# pH and Alkalinity

***URI WATERSHED WATCH, Cooperative Extension***
***College of the Environment and Life Sciences (CELS)***
***Department of Natural Resources Science (NRS)***
***Coastal Institute in Kingston, 1 Greenhouse Road, Kingston, Rhode Island 02881-0804***

*Kelly Addy, Linda Green, and Elizabeth Herron*

**URIWW-3, July 2004**

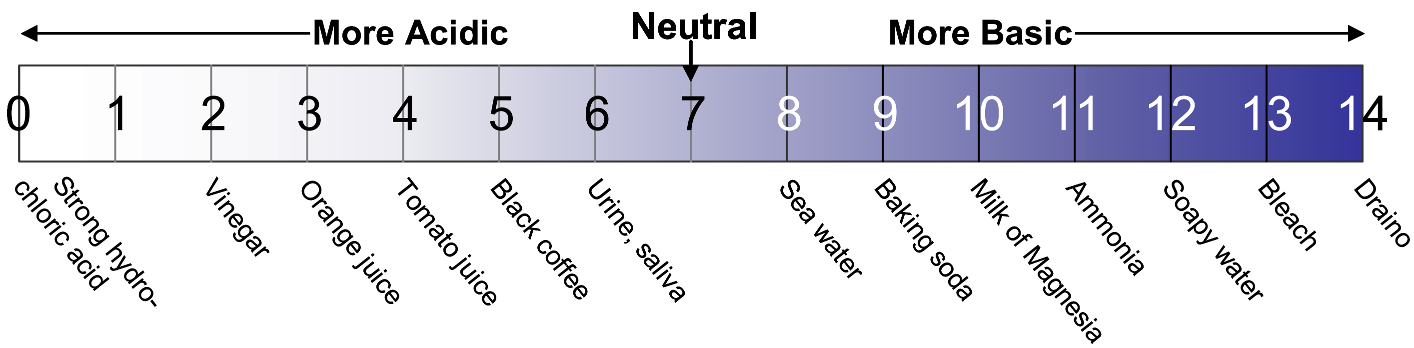



*Figure 1: pH scale and examples of solutions at particular pH's.*

## What is pH?

pH, one of the most common analyses in soil and water testing, is the standard measure of how acidic or alkaline a solution is. It is measured on a scale from 0 – 14 (Figure 1). pH of 7 is neutral, pH less than 7 is acidic, and pH greater than 7 is basic. The closer pH gets to 1, the more acidic. The closer pH gets to 14, the more basic. Examples of the pH of some common items are listed in Figure 1. Acids and bases are two extremes like hot and cold. Mixing acids and bases together can even out the extreme effects much like mixing hot and cold water to even out water temperature.

The pH scale is logarithmic, which means that a unit *decrease* in pH equals a ten fold *increase* in acidity. For instance, tomato juice (pH 4) is ten times more acidic than black coffee (pH 5).

Hydrogen ($H^+$) ions (ions are atoms or groups of atoms with negative or positive charge) control acidity levels. pH measures the concentration of $H^+$ and hydroxide ($OH^-$) ions which make up water ($H_2O$):

$$H^+ + OH^- = H_2O$$

When the two ions are in equal concentration, the water is neutral, whereas the water is acidic if $H^+ > OH^-$ and basic when $OH^- > H^+$.

## Why is pH important?

Aquatic organisms need the pH of their water body to be within a certain range for optimal growth and survival. Although each organism has an ideal pH, most aquatic organisms prefer pH of 6.5 – 8.0. Outside of this range, organisms become physiologically stressed. Reproduction can be impacted by out-of-range pH, and organisms may even die if the pH gets too far from their optimal range.

In addition to directly affecting the physiology of aquatic organisms, additional aspects of lake dynamics are influenced by pH. Low pH can cause the release of toxic elements and compounds from sediments into the water where they may be taken up by aquatic animals or plants. Changes in pH also influence the availability of plant nutrients, such as phosphate, ammonia, iron and trace metals, in the water.

### Water quality standards for pH?

The U.S. E.P.A. considers lakes with pH less than 5 "acidified." Aquatic organisms may be stressed in such acidified lakes. The RI Department of Environmental Management (DEM) has a fresh water pH criteria of 6.5 – 9.0 or as what occurs naturally. The sea water pH criteria is 6.5 – 8.5, but not more than 0.2 units outside the normally occurring range.

