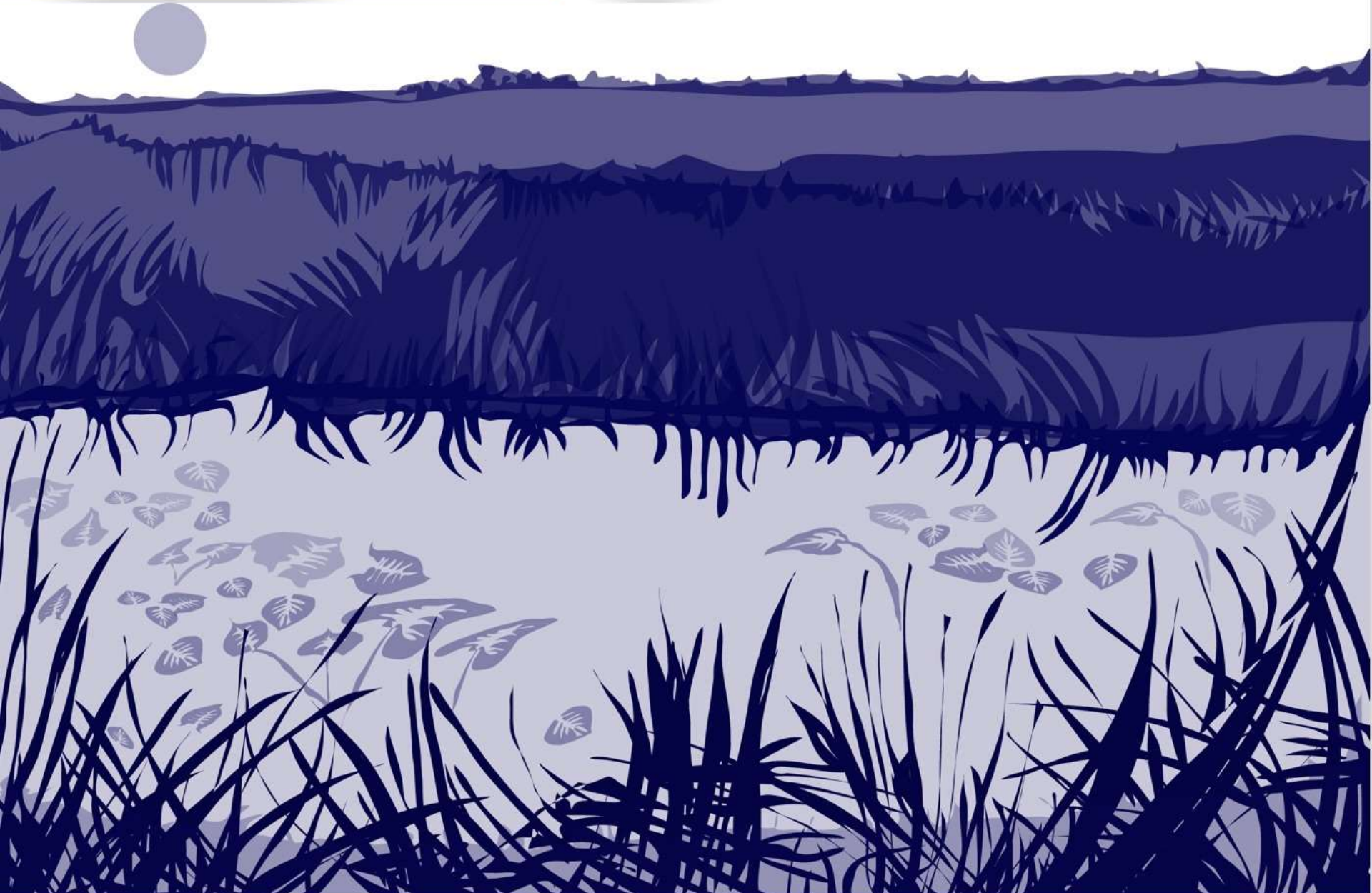
THE GLOBE PROGRAM
A worldwide science and education program

Hydrosphere • Alkalinity Protocol



Overview

- **This module:**
  - **Reviews the selection of a GLOBE hydrology site**
  - **Reviews the water sampling technique used in GLOBE hydrology protocols**
  - **Provides a step by step introduction of the protocol method**

• Learning Objectives

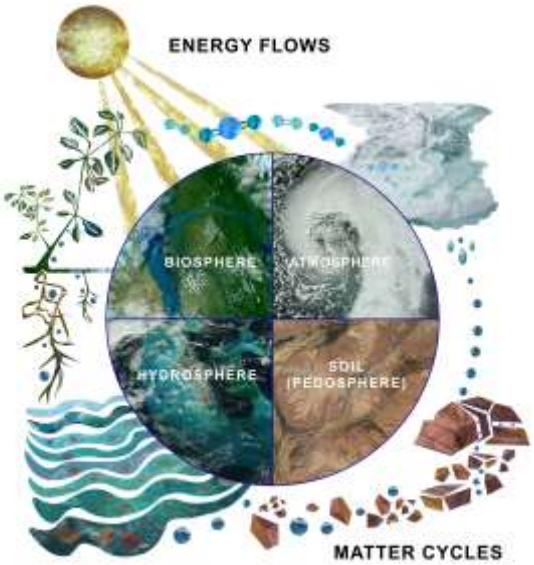
- **After completing this module, you will be able to:**
  - **Define water alkalinity and explain how environmental variables affect the alkalinity of a water body**
  - **Describe the importance of instrument calibration and quality control procedures in the the collection of accurate data**
  - **Conduct alkalinity measurements using a test kit**
  - **Upload data to the GLOBE portal**
  - **Visualize data using GLOBE's Visualization System**

