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Chapter 2:
Getting Started

Chemical Analysis of the Water

Dependent on your area, you may measure for several parameters. In this manual, we'll discuss the eight parameters that all PaSEC groups monitor for:

- Temperature
- pH
- Dissolved Oxygen
- Specific Conductance (also referred to as Conductivity)
- Phosphate (Ortho and/or Total)
- Nitrate
- Total Alkalinity
- Sulfate

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Temperature

What is temperature? Temperature is the relative hotness or coldness of a substance.

Where does temperature come from? The four main influences on temperature are sun, air, land and water. Each of these contributes to the temperature of an environment.

Why do we study temperature? Aquatic plants and organisms require a certain water temperature in order to survive. The temperature of the water affects their ability to carry out their life functions in several ways:

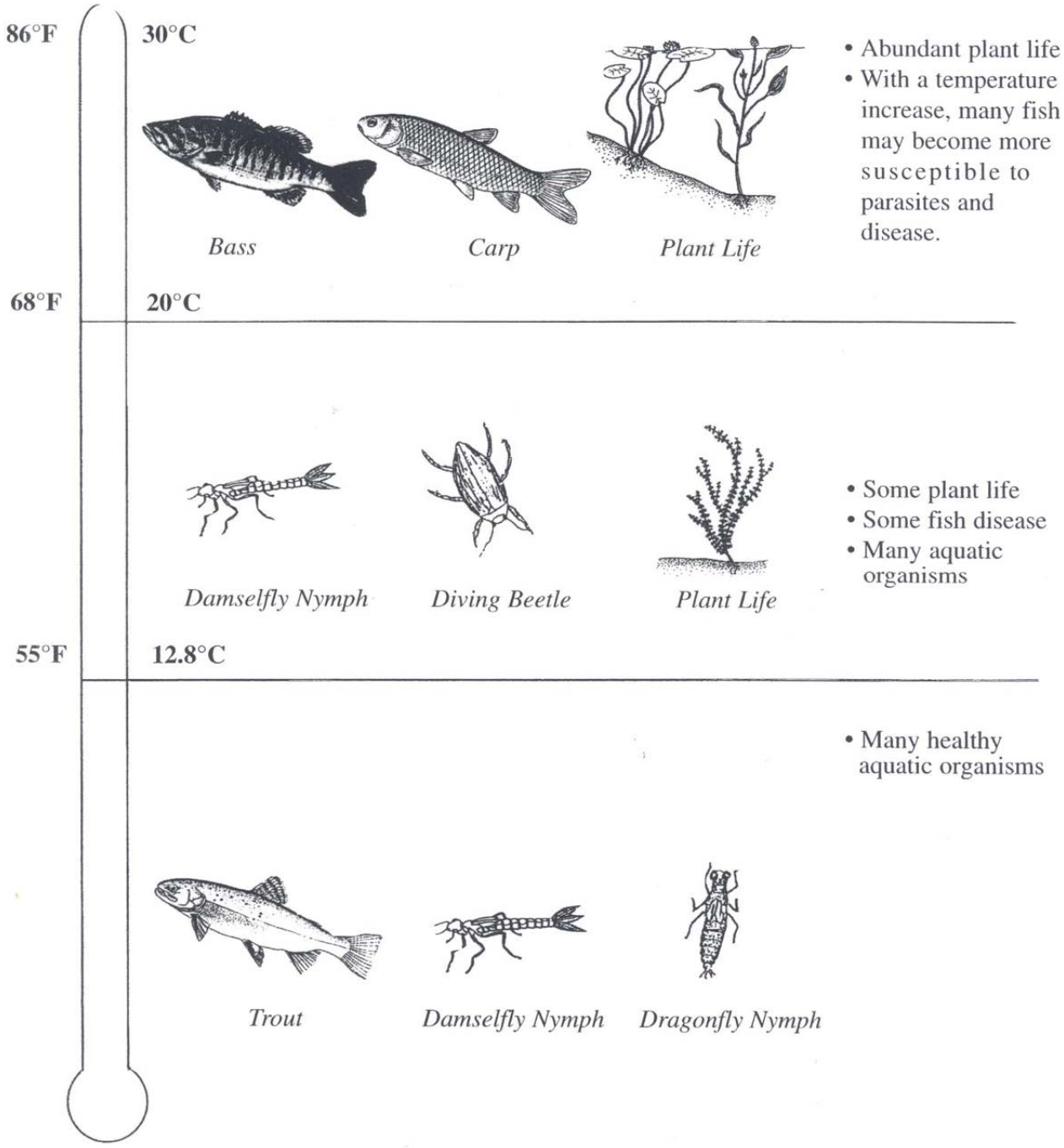
1. The rate of photosynthesis by algae and other aquatic plants increases in warm waters and decreases in cooler waters.

