines the solubility (amount that can be dissolved in the water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.). For example, in addition to affecting how much and what form of phosphorus is most abundant in the water, pH also determines whether aquatic life can use it. In the case of heavy metals, the degree to which they are soluble determines their toxicity. Metals tend to be more toxic at lower pH because they are more soluble.

Diagram of pH

As diagram below shows, pH ranges from 0 to 14, with 7 being neutral. pHs less than 7 are acidic while pHs greater than 7 are alkaline (basic). Normal rainfall has a pH of about 5.6—slightly acidic due to carbon dioxide gas from the atmosphere. You can see that acid rain can be very acidic, and it can affect the environment in a negative way.





Why care about pH?

Water with an extremely high or low pH is deadly. Water with relatively low pH (acidic) may reduce the hatching success of fish eggs and irritate fish and aquatic macroinvertebrates (water bugs) gills and damage membranes. Amphibians are particularly vulnerable, probably because their skin is so sensitive to pollutants. Some scientists believe the recent drop in amphibian numbers around the world is due to low pH levels caused by acid rain.

2 Temperature

The temperature of water is a measure of how much heat energy the water contains. In the U.S. we usually use the Fahrenheit scale to measure temperature. On this scale water freezes at 32 degrees and boils at 212 degrees. However, scientists usually use the Centigrade (or Celsius) scale. Water freezes at 0 degrees C and boils at 100 degrees C.

Converting Celsius to Fahrenheit	Converting Fahrenheit to Celsius
°F = [(9/5) x °C] + 32	°C = (5/9) x (°F−32)

Why care about temperature?

Temperature exerts a major influence on biological activity and growth. Temperature governs the kinds of organisms that can live in rivers and lakes. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have a preferred temperature range.

Macroinvertebrates, fish and amphibians are cold-blooded. The metabolisms of these animals are affected by temperature. It speeds up and slows down based on the surrounding temperature. If the temperature changes too drastically, their metabolisms may not function as well, decreasing their ability to reproduce and survive. Optimal temperature ranges for organisms vary. Trout do best at temperatures below 22°C while carp may do fine in temperatures as high as 28°C. Fish can be divided into two groups, coldwater fish (who require fairly cool temperatures) and warmwater fish (who can survive in warmer water temperatures). Warm water holds less dissolved oxygen than cool water, and may not contain enough dissolved oxygen for the survival of different species of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures.

Temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature. Water, particularly groundwater, with higher temperatures can dissolve more minerals from the rocks it is in and will therefore have a higher electrical conductivity. It is the opposite when considering a gas, such as oxygen, dissolved in the water. Think about how much bubblier a cold soda is compared to a warm one. The cold soda can keep more of the carbon dioxide bubbles dissolved in the liquid than the warm one can, which makes it seem fizzier when you drink it.

Natural factors that influence temperature:

- Geographic area – waterways reflect the surrounding climate. If the climate is warm all year, the water is generally warm. Waterways in colder climates tend to change more throughout the year.
- Seasons – air temperature affects water temperature. During the winter water may freeze and during the summer the water may be warm.
- Sources of water – waterways fed by snow melt will be cold during the spring and summer. Waterways fed by hot springs may keep water warm throughout the year.
- Channel shape – Because stream water heats up from the sun and from contact with the warmer earth, a narrow, deep stream will be cooler than a wide, shallow stream, if all other factors are equal.
- Riparian shading – Streams that receive shade from riparian vegetation may have cooler temperatures than those that are exposed to more sunlight.

3 Electrical Conductivity / Total Dissolved Solids

Electrical conductivity (EC) estimates the amount of total dissolved salts (TDS), or the total amount of dissolved ions in the water. The TDS is the weight of this material per unit volume (usually given as milligrams per liter). Although simple, the analysis requires an expensive drying oven, a very sensitive and expensive weighing scale (analytical balance) and a lot of space and time. However, the water quality parameter electrical conductivity (EC) provides a simple, inexpensive measure of TDS that can be determined precisely and accurately in the field using automated electronic sensors.