Estimated time to complete this module: 1.5 hours

The Hydrosphere

The hydrosphere is the part of the Earth system that includes water, ice and water vapor. Water participates in many important natural chemical reactions and is a good solvent. Changing any part of the Earth system, such as the amount or type of vegetation in a region or from natural land cover to an impervious one, can affect the rest of the system. Rain and snow capture aerosols from the air. Acidic water slowly dissolves rocks, placing dissolved solids in water.

Dissolved or suspended impurities determine water's chemical composition. Current measurement programs in many areas of the world cover only a few water bodies a few times during the year. GLOBE Hydrosphere protocols will allow you to collect valuable data to help fill these gaps and improve our understanding of Earth's natural waters.



The Earth System: Energy flows and matter cycles.

Alkalinity Protocol

Alkalinity and pH are properties of water that are related, but different. Alkalinity is the measure of the pH buffering capacity of the water. pH, on the other hand, is the acidity of water.

Alkalinity is expressed as the amount of calcium carbonate ($CaCO_3$) in your water, although other substances can contribute to alkalinity as well. The units of alkalinity are either part per million (ppm) or mg/L. These units are equivalent, as 1 ppm = 1 mg/L.

Alkalinity comes from dissolved rocks, particularly limestone ($CaCO_3$), and soils. It is added to the water naturally as water comes in contact with rocks and soil. Water dissolves the $CaCO_3$, carrying it into streams and lakes. Those water bodies that have high alkalinity are well buffered and resist changes in pH even when acid is added to the water.

Why Collect Water Alkalinity Data?

- pH is a very important water quality parameter. Many plants and animals have very specific pH requirements and are harmed by sudden pH changes or extreme pH values. What happens to the pH of your water if acid is added? The answer depends on how much alkalinity is in the water and how much acid is added.
- Let us say your water has a high alkalinity. When acid is added to the water, the alkalinity *neutralizes* the acid. Some of the alkalinity will be used up, so that alkalinity will go down. If more acid is added, the alkalinity will continue to decrease. Eventually, when the alkalinity is low enough, adding acid will cause the pH to decrease.

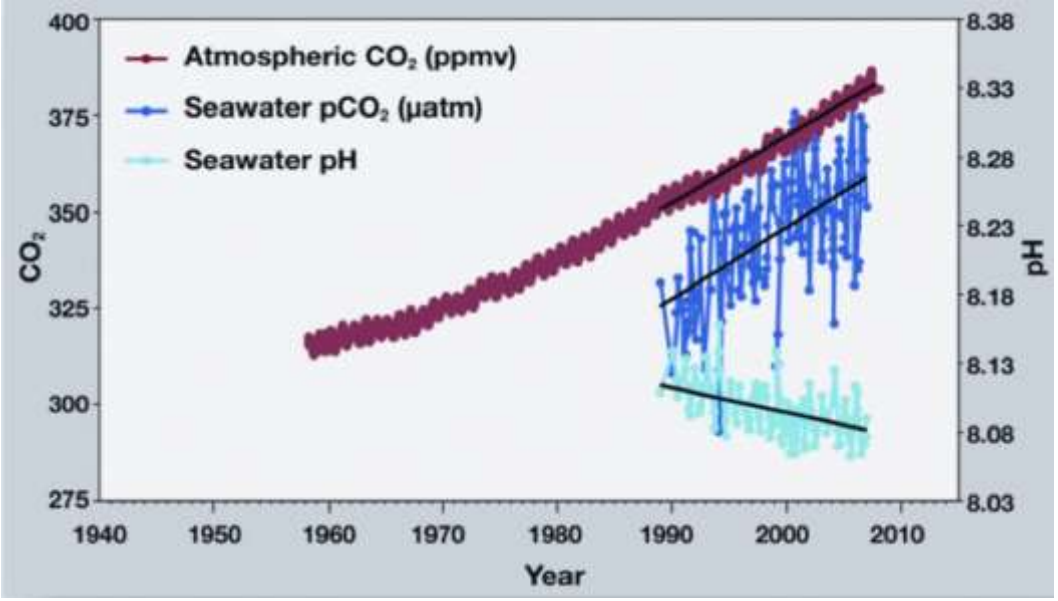
Buffering

When water has high alkalinity, we say that it is *well buffered*. It resists a decrease in pH when acidic water, such as rain or snowmelt, enters it. Alkalinity comes from dissolved rocks, particularly limestone (CaCO3), and soils. It is added to the water naturally as water comes in contact with rocks and soil. Water dissolves the CaCO3, carrying it into streams and lakes. Lakes and streams in areas rich in limestone bedrock will tend to have a higher alkalinity than those in regions with non-carbonate bedrock.

