Name Date

pH

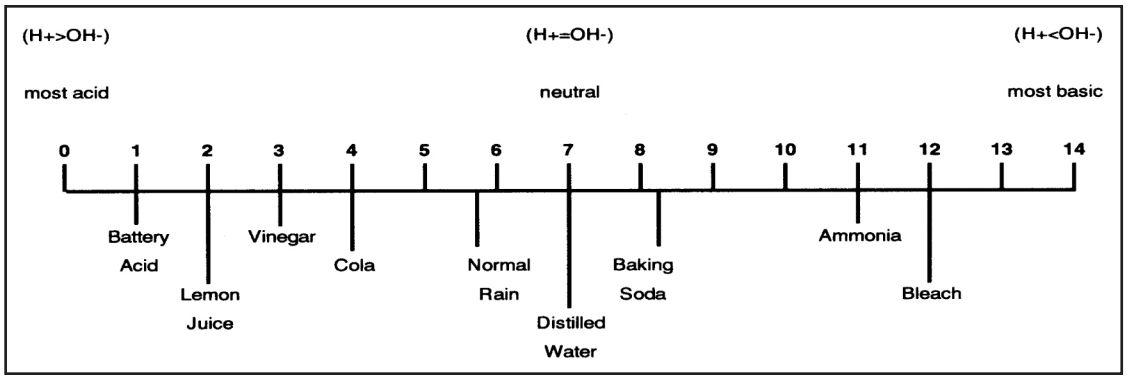
Fact Sheet

What is pH?

pH is a measure of how acidic or basic (alkaline) the water is (the term pH comes from the French: "puissance d'Hydrogène" which means strength of the hydrogen). It is defined as the negative log of the hydrogen ion concentration.

The pH scale is logarithmic and goes from 0 to 14. For each whole number increase (i.e. 1 to 2) the hydrogen ion concentration decreases ten fold and the water becomes less acidic.

As the pH decreases, water becomes more acidic. As water becomes more basic, the pH increases.



pH scale showing the values of some common substances. (Source: U.S. Fish and Wildlife Service)

Why is pH Important?

- Many chemical reactions inside aquatic organisms (cellular metabolism) that are necessary for survival and growth of organisms require a narrow pH range.
- At the extreme ends of the pH scale, (2 or 13) physical damage to gills, exoskeleton, fins, occurs.
- Changes in pH may alter the concentrations of other substances in water to a more toxic form. Examples: a decrease in pH (below 6) may increase the amount of mercury soluble in water. An increase in pH (above 8.5) enhances the conversion of nontoxic ammonia (ammonium ion) to a toxic form of ammonia (un-ionized ammonia).
- The pH of human tissue fluid ranges from 7.35. to 7.45. To protect mucous membranes recommended pH ranges for swimming pools is 7.2-7.8.

How is pH Measured?

Indicators:

- pH test kits. Colorimetric tests are based on indicator dyes that change color over a range of pH.
- pH paper. The famous litmus test is based on a vegetable dye that changes

pH

Fact Sheet (continued)

color. Other indicator dyes are more sensitive to changes in pH. Only pH strips with non-bleeding indicators are suitable for water monitoring.

Electrodes (pH meters and probes):

- A two electrode system consisting of a glass electrode containing an electrolyte solution and a reference electrode. When placed in water, an electrical force produced between the internal solution and the water can be measured. This force is a measure of pH.

What Affects it in Water?

Pure water (de-ionized) has a pH of 7.0. What causes the pH to change? There are two major factors:

- Buffering capacity
- Input of basic or acidic substances (manmade or natural)

Buffering Capacity

A buffer is like a chemical cushion that neutralizes acids or bases when added to the water. All natural waters (except rain) have some natural buffering capacity. Examples of natural buffer are:

- CO_2 from the air dissolves in water and forms a buffer (carbonic acid H_2CO_3)
- Minerals (calcium, magnesium, others) which come from rocks, such as limestone, dissolve in water

Input of basic or acidic substances (manmade or natural)

pH can change because of external inputs. You might measure a difference in pH along a stream due to:

- A change in tree type, for example: conifer needles are acidic and maple leaves are basic
- A change in stream bottom material, e.g., gravel vs silt vs bedrock
- A large change in temperature
- A change in human activity affecting the stream

Other Factors

- In fresh water, increasing temperature decreases pH.
- Waters with high algal growth can show a diurnal change in pH. When algae grow and reproduce they use CO_2. This reduction causes the pH to increase. This increase in pH may exceed 8.5, especially during the spring when nutrients are readily available. Therefore, if conditions are favorable for algal growth (sun-

pH

Fact Sheet (continued)

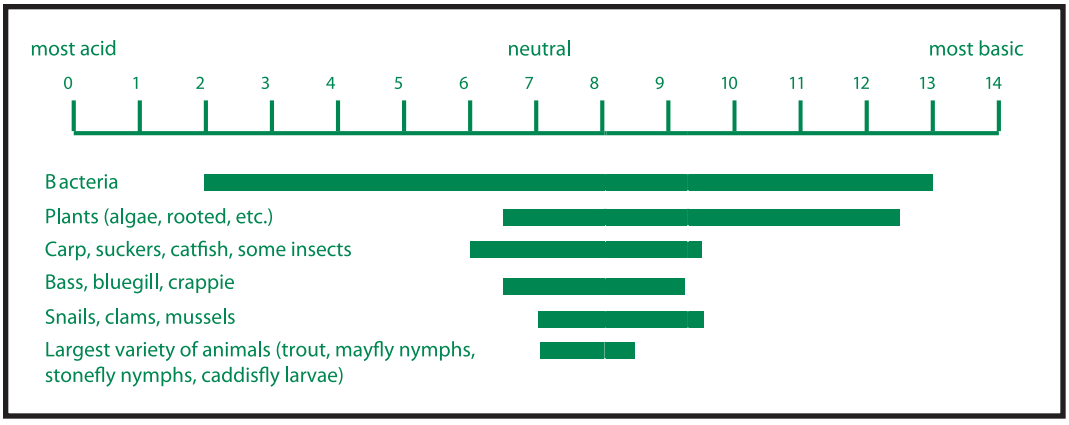
light, warm temperatures), the water will be more alkaline. Maximum pH usually occurs in late afternoon, and pH will decline at night when cellular respiration adds CO_2 to water. Because algal growth is restricted to light penetrating zones, pH can vary with depth in lakes, estuaries, bays and ocean water.

