# ANALYZING HARDNESS

**Objectives:**
The student will be able to:

- The student will be able to test samples of water to determine how a chemical water softener (borax, washing soda) affects water's ability to form suds.

**Suggested Grade Level:**
6-8

**Subjects:**
Chemistry, Geology, Math

**Time:**
Approximately 50 minutes

**Materials:**
- borax or washing soda
- different samples of water including a sample of water from student homes
- distilled water
- second timer
- test tubes with stoppers or small bottles with corks or caps
- medicine dropper
- soap
- marking pencil
- student sheets

## BACKGROUND INFORMATION

Water that contains large amounts of dissolved calcium or magnesium is considered to be "hard." The chemical weathering of rocks containing calcite, dolomite, or ferromagnesium minerals leaching into groundwater supplies or streams is often the source of hard water for home use. Hard water causes several problems in homes.

A reaction occurs when hard water comes in contact with detergents. During this process the calcium ions precipitate the fatty acids from the soap. A form of scum or gelatinous, gray curd forms. The curd forms as calcium ions are removed from the water. This process continues until all of the calcium ions are bound up in the curd. The soap will not lather until all of the calcium ions are bound in the curd. For this reason, households that have hard water must use larger amounts of detergent.

Hard water causes other household problems by precipitating a scaly deposit inside tea kettles, hot water tanks, and hot water pipes. This scaly deposit consists of carbonate salts that, over time, can build up enough to clog an entire hot water piping system in a home. The entire hot water piping system must then be replaced.

"Soft" water carries ions that do not react with the soap and therefore allows lathering. Water softeners are available for home use, that replace calcium ions with sodium ions. The sodium ions do not affect lathering or cause scaly deposits to build up. Soft water containing large amounts of sodium may be harmful, however, for persons with salt-free or low-sodium diets. Soft water tends to be significantly more aggressive than hard water and can leach metals from pipes (primarily lead and copper). Some water suppliers add zinc ortho phosphates to the water to reduce its softness and balance its pH to near 7.0.

## ADVANCE PREPARATION

A. Make a soap solution by dissolving a walnut-sized piece of soap in 1/2 liter (about 1 pint) of water.

B. Collect samples of water from different places, such as a stream, a river, a lake, a well, a spring, and a faucet. You may also use various brands of bottled water from different locations in the US,

# P R O C E D U R E

I. Setting the stage

A. Place half of each sample in a separate bottle so that each bottle is half full. Place distilled water into one pair of bottles. Label each sample.
Ask students to bring in water samples from their homes making sure that they thoroughly clean out and rinse the containers several times before filing the container.

II. Activity

A. Have the students follow these steps:
1. Using a medicine dropper, add ten drops of the soap solution to one of the distilled water samples.

2. After closing the bottle, shake for several seconds and lay the bottle on its side. Observe the suds in the bottle.

3. If, at the end of one minute, no suds remain, continue to add the soap solution one drop at a time until some suds remain at the end of one minute.

4. Record on the student sheet the total number of drops of soap solution needed for the water sample to contain suds.

B. Repeat steps 1 - 4 for each of the different samples of water collected. Record the data on the student sheet.

C. Repeat steps 2, 3, and 4 with the other set of samples. Treat each water sample by dissolving a few crystals of either washing soda or borax in each sample before adding the soap solution. This should make the water sample softer but do not announce this to the students, let them figure it out.

D. Repeat the test with water samples from student's homes.
Have students graph the results of the treatments. (See a sample graph on the student sheet.)

III. Follow-Up

A. Have the students answer the following questions:
1. Using the data you recorded in the table under "No Water Softener," which water sample was the softest? Which was the hardest?

2. List all of the samples in order of hardness, beginning with the softest.

3. Why is the method used in this activity a way of determining the relative hardness of water rather than the actual hardness of water?

4. How were the results different when the samples were treated with a water softener?

5. What conclusions can you draw from the results observed when the chemical water softener was added to the samples?

## IV. Extensions

A. Have groups of students investigate different commercial water softening products that are sold for home installation. Have them look at the method for water softening they use, materials and equipment needed, and how it is to be installed in the home. Have the students give a sales presentation to the class that discusses the options one would have as a homeowner purchasing such a system. Be sure to include the price of the equipment as well as any problems or limitations of each system.

## R E S O U R C E S


McGeary, David and Charles C. Plummer, Physical Geology: Earth Revealed, 2nd Edition, Wm. C. Brown Publishers, Dubuque, Iowa, 1994.

Project Wet: Curriculum and Activity Guide, Watercourse and Western Regional Environmental Education Council, 1995. Obtain from Project Wet: Water Education for Teachers, 201 Culbertson Hall, Montana
.



**Thank you to the Environmental Protection Agency *Water Sourcebook* for this activity!**

**http://water.epa.gov/learn/kids/drinkingwater/wsb_index.cfm**

**STUDENT SHEET**

# HOW HARD OR SOFT IS YOUR WATER?

Directions:
1. Fill each test tube or jar half full with sample water and cap it.
2. Label each sample.
3. Using a medicine dropper, add ten drops of the soap solution to the first sample (distilled water).
4. Shake the sample for five seconds, lay it on its side, and observe the suds.
5. Time for one minute. If no suds