Buffering solutions resist changes. The lake on the right is surrounded by limestone which weather to produce carbonate and bicarbonate ions. These raise the water's alkalinity. The lake on the left is formed in igneous rock, which does not produce carbonates when weathered. The lake on the right is resistant to change when acid is added, whereas the lake on the left will change more readily.

Example: Ocean Acidification-1

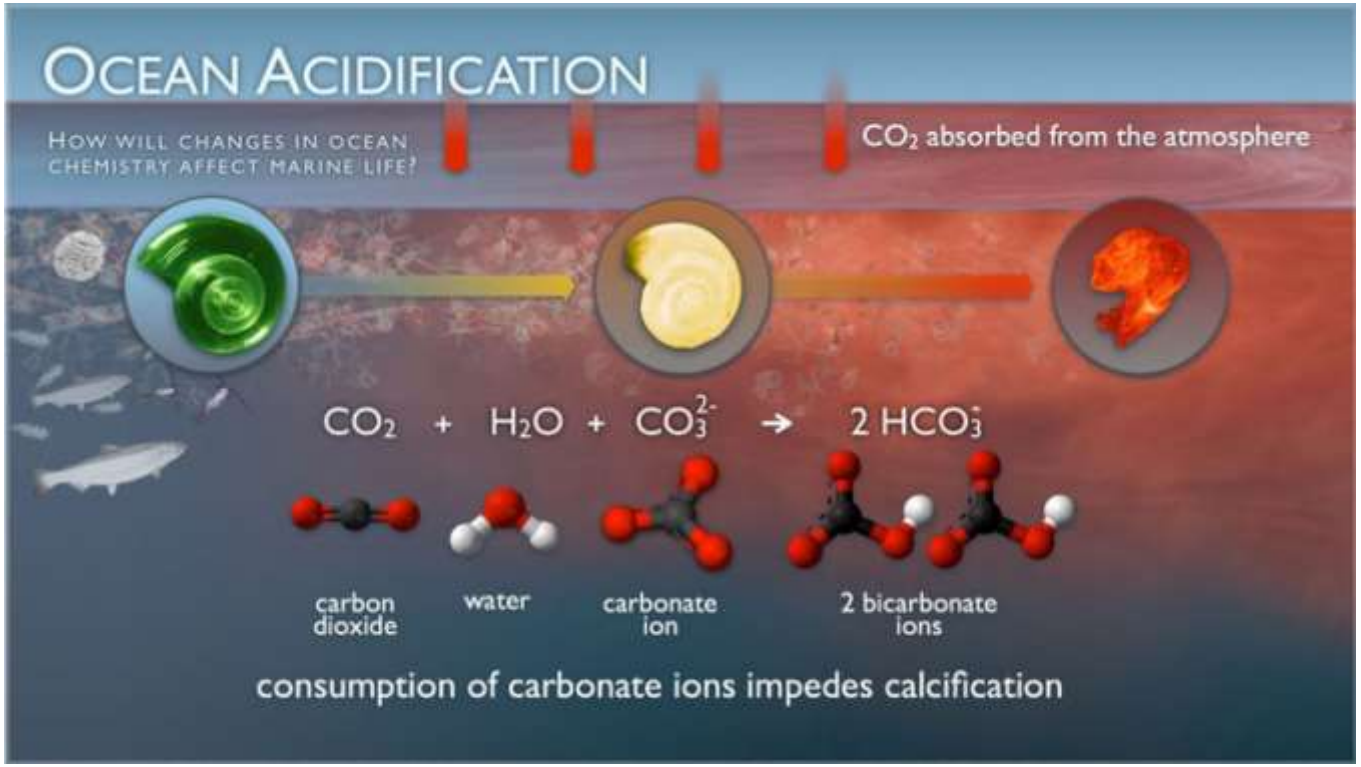
The measurement of pH, total alkalinity and dissolved inorganic carbon are important for monitoring ocean acidification. Ocean acidification (OA) is the decrease in ocean pH as a result of an increase in carbon dioxide ($CO_{2)}$ absorption by seawater. OA is a prominent concern in today's world. CO_2 is pumped into the atmosphere from everyday human activities, such as emissions from vehicles and industrial pollution. Each year approximately 25% of the CO_2 pumped into the atmosphere is absorbed by the ocean. Although plants can use CO_2 for photosynthesis, the increase also has negative implications. As the amount of CO_2 absorbed by ocean the increases, the pH is expected to continue decreasing.