2. Aquatic life requires a specific level of dissolved oxygen in order to survive. Temperature has a direct effect on the level of dissolved oxygen in the water. The colder the water, the higher the dissolved oxygen level will be; the warmer the water, the lower the dissolved oxygen level.

3. Organisms' sensitivity towards pollution, parasites and disease becomes greater as the water temperature rises.

Temperature Scale

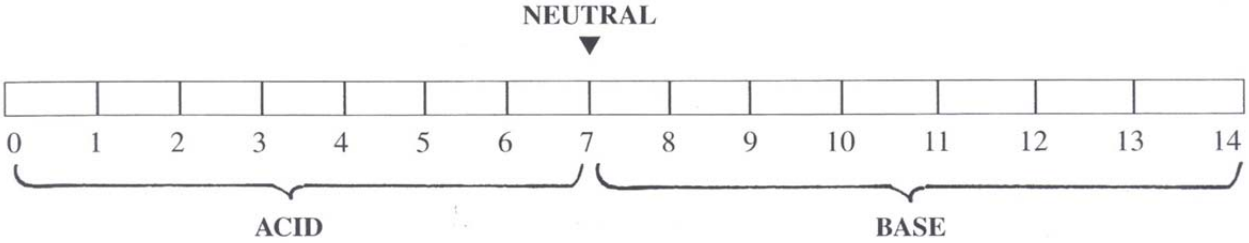
Aquatic organisms have adapted to survive within a range of water temperatures. Very high or very low water temperatures make it more difficult for organisms to survive. High water temperatures also cause aquatic life to become more sensitive to pollution, parasites, and disease.



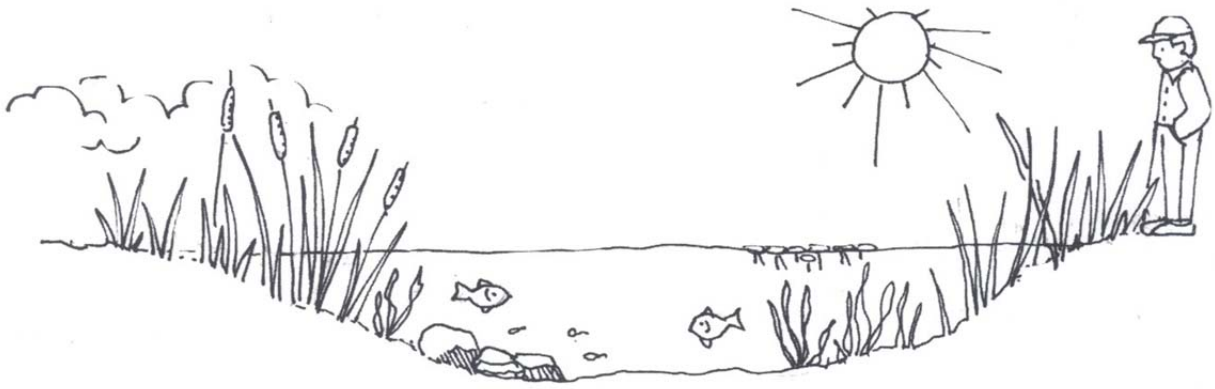
pH

What is pH? The strength of acids and bases is measured on the "pH scale." The scale runs from 0-14. A solution rated below 7 is an acid, and a solution above 7 is a base. Seven (7) is the neutral point and is neither an acid or a base. Movement away from the neutral point shows an increase in the strength of an acid or a base.

Some examples of acids are oranges, lemons, and vinegar. Oranges contain an acid called citric acid. Acids are materials that can sting or burn the skin. Some examples of bases are baking soda, soap, ammonia and milk. Bases are often materials that have a slippery feel.