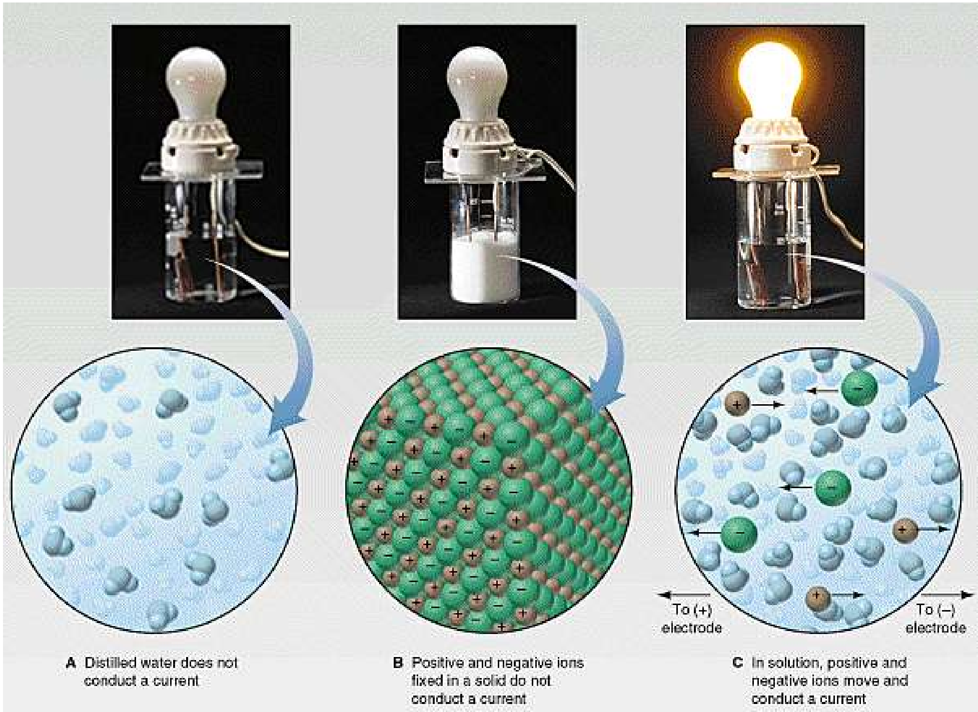
Most of the TDS of natural waters is comprised of inorganic compounds – mineral as opposed to the organic compounds derived from organisms. Although there are at least traces of many elements, the great majority of the TDS load is from four negative ions (bicarbonate, carbonate, chloride, sulfate) and four positive ions (calcium, magnesium, sodium and potassium).

Relationship between Electrical Conductivity and Total Dissolved Solids

Conductivity is a measure of water's ability to conduct an electric current and is directly related to the total dissolved salt content of the water. This is because the salts dissolve into positive and negative ions that can conduct an electrical current proportionately to their concentration. It is called EC, for electrical conductivity, and is reported in micromhos per centimeter (umhos/cm) which has been recently renamed as uS/cm (microSiemens per centimeter). EC is temperature sensitive and increases with increasing temperature. Most modern probes automatically correct for temperature, standardize all readings to 25°C.

Why is it important?

Aquatic organisms require a relatively constant concentration of the major dissolved ions in the water, much as we require relatively constant concentration of certain dissolved ions in our blood and other bodily fluids. Levels too high or too low may limit survival, growth or reproduction.



4 Bacteria (E. coli, coliform)

Coliform bacteria are microscopic organisms. They originate in the intestinal tract of warm blooded animals and may also be found in soil and vegetation.

Human Influences that cause an increase in coliform bacteria:

- Most coliform bacteria enter streams or rivers through direct deposition of waste in the water and runoff from areas with high concentrations of animals. Domesticated animals contribute heavily to bacterial pollution.
- Runoff from woodlands, septic tanks, and sewage plants may cause an increase in coliform and other bacterial pollution.

Why care about coliform bacteria?

Health Concerns: Total coliform bacteria is generally harmless. However, coliforms indicate that disease causing bacteria (viruses or parasites) may be present. The water may be contaminated with sewage or similar wastes. Diseases which may be present in water that tests positive for coliform bacteria include: typhoid fever, • cholera, hepatitis, dysentery, giardiasis, and hemolytic uremic syndrome.

What is the drinking water standard for coliform?

The established standard for bacteria in drinking water includes total coliforms, fecal coliforms, and E. coli. Municipalities that collect less than 40 total coliform samples per month may have no more than one sample that tests positive. Those collecting over 40 samples per month are required to have no more than 5% test positive. No samples should test positive for fecal coliform or E. coli. There is no standard for private wells, nor is any testing required, which means the owners of private wells must test their own water.

5 Dissolved Oxygen

Why Is It Important?

Dissolved oxygen is a molecule of O_2 that is dissolved into the water. It is invisible to our naked eye. It is not the bubbles in water, nor the oxygen component of the water molecule H_2O. Dissolved oxygen can get into the water two ways, through atmospheric oxygen mixing into a stream in turbulent areas or by the release of oxygen from aquatic plants during photosynthesis.

All animals need oxygen to survive. Dissolved oxygen is what makes aquatic life possible. Changes in oxygen concentration may affect species dependent on oxygen-rich water, like many macroinvertebrate species. Without sufficient oxygen they may die, disrupting the food chain.