http://www.pmel.noaa.gov/co2/story/OA+Observations+and+Data

Example: Ocean Acidification-2

The pH of the ocean directly affects organisms that form calcium carbonate shells or structures, like corals, oysters, clams and sea urchins. When the ocean water is more acidic, it causes the calcium carbonate to dissolve and makes it more difficult for the organisms to make their calcium carbonate skeletons. Read more here from NASA's Earth Observatory.



http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F

Let's do a quick review before moving onto data collection! Question 1

Alkalinity is expressed as the amount of ____ in your sample

A. Acid

B. Calcium carbonate

C. Sodium chloride

D. Base

Let's do a quick review before moving onto data collection! Answer to Question 1

Alkalinity is expressed as the amount of ____ in your sample

A. Acid

B. Calcium carbonate- correct ☺

C. Sodium chloride

D. Base

Let's do a quick review before moving onto data collection! Question 2

True or false: 1 ppm= 1 mg/L

A. True

B. False

Let's do a quick review before moving onto data collection! Answer to Question 2

True or false: 1 ppm= 1 mg/L

A. True – correct ☺

B. False

Let's do a quick review before moving onto data collection! Question 3

When a water body has high alkalinity

A. It has a low pH

B. It is well buffered

Let's do a quick review before moving onto data collection! Answer to Question 3

When a water body has high alkalinity

A. It has a low pH

B. It is well buffered – correct ☺

Now we will explore how to collect alkalinity data in the following slides

Alkalinity Protocol at a Glance

When	Weekly, if possible. Quality Control Procedure: twice a year
Where	Hydrosphere Study Site
Time Needed	15 minutes, Quality Control Procedure 20 minutes
Prerequisites	Described Hydrosphere Study Site Make your Baking Soda
Key Instrument	Commercial Alkalinity Test Kit
Skill Level	Middle and Secondary
References	Alkalinity Protocol Field Guide Making the Baking Soda Alkalinity Standard Guide Hydrosphere Investigation Quality Control Data Sheet Quality Control Procedure for Alkalinity Lab Guide

Simultaneous or Prior Investigations Required

The Water Alkalinity Protocol will allow you to determine the buffering capability to changes in the pH of your water body. This protocol is conducted at your **GLOBE Study Site**. You will need to define your **GLOBE Study Site** where you will conduct your **Hydrosphere Investigation** prior to beginning this protocol. The **Hydrosphere Investigation Data Sheet** is used to record all the hydrosphere measurements, including alkalinity. You will also want to map your Hydrosphere Site at some point. Since there is a close connection between alkalinity and pH, it would be helpful to collect pH data along with alkalinity. Additionally, atmospheric measurements of temperature and precipitation are helpful in interpreting the data.

Find your documents here:

GLOBE Study Site Definition Sheet

Hydrosphere Investigation Data Sheet

Mapping your Hydrosphere Study Site Field Guide

How to Collect Your Data
Site Selection: Hydrosphere Study Site

All your hydrosphere measurements are taken at the same Hydrosphere Study Site. This may be any surface water site that can be safely visited and monitored regularly, although natural waters are preferred. Sites may include (in order of preference):

- **1. Stream or river**
- **2. Lake, reservoir, bay or ocean**
- **3. Pond**
- **4. An irrigation ditch or other water**
- **body, if natural body is not available**

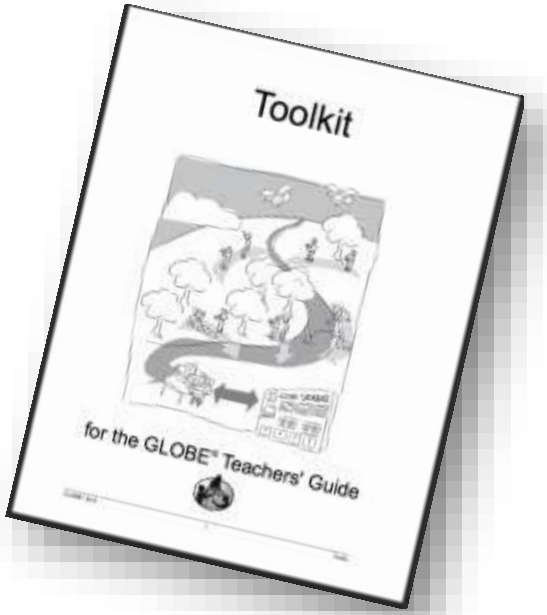
Site Selection: Hydrosphere Study Site

Select a specific site where the hydrosphere measurements (water temperature, dissolved oxygen, nitrate, pH, alkalinity, turbidity, and either conductivity or salinity) will be taken. If the selected study site is a moving body of water (i.e. stream or river), locate your sampling site at a riffle area as opposed to still water or rapids. This will provide a more representative measurement of the water in the stream or river.

If the selected study site is a still body of water i.e. a lake or reservoir), find a sampling site near the outlet area or along the middle of the water body. Avoid inlet areas. A bridge or a pier are good choices. If your water body is brackish or salty, you will need to know the times of high and low tide at a location as close as possible to your study site.