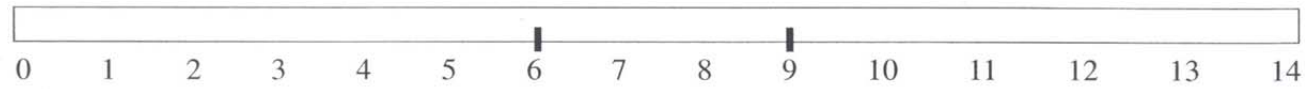
Where does pH come from? There are many factors that affect the pH of water. In an aquatic system, the pH value is affected by the plants, soils and organisms found there. This pH value can also be affected by human actions.



Why do we study pH? Aquatic organisms require a specific pH in order to survive. When pH becomes too high or low, it can stress the aquatic animals and cause them to become sick or to die. Very high and low levels of pH can be a sign of severe pollution.

pH Scale

Most aquatic organisms have adapted to survive in water that has a pH range between 6 and 9.



Bacteria

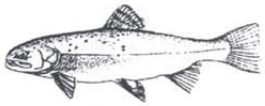
Bacteria

Bacteria

Dragonfly Nymph

Aquatic Plants

Damselfly Nymph



Trout

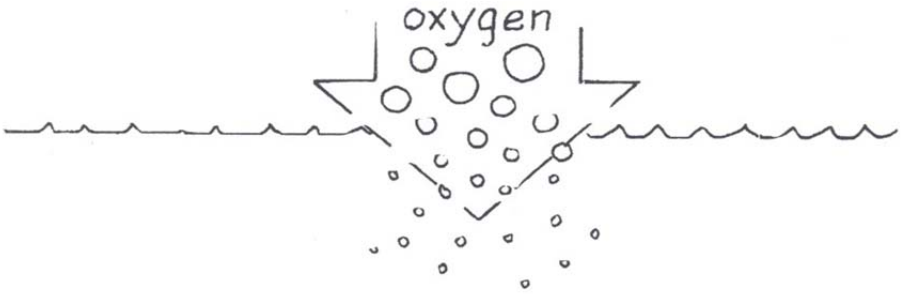
Shiner

Water Boatman

Aquatic Plants

Dissolved Oxygen

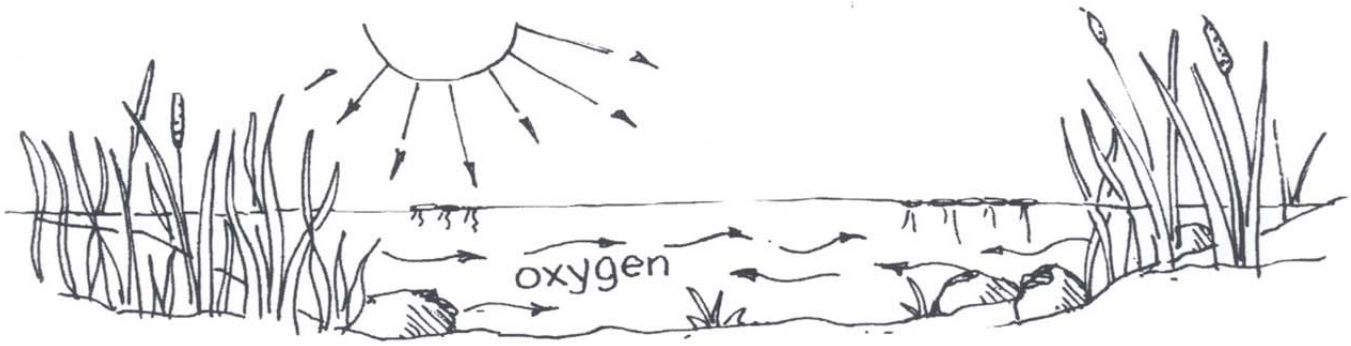
What is dissolved oxygen? Oxygen is a gas that almost all organisms need to survive. Oxygen that is mixed into water is called dissolved oxygen.



Where does dissolved oxygen come from? Dissolved oxygen comes from two places:

(1) The Air: Both wind and wave action take oxygen from the air and mix it into the water.