## What affects pH?

Some variables that influence pH include:

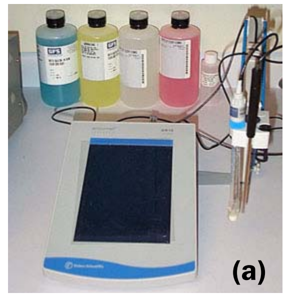
**Bedrock** (the solid rock underlying surface soils) of a location. Since we are in a glaciated area, our water generally has a lower pH (more acidic). However, areas with limestone bedrock, including areas in Lincoln, RI, generally have higher pH waters (more basic).

**Acid rain** (atmospheric deposition). The presence of acid rain can lower the pH in lakes making them more acidic. For more information on acid rain, please visit the U.S. Environmental Protection Agency (U.S. E.P.A.) web site at http://epa.gov/airmarkets/acidrain/

**Water use.** Municipal water suppliers often raise the pH of drinking water to prevent corrosion of pipes, often to pH 9.

**Wastewater discharge.** Materials added to water during domestic water use, such as detergents and soap-based products are often alkaline which can increase the pH of water (more basic). Wastewater treatment facilities are required to adjust the pH of wastewater that is outside of acceptable limits (U.S. E.P.A. range 5 – 10) prior to discharge into streams or estuaries. See the Narragansett Bay Commission's "P2 Facts: pH Control" http://www.narrabay.com/publications.asp for more information.

**Carbon dioxide** ($CO_2$). pH fluctuates throughout the day in a lake or pond largely in response to changing $CO_2$ levels. $CO_2$ dissolved in water forms a mild acid. When $CO_2$ is high, pH falls (more acidic). In the morning, $CO_2$ levels are high as a result of respiration that occurred in the pond overnight. As sun rises, plants and algae begin photosynthesis thereby consuming $CO_2$ and causing the pH to rise (more basic) as the day progresses. Algae blooms can significantly increase this effect.





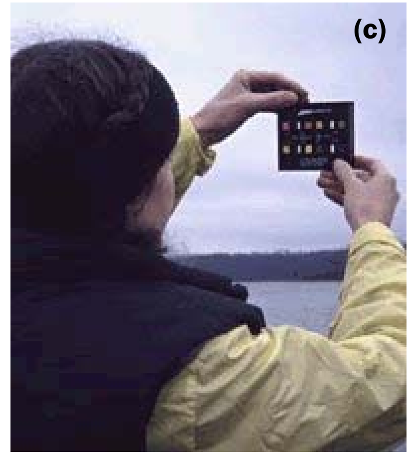



*Fig. 2. (a) Laboratory quality pH meter and electrode with multiple reagents. (b) pH "pocket pal" for field monitoring of pH. (c) Volunteer uses a color comparator to assess pH (photo from EPA).*

## How is pH measured?

pH can be measured electronically or visually. There are three main methods routinely used in water quality monitoring (Figure 2):

1. Laboratory quality pH meter and electrode
2. pH "pocket pals" and multi-parameter probes
3. Color comparators / pH strips

The pH meter and electrode, generally restricted to laboratory analysis of field collected samples, offers the highest degree of accuracy and precision. This pH meter-electrode measures the electric potential which is a function of the $H^+$ activity in water samples. Calibration is completed with two buffer solutions. URI Watershed Watch (URIWW) uses a pH meter and electrode to measure the pH of lake and stream samples.

The latter two methods can be easily used in the field. pH "pocket pals" and multi-parameter probes are electronic hand-held testers that are dipped directly into the water body and provide digital read out of pH. Pocket pals are typically calibrated with one buffer.

With color comparators, you add a reagent to the water sample that colors the sample for a visual comparison. pH strips are dipped into water samples and then change color according to the pH. The intensity of the color is proportional to the pH in the sample, and colors are compared on a chart.

## What is the pH of RI inland waterways?

pH in RI lakes and ponds generally increases as you move from south to north. In 2003, the pH range of inland waterways monitored by URIWW was 5.1 - 8.2 Visit the Monitoring Data page (parameter data) http://www.uri.edu/ce/wq/ww/html/ww_data.htm of the URIWW web site for site specific pH data.