Sources for Equipment You Need for the Water Alkalinity Protocol

The following resources summarize the measurements associated with each protocol, associated skill level, scientific specifications for the instruments, and how to access the equipment you need (purchase, build, or download).



Where to find specifications for instrument used in GLOBE investigations

Where to find scientific instruments used in GLOBE investigations

Quality Control Procedure: Create Baking Soda Alkalinity Standard

Assemble Equipment

distilled water

digital Scale or balance

500 ml graduated cylinder

stirring rod

100 ml graduated cylinder

500 ml beaker

Gloves, safety glasses

Assemble Documents

Making the Baking Soda Alkalinity Standard

Water Alkalinity Protocol: Quality Control Overview

Alkalinity kits are based on the technique of adding a pH sensitive color indicator to the sample and then adding an acid titrant solution drop by drop until a color change is observed. To ensure accurate readings:

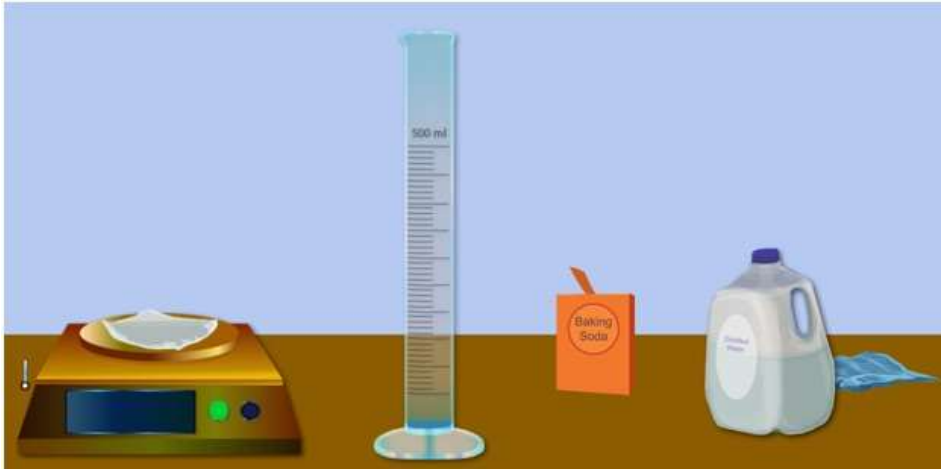
- The alkalinity kit should be kept in a dry place away from direct heat.
- All chemicals should be kept tightly capped.
- Chemicals in the kits should last a year if they are not contaminated, and are stored in a dry area away from extreme heat.
- The alkalinity standard should be kept refrigerated after opening and discarded after one year.
- Store the titrator with the plunger removed to avoid the rubber end sticking in the tube.
- Perform the Quality Control Procedure every 6 months.

Be sure to pay close attention to your quality control procedure. Without the quality control steps your alkalinity data will not be meaningful or comparable to data collected by others!

Quality Control Procedure: Create Baking Soda Alkalinity Standard

1. Weigh out 1.9g of baking soda into 500-mL graduated cylinder.
2. Pour distilled water into the same beaker up to the 500-mL mark.
3. Pour solution into beaker and stir until completely dissolved.
4. Rinse the 500-mL graduated cylinder with distilled water.
5. Using the 100-mL graduated cylinder measure 15-mL of the solution and pour into clean 500-mL graduated cylinder.
6. Add distilled water to the solution in the graduated cylinder to the 500-mL mark.

This is your standard solution and the approximate alkalinity should be 84 mg/L.



Quality Control Procedure for Alkalinity-1

Assemble Equipment

- Alkalinity test kit
- Alkalinity standard, purchased or made
- Distilled water in wash bottle
- Goggles
- Pen or Pencil
- Protective gloves
- 100-ml graduated cylinder

- **Assemble Documents**
- Hydrosphere Investigation Quality Control Data Sheet
- Quality Control Procedure for Alkalinity

- **Time:** 15 minutes
- **Frequency**: Conduct quality control procedure twice a year

Quality Control Procedure for Alkalinity-2

Check the accuracy of the alkalinity kit with this procedure

1. Put on the gloves and goggles.
2. Fill in the top of the hydrosphere Investigation Data Sheet. Make note of the standard being used along with kit manufacturer and model number.
3. Measure the alkalinity of your standard according to your kit's directions.
4. Record the results on the data sheet.
5. Compare the results with the value of your standard. If using the baking soda standard results should be **84 mg/L ± 10 mg/L**. Otherwise check the range for your kit.
6. If measured value is not within the expected range, repeat procedure with a fresh standard sample
7. If the value is still not within range, discuss possible problems with a master trainer.