(2) Algae and Aquatic Plants: During the process of photosynthesis, oxygen is given off by

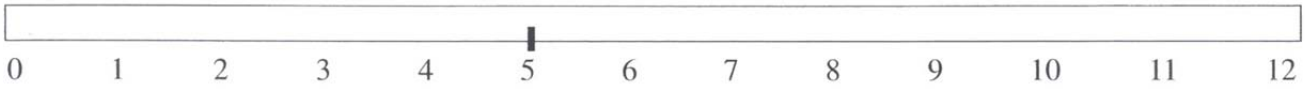


algae and other aquatic plants.

Why do we study dissolved oxygen? All aquatic organisms need dissolved oxygen to survive. Many types of water pollution affect the amount of dissolved oxygen in the water. If the level fallstoo low, aquatic life cannot exist.

Dissolved Oxygen Scale

Aquatic organisms need different levels of dissolved oxygen to survive. Dissolved oxygen is measured in parts per million (ppm*). Most organisms need at least 5ppm of dissolved oxygen to survive.



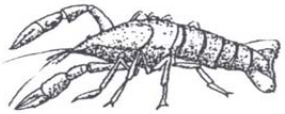
2-5ppm
Few organisms can live at this level. Low dissolved oxygen can be a sign of severe pollution.

Tubifex Worms

Midge Larvae

Bacteria

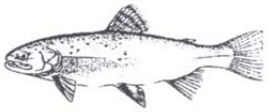
5-12ppm
Many organisms live at this level. Their presence indicates good water quality.



Crayfish

Water Strider

Diving Beetle



Trout

Water Boatman

Damselfly Nymph

Dragonfly Nymph

Tadpole

Shiner

*see glossary for explanation.

Specific Conductance or Conductivity

What is conductivity?
Conductivity is a measure of the ability of water to pass an electrical current.

Where does conductivity come from?
Conductivity in rivers is affected primarily by the geology of the area through which the water flows.

Granite bedrock tends to lower the conductivity of rivers, because granite is composed of more inert materials that do not ionize (dissolved into ionic components) when washed into the river.

Clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water. Think about salt as an example of ionization. When salt is dissolved in water, it ionizes into Sodium (Na^+) ions and Chloride (Cl^-) ions. Salt water would be a conductor of electricity, and would have a high conductivity reading.

Why do we study conductivity?

- Discharges into rivers can change the conductivity depending on their make-up.
- A failing sewage system would raise the conductivity due to the presence of chloride, phosphate and nitrate.
- Salts spread on the road after a snowstorm would raise the conductivity due to the presence of ionized materials washing into the nearest waterway.
- An oil spill would not increase the conductivity, because oil is an organic compound that does not ionize.

Conductivity is measured in microsiemens per centimeter (μS/cm) or micromhos per centimeter (μmhos/cm); they are the same unit. Below are some ranges of conductivity for various kinds of water and water usages:

Water type/use	***Range***
Distilled water	0.5 to 3.0 μS/cm
Rivers in the U.S.	50 to 1500 μS/cm
Studies of inland fresh water streams that support good mixed fisheries	150 to 500 μS/cm
Industrial water discharges	Up to 10,000 μS/cm

Phosphate

What are phosphates? Phosphorus is an essential element, usually present in aquatic ecosystems as phosphate. All aquatic organisms need phosphorus to grow.

Where do phosphates come from?

1) Rocks: Rain and wave action break down and dissolve phosphate rich rocks, releasing the phosphates into the soil and water.

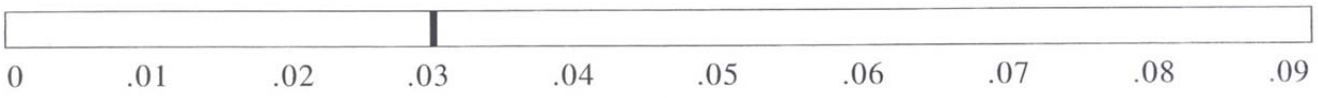
2) Human and animal waste: The human body and animals release phosphates through their waste, and it enters the soil and water.

3) Decaying plants and animals: Phosphates are released into the soil by fungi and bacteria as they decompose dead plant and animal matter.

Why do we study phosphates? Phosphates stimulate the growth of plankton and aquatic plants. Too much growth can "choke" the waterway, and when the plants die, their decomposition uses up much of the oxygen. Many fish and organisms then die. This process of excessive plant growth is called eutrophication, and can be greatly sped up by human actions.