- Manmade inputs that reduce pH include acid rain (from automobiles or industrial sources), and acid mine drainage. Nutrients can indirectly affect pH by stimulating algal growth.

What are Acceptable Ranges?

Most natural environments have a pH between 4 and 9. The pH of seawater is usually between 7.5 and 8.4. In fresh water, pH in the range of 6.5 to 8.5 should protect most organisms. However, the range of pH tolerated by organisms varies, as can be seen in this chart.

pH Ranges that Support Aquatic Life



What are the Water Quality Objectives?

The water quality objectives for pH vary from region to region. Check with the Regional Water Quality Control Board in your area. Water quality objectives are included in their Basin Plan. A general objective states that for ocean waters of California, the pH shall not be changed at any time more than 0.2 pH units from that which occurs naturally.

- For the North Coast Region (Region 1): There are numerical objectives for pH in the Basin Plan. In general, these require the pH to not fall below a certain value (6.5 to 7.5, depending on the water body) or to exceed a certain value (8.0 to 9.0, depending on the water body). For waters without specific objectives, the pH shall not be depressed below 6.5 nor raised above 8.5. Changes in normal pH shall not exceed:
  0.2 units, for waters with marine (MAR) or saline (SAL) beneficial uses,
  0.5 units, for fresh waters supporting coldwater (COLD) or warmwater (WARM) fisheries.
- For the San Francisco Bay Region (Region 2): The pH shall not be depressed below 6.5 nor raised above 8.5.

Name Date

pH

Fact Sheet (continued)

- For the Central Coast Region (Region 3): The objective depends on the beneficial uses of the water. The pH shall not be depressed below 6.5 nor raised above 8.5 for waters that have the following designated uses: municipal and domestic supply, agricultural supply, water contact recreation, and non-contact water recreation. For waters that support cold (COLD) or warm (WARM) freshwater habitat, or marine (MAR) habitat, the pH shall not be depressed below 7.0 nor raised above 8.5. Changes in normal pH shall not exceed 0.5 (COLD, WARM) or 0.2 units (MAR).
- For the Los Angeles Region (Region 4): The pH of inland surface waters and bays or estuaries shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharges. Ambient pH levels shall not be changed more than 0.5 units (inland surface waters) or 0.2 units (bays and estuaries) from natural conditions as a result of waste discharge.
- For the Central Valley Region (Region 5): For the Sacramento and San Joaquin Valleys, the pH shall not be depressed below 6.5 or raised above 8.5. Ambient pH levels shall not be changed more than 0.5 units in fresh waters with designated COLD or WARM beneficial uses. For the Tulare basin, the pH shall not be depressed below 6.5 or raised above 8.3 or changed at any time more than 0.3 units from normal ambient pH.
- For the Lahontan Region (Region 6): In fresh waters with designated beneficial uses of COLD or WARM, changes in normal ambient pH levels shall not exceed 0.5 pH units. For all other waters of the Region, the pH shall not be depressed below 6.5 nor raised above 8.5. However, some waters may have natural pH levels outside this range. Compliance for those waters will be determined on a case-by-case basis. There are pH objectives specfic to certain waters (e.g. Eagle Lake, Lake Tahoe) in the Region.
- For the Colorado River Basin Region (Region 7): Since the regional waters are somewhat alkaline, pH shall range from 6.0 - 9.0. Discharges shall not cause any changes in pH detrimental to beneficial uses.
- For the Santa Ana Region (Region 8): The pH shall not be depressed below 6.5 nor raised above 8.5 as a result of controllable water quality factors.
- For the San Diego Region (Region 9): The pH shall not be depressed below 6.5 nor raised above 8.5 for inland surface waters. For bays and estuaries, the pH shall not be depressed below 7.0 nor raised above 9.0. Changes in normal pH shall not exceed:
  0.2 units, for waters with marine (MAR), estuarine (EST), or saline (SAL) beneficial uses,
  0.5 units, for fresh waters supporting cold (COLD) or warm (WARM) water fisheries.

Sources and Resources

This Fact Sheet is implemented by the Clean Water Team (CWT), the Citizen Monitoring Program of the California State Water Resources Control Board. This fact sheet has been revised by CWT from an original document authored by Gwen Starrett, former State Coordinator for Citizen Monitoring. Please contact your Regional CWT Coordinator for further information and technical support. For an electronic copy, to find many more CWT guidance documents, or to find the contact information for your Regional CWT Coordinator, visit www.swrcb.ca.gov/nps/volunteer.html. If you wish to cite this FS in other texts you can use "CWT 2004" and reference it as follows: "Clean Water Team (CWT) 2004. pH Fact Sheet, FS-3.1.4.0(pH). in: The Clean Water Team Guidance Compendium for Watershed Monitoring and Assessment, Version 2.0. Division of Water Quality, California State Water Resources Control Board (SWRCB), Sacramento, CA."