Maximum Acceptable Differences for Common Alkalinity Test Kits

Kit manufacturer	Precision
LaMotte	± 8 mg/L
Hach	± 6.8 mg/L (Low Range, 0-10 mg/L)
	± 17 mg/L (High Range, 0-50 mg/L)

How to Collect your Data: Alkalinity Water Protocol-1

Assemble Equipment

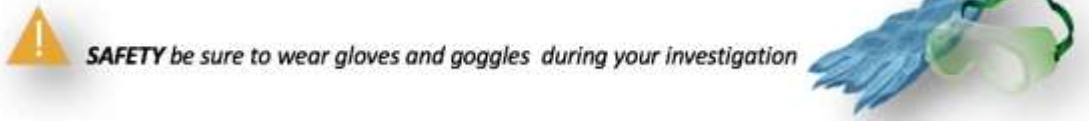
Assemble Necessary Documents:

- Hydrosphere Investigation Data Sheet
- Alkalinity Water Protocol

How to Collect your Data: Alkalinity Water Protocol-2

1. Fill in the top part of the Hydrosphere Investigation Data Sheet.
2. Put on protective gloves and goggles.
3. Follow the measurement instructions according to the alkalinity kit.
4. Record the measurement on Hydrosphere Investigation Data Sheet.
5. Repeat measurement twice using fresh water samples and record on data sheet as observers 2 and 3.
6. Calculate the average.

Each individual measurement should be within acceptable range specified by test kit. If one measurement is not in range, discard and find the average of the other two. If two or more are out of range repeat protocol from step 3.



Technique Tips for Using Alkalinity Test Kits

- Measure carefully. Read the volume of the sample in the sample bottle at eye level Read at the bottom of the meniscus.
- If using a titrator, make sure that the titrator is being read correctly. Most kits include instructions for the proper use of titrators.
- If the alkalinity kit uses drops, hold the dropper bottle vertically so that all of the drops are the same size.
- During the Quality Control Procedure and actual water testing, be sure to note the color change that gives the correct alkalinity. In many kits, it is an intermediate color change that gives the correct alkalinity and not the final color. For kits with an intermediate color (such as a LaMotte kit), if you are not sure when the intermediate color change occurs, read the titrator or write down the number of drops when you think it might be first occurring. For kits with only one color change during titration, add one more drop to see if the color changes further. If it does not, use the previous number you wrote down.

Let's do a quick review- Question 4

How often should you perform the quality control procedure?

A. Every 6 months

B. Once a calendar year

C. Never, as long as you have made your own baking soda alkalinity standard and can vouch for its quality

Let's do a quick review- Answer to Question 4

How often should you perform the quality control procedure?

A. **Every 6 months- correct! ☺**

B. Once a calendar year

C. Never, as long as you have made your own baking soda alkalinity standard and can vouch for its quality

Let's do a quick review -Question 5

Each measurement you make should be within the acceptable range of the test kit. If one of your three measurements is not in the range, you

A. Repeat the protocol from the beginning
B. Discard one of the measurements and average the other two
C. Average all three measurements and make a note in the metadata

Let's do a quick review - Answer to Question 5

Each measurement you make should be within the acceptable range of the test kit. If one of your three measurements is not in the range, you

A. Repeat the protocol from the beginning

B. Discard one of the measurements and average the other two- correct! ☺

C. Average all three measurements and make a note in the metadata

Let's do a quick review - Question 6

When measuring, read the volume of the sample at eye level. Then,

A. Record the measurement at the top of the meniscus
B. Average the value between the top and the bottom of the meniscus
C. Record the measurement at the bottom of the meniscus

Let's do a quick review - Answer to Question 6

When measuring, read the volume of the sample at eye level. Then,

A. Record the measurement at the top of the meniscus

B. Average the value between the top and the bottom of the meniscus

C. Record the measurement at the bottom of the meniscus- correct! ☺

In the next few slides, we will review how to report data to GLOBE and visualize data using the GLOBE Visualization System.

Reporting your Data to GLOBE

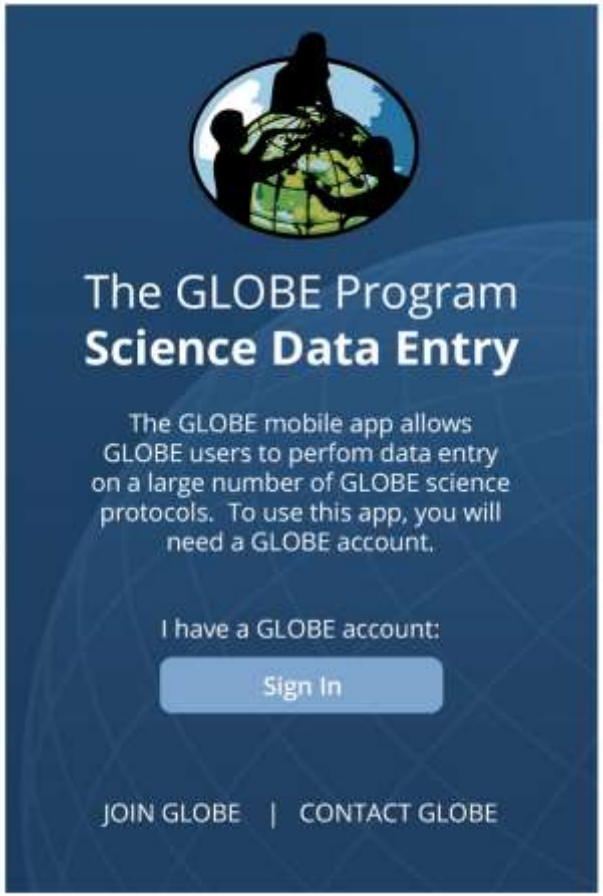
Live Data Entry: Upload your data to the official GLOBE science database

Email Data Entry: Send data in the body of your email (not as an attachment) to **DATA@GLOBE.GOV**

Mobile Data App: Download the GLOBE Science Data Entry app to your mobile device and select the right option.