Phosphate Scale

All aquatic organisms need phosphate to grow. Phosphate is measured in parts per million (ppm).
Most unpolluted streams have levels below 0.03 ppm. Total phosphate levels should be 0.1 ppm or lower.



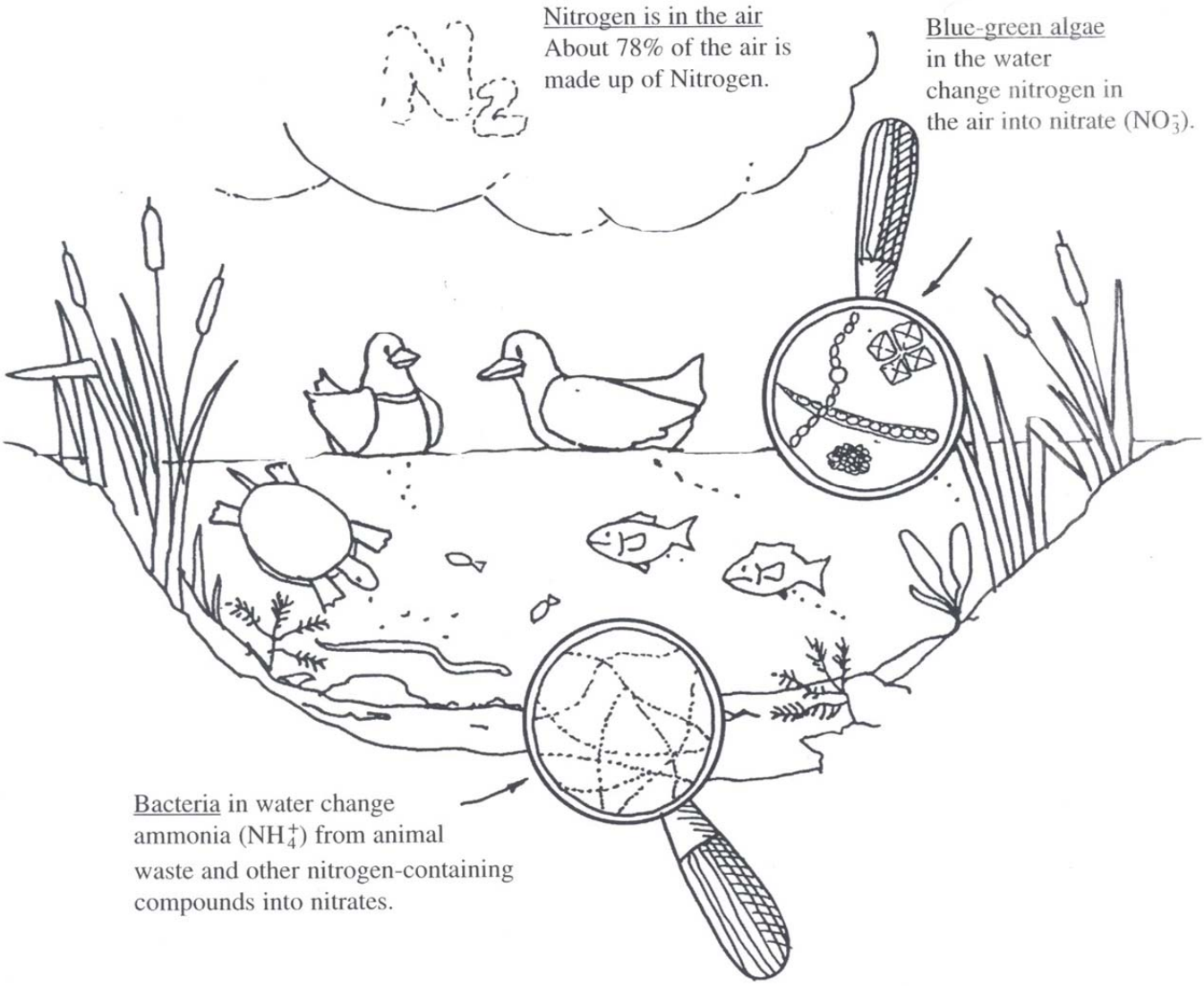
0 - 0.03 ppm
Amount of phosphate in healthy streams.