Natural factors that influence dissolved oxygen:

- Aquatic life-animals living in water use up dissolved oxygen. Bacteria take up oxygen as they decompose materials. Dissolved oxygen levels drop in a water body that contains a lot of dead, decomposing material.
- Elevation-the amount of oxygen in the atmosphere decreases as elevation increases. Since streams get much of their oxygen from the atmosphere streams at higher elevations will generally have less oxygen.
- Salinity (saltiness)-Salty water holds less oxygen than fresh water.
- Temperature-cold water holds more dissolved oxygen than warmer water.
- Turbulence-more turbulence creates more opportunities for oxygen to enter streams.
- Vegetation-riparian vegetation directly affects dissolved oxygen by releasing oxygen into the water during photosynthesis. It indirectly affects dissolved oxygen concentrations because vegetation shading a stream may decrease water temperatures and as temperature decreases dissolved oxygen increases.

Why care about dissolved oxygen?

All terrestrial and aquatic animals need oxygen to survive. Many aquatic macroinvertebrate species depend on oxygen-rich water. Without sufficient oxygen they may disappear. Even a small change in dissolved oxygen concentration can affect the composition of aquatic communities. Many fish require a certain dissolved oxygen range in order to survive.

Oxygen concentration can also affect other chemicals in the water. For example, cadmium stays in a solid form in the presence of oxygen and sinks to the bottom of the water. However, if the water goes anoxic (without oxygen) cadmium may dissolve into the water. This is a problem because cadmium (as with other hard metals) is poisonous to animals.

6 Nitrogen

There are two main groups of nitrogen, organic and inorganic. Organic nitrogen includes all of the nitrogen that is part of living animals, animal wastes and the remains of living things. Organic forms of nitrogen must be broken down into inorganic forms in order to be used by plants. Examples of inorganic nitrogen are N_2, $N0_3$, NH_3, $N0_2$. Nitrate ($N0_3$) is the most common form of inorganic nitrogen found in waterways. Plants can directly use this form of nitrogen to build proteins.

Why care about nitrogen?

- Environment: When waterways become over fertilized with nitrogen there can be heavy plant growth. Excessive plant growth can decrease the aesthetic value of the water because of the smelly decomposing mats of vegetation. Also, when bacteria decompose dead plant material they use up dissolved oxygen which is important for the survival of macroinvertebrates and other aquatic organisms.
- Human Health: High concentrations of nitrate in drinking water can cause methemoglobinemia (also known as blue baby syndrome). Concentrations greater

than 10 parts per million can be harmful to young babies, and should be avoided by nursing mothers. Find out more about nitrate.

- Livestock Health: Concentrations of nitrate over 100 parts per million are toxic to livestock. Nitrates are odorless, colorless, and tasteless so it is important to test feed and drinking water to determine levels of nitrate.

7 Hardness

Water is considered "hard" when it has relatively high levels of calcium (above, left) and magnesium (above, right) and other metals. The more minerals that are present the harder the water is. It is referred to as "hard" water because it requires more soap for a good lather, making it harder to clean with than soft water. There are both benefits and drawbacks to having hard water, depending on what the water is being used for.

Why care about the hardness of your water?

Benefits of hard water:	**Problems of hard water:**
• Calcium and magnesium are part of the dietary needs of humans. Hard water can be a valuable source for these nutrients. • Some studies have found a correlation between hard water and lower cardiovascular disease mortality. • Hard water is less likely than soft water to cause corrosion of pipes. Soft water can dissolve certain metals that are potentially toxic (like cadmium and lead). • Hard water has less sodium than soft water. Soft water can be a significant source of sodium and may be of concern to those who need to restrict their sodium intake for health reasons.	• Spotting on glass • deposits in hot water heaters • scalding on sinks and fixtures • clothes feeling harsh or looking dingy • film on bathroom surfaces • sticky dull hair

8 Activity Sheet for Field Experiment

Please note your reading in following Table:

Sr. No.	Water Quality Parameters	Sample 1	Sample 2	Sample 3
1	Location of Sample			
2	pH			
3	Electrical Conductivity			
4	Total Dissolved Solids			
5	Temperature			
6	Bacteria			
7	Pesticides			
8	Nitrates			
9	Nitrites			
10	Iron			
11	Lead			
12	Hardness			
13	Chlorine			
14	Copper			

9 Water Quality Quiz

1. What happens to the amount of dissolved oxygen when the temperature decreases?

2. Turbidity is a measure of?

3. Why is algal bloom a concern to water quality?

4. What happens to the pH of a stream after an acidic rainfall?

5. Name as many factors you can think of that cause water pollution.

6. True or false. Leaves should be raked down a storm drain so they can decompose in the stream and provide food for the fish.

7. Generally, Does higher DO indicate better or worse water quality?

8. One organism that can deplete the oxygen level of the water is_______?

9. Discharge of large amounts of warm water from industrial plants is called ________ pollution?

10. What is Clean Water Act?