For Android via **Google Play**

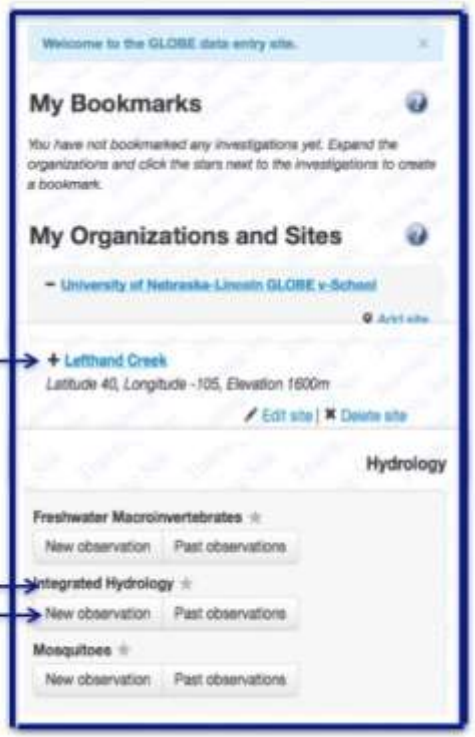
For IOS via the **App Store**



Entering your data via Live Data Entry or Data Entry Mobile App-1

Identify your Sampling site

Select *"Integrated Hydrology"* and *"New observation"*



Entering your data via Live Data Entry or Data Entry Mobile App-2

1. Select water body state

2. Select protocol

⚠ *Be sure to enter data Specifying kind of kit used*

3. Enter each measurement and click "add"

You are done! Want to check who else has submitted alkalinity data using the GLOBE Visualization System?

4. Click to send data

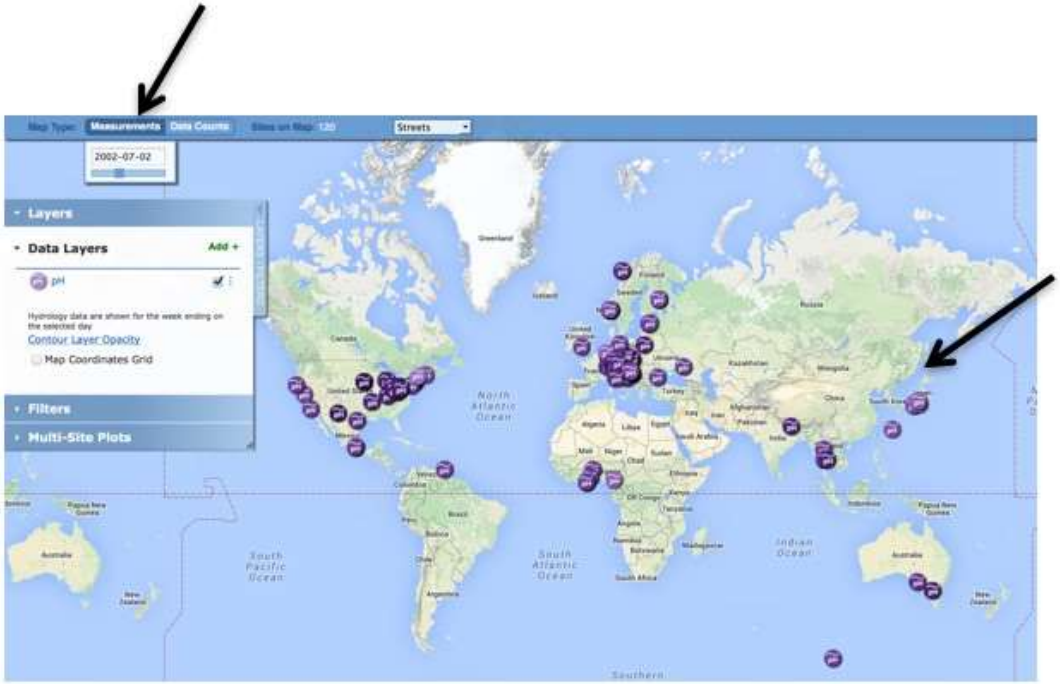
Visualize and Retrieve Alkalinity Data: 1/3

GLOBE provides the ability to view and interact with data measured across the world. Select our visualization tool to map, graph, filter and export nitrate data that have been measured across GLOBE protocols since 1995. Here are screenshots steps you will use when you use the visualization tool:

Link to step-by-step tutorials on Using the Visualization System will assist you in finding and analyzing GLOBE data: PDF verson

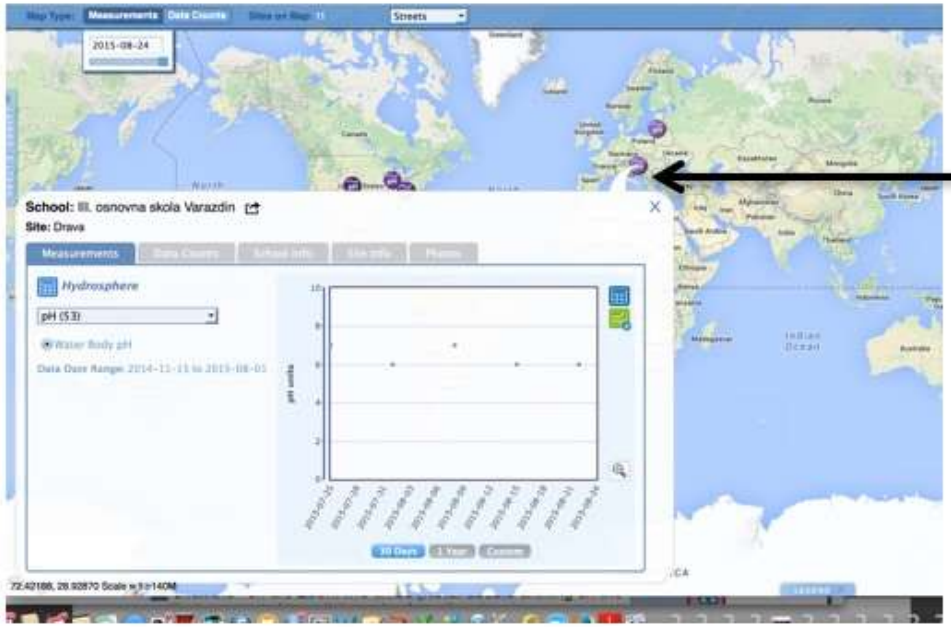
Visualize and Retrieve Water pH Data: 2/3

Select the sampling site for which you need nitrate data, and a box will open with data summary for that site.



Locations where alkalinity data is available for the week you selected

Visualize and Retrieve Water pH Data: 3/3



Clicking on a location will open to a map note providing alkalinity data for that location and time. Follow instructions in the tutorial to download data as a .csv file for analysis.

Review questions to help you prepare to conduct the Hydrosphere Alkalinity Protocol

1. The hydrosphere connects all parts of the Earth system: what are three forms that water can be found on Earth?
2. Where does a water body's alkalinity originally come from, in natural settings?
3. What does it mean when we say that a water body is well-buffered?
4. Alkalinity is reported as the concentration of (this substance)_____ in units of either ppm or _____.
5. If the alkalinity of water is below 100 mg/L , would it be described as or pH sensitive or well buffered?
6. What step do you need to complete before beginning the Alkalinity measurements using the test kit?
7. You should always hold your titrator at a slight angle/vertically/horizontally
8. Most water bodies have alkalinity values between 40-300 ppm. What would that measurement be in mg/L?
9. What are the safety precautions you should take when doing any of the hydrology protocols?
10. How does alkalinity of a water body relate to its pH?

Are you ready to take the quiz?

- **You have now completed the slide set. If you are ready to take the quiz, sign on and take the quiz corresponding to Alkalinity Protocol.**
- **You can also review the slide stack, post questions on the discussion board, or look at the FAQs on the next page.**
- **When you pass the quiz, you are ready to take Alkalinity Protocol measurements!**

FAQ: Frequently Asked Questions

How can I be sure when the color change has happened?

Become familiar with the color change by doing the Quality Control Procedure.

Should I worry if my water site has very low alkalinity?

Some areas will naturally have low alkalinity. This might be true in mountain streams. The waters have not contacted rocks or soil long enough for the rocks to dissolve. This just means that these areas are more sensitive to acid additions.

How do I know if my data are reasonable?

Alkalinity values range from close to 0.0 ppm to more than 500 ppm, although most water bodies will have values between 40-300 ppm. Discovering unusual values in the data often depends on knowledge of typical patterns at a site. If a site has been measured with almost no alkalinity for many months, then suddenly has 300 ppm, students should recognize a deviation from the normal pattern and investigate further. Other sites may naturally have large swings in alkalinity in response to precipitation, snowmelt, or other inputs into the system.

Additional Questions

- **What is the relationship between changes in alkalinity and changes in pH?**
- **How does the type of rocks or composition of soil near the site affect the alkalinity of the water?**
- **What environmental factors can alter the alkalinity of the site?**
- **Are there seasonal patterns or changes in alkalinity at your site? Is this site specific?**

We want your Feedback!

Please provide us with feedback about this module. This is a community project and we welcome your comments, suggestions and edits! Comment here: eTraining Feedback
Questions about the content of this module? Contact GLOBE eTraining: rlow@ucar.edu

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