Higher than 0.03
Phosphates increase plant and algae growth. When large numbers of plants begin to die, they are decomposed by bacteria, which use and remove oxygen from the water. If the oxygen falls low enough, it can kill aquatic life.

Nitrate

What are nitrates? Nitrates are compounds containing the element nitrogen. Nitrogen is an essential protein component required by both plants and animals.

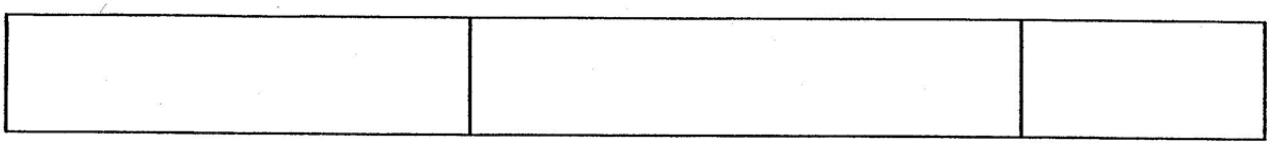
Where do nitrates come from?



Why do we study nitrates? High levels of nitrates in water can cause excessive algae and aquatic plant growth. As the algae and aquatic plants die, their decomposition by oxygen-using bacteria uses up oxygen faster than oxygen can be put into water, so fish and other organisms die. This natural process of excessive plant growth is called eutrophication, and high levels of nitrates added to the water by human activity greatly speeds up this process.

Nitrate Scale

All aquatic organisms need nitrate to form required proteins to live. Nitrate is measured in parts per million (ppm). Unpolluted waters have nitrate levels below 4.4 ppm.



0 **unpolluted**

Normal Plant Growth

4.4 **polluted supplies**

Excess Plant Growth

When large numbers of plants begin to die, they are decomposed by bacteria, which use and remove oxygen from the water. If the oxygen falls low enough, it can kill aquatic life.

44 unsafe levels in drinking water supplies

Total Alkalinity

What is total alkalinity?

Alkalinity is a measure of the capacity of water to neutralize acids. It is the buffering capacity, or the water's ability to resist changes in pH.

Where does alkalinity come from?

Alkalinity in streams is influenced by rocks and soils, salts, and certain plant activities that bring alkaline compounds into the stream such as bicarbonates, carbonates and hydroxides. These compounds remove H^+ ions and decrease the acidity of the water.

For example, limestone (calcium carbonate, or $CaCo_3$) is a very water-soluble material. A stream in a geographic area containing limestone will have a high alkalinity and a good buffering capacity. Pollutants such as acid rainfall, which would tend to decrease the pH of the water, would be buffered by the presence of the limestone preventing the pH from becoming too acidic.

Why do we study alkalinity?

Measuring alkalinity is important in determining a stream's ability to neutralize (buffer) acidic pollution from rainfall, wastewater or other industrial effluents.

Without a high buffering capacity, the water's pH could be affected by acidic effluents that could kill the organisms within the stream.

Sulfate

What are sulfates?

Sulfates are the second most common anions (compounds with a negative charge) in natural waters, derived largely from sedimentary rocks. Sulfates are the most common form of sulfur that is taken up by plants.

Where do sulfates come from?

Sulfates enter the water in three ways:

1. Breakdown of detritus (debris)
   When detritus breaks down, hydrogen sulfide is released by the oxygen lacking sediments, which is the common rotten egg smell of decaying vegetation.

2. Acid Rain
   When sulfur dioxide emissions are released from automobiles and factories, they are converted to sulfuric acid in the atmosphere. These acids combine with moisture in the air, and then fall to the earth as rain or snow.

3. Acid Mine Drainage
   This is very common in the coal regions of Pennsylvania. Coal contains naturally occurring amounts of iron sulfide, called pyrite. When pyrite reacts with oxygen in the water it forms sulfuric acid, which is extremely acidic.

Why do we study sulfates?

As sulfates in the form of sulfuric acid enter streams and rivers they can decrease the pH of the body of water making it intolerable for certain species of aquatic life. Acid mine drainage alone can potentially cause the pH of the water to fall into a range of 1 to 5, which is very acidic.