## pH of Drinking Water

The pH of drinking water generally is not a health concern. However, acidic water can leach metals from plumbing systems which can cause health problems. For more information on pH in private drinking water wells, please refer to "Healthy Drinking Waters for Rhode Islanders: pH-Acidity of Private Drinking Water Wells," http://www.uri.edu/ce/wq/has/html/has_wellfacts.html a publication of the RI Department of Health and URI Cooperative Extension.

*Table 1: U.S. E.P.A. Classification[1] of lakes and ponds based on alkalinity as measured in concentration of calcium carbonate ($CaCO_3$).*

| U.S. E.P.A. category | Concentration of $CaCO_3$ (mg/L) |
|---|---|
| Acidified | < 1 and pH < 5 |
| Critical | < 2 |
| Endangered | 2 – 5 |
| Highly Sensitive | 5 – 10 |
| Sensitive | 10 – 20 |
| Not Sensitive | > 20 |

## What is Alkalinity?

Alkalinity is the buffering capacity of a water body. It measures the ability of water bodies to neutralize acids and bases thereby maintaining a fairly stable pH. Water that is a good buffer contains compounds, such as bicarbonates, carbonates, and hydroxides, which combine with $H^+$ ions from the water thereby raising the pH (more basic) of the water. Without this buffering capacity, any acid added to a lake would immediately change its pH.

## Why is alkalinity important?

Aquatic organisms benefit from a stable pH value in their optimal range. To maintain a fairly constant pH in a water body, a higher alkalinity is preferable. High alkalinity means that the water body has the ability to neutralize acidic pollution from rainfall or basic inputs from wastewater. A well buffered lake also means that daily fluctuations of $CO_2$ concentrations (discussed above) result in only minor changes in pH throughout the course of a day.

## What affects alkalinity?

Alkalinity comes from rocks and soils, salts, certain plant activities, and certain industrial wastewater discharges (detergents and soap-based products are alkaline). If an area's geology contains large quantities of calcium carbonate ($CaCO_3$, limestone), water bodies tend to be more alkaline. Granite bedrock (much of RI) is deficient in alkaline materials to buffer acidic inputs. Addition of lime as a soil amendment to decrease acidity in home lawns can runoff into surface waters and increase alkalinity.

## What are the water quality standards for alkalinity?

The U.S. E.P.A. developed 6 categories to describe alkalinity status of lakes and ponds (Table 1). As the concentration of $CaCO_3$ increases, the alkalinity increases and the risk of acidification decreases.

[1]Godfrey, P.J., M.D. Mattson, M.-F. Walk, P.A. Kerr, O.T. Zajicek, and A. Ruby III. 1996. *The Massachusetts Acid Rain Monitoring Project: Ten Years of Monitoring Massachusetts Lakes and Streams with Volunteers.* Publication No. 171. University of Massachusetts Water Resources Research Center.

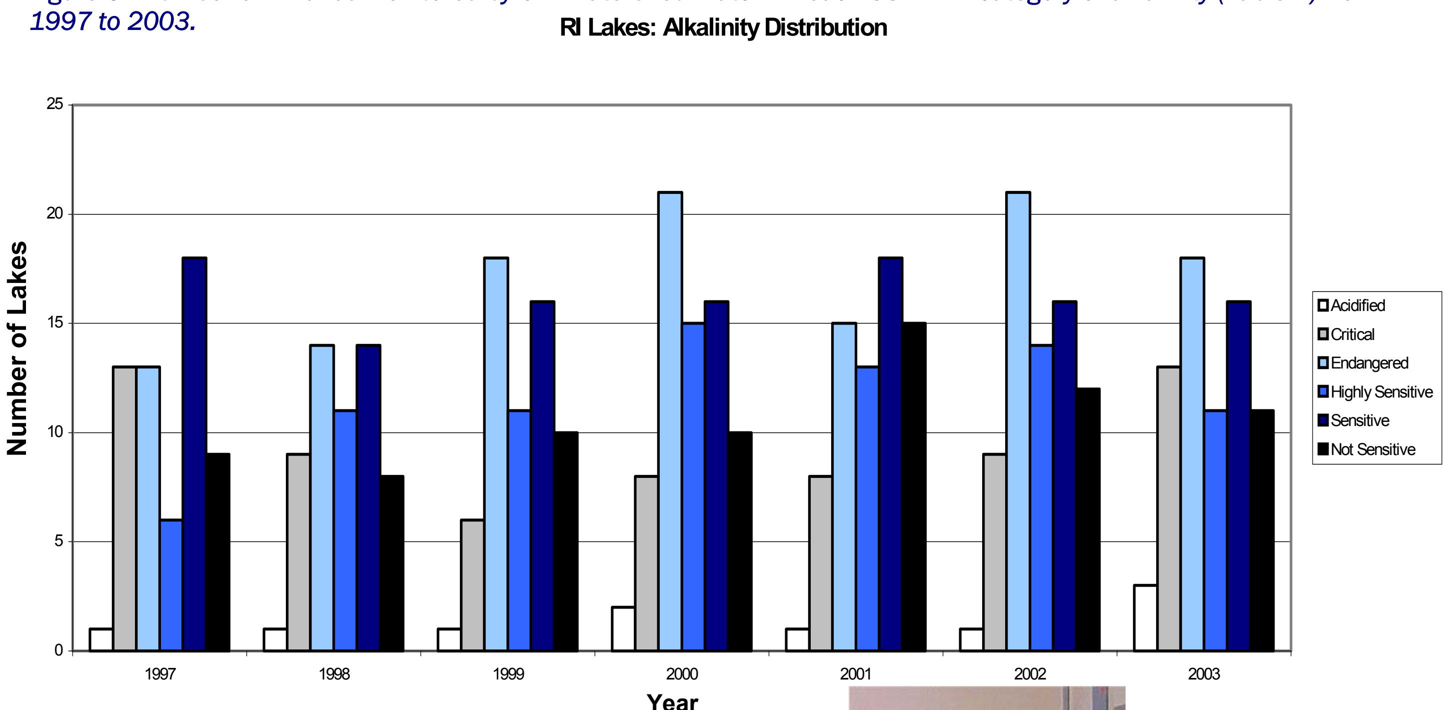
## How is alkalinity measured?

Alkalinity, reported as mg/L $CaCO_3$, is measured as the amount of acid (e.g., sulfuric acid) needed to bring the water sample to a pH of 4.2. At this pH, all the alkaline compounds of the sample are "used up." Laboratory technicians use a buret (a graduated glass tube with a small opening at its base and stopcock for delivering measured quantities of liquid) to dispense the sulfuric acid drop by drop into the water sample while continuously monitoring the change in pH with a pH meter and electrode or pH "pocket pal." Field kits are also available, but they typically target a higher range of alkalinity than in RI waterways.

## What is the alkalinity of RI lakes and ponds?

Through its water collections, URIWW monitors alkalinity three times per year (Figures 3, 4). Only a few ponds have appeared in the acidified category. This appears to be a natural condition for these lakes. The more oligotrophic (low nutrient) lakes tend to have lower alkalinity while eutrophic (high nutrient) lakes tend to have higher alkalinity. In general, most locations stay within the same category from year to year. Visit the Monitoring Data page (parameter data) http://www.uri.edu/ce/wq/ww/html/ww_data.htm of the URIWW web site for more information.

*Figure 3. Number of RI lakes monitored by URI Watershed Watch in each US E.P.A. category of alkalinity (Table 1) from 1997 to 2003.*




To learn more about the URI Watershed Watch program or pH monitoring, please contact:
Linda Green, Program Director
401-874-2905; lgreen@uri.edu
Elizabeth Herron, Program Coordinator
401-874-4552; emh@uri.edu

*Figure 4. Measuring alkalinity in the URIWW laboratory.*

Kelly Addy, M.S., Linda Green, M.S., and Elizabeth Herron, M.A. are members of the Dept. of Natural Resources Science, College of the Environment and Life Sciences, University of Rhode Island. Contribution #4059 of the RI Agricultural Experiment Station, with support from RI Cooperative Extension, RI Department of Environmental Management, and RI Seagrant. Cooperative Extension in Rhode Island provides equal opportunities without regard to race, age, religion, color, national origin, sex or preference, creed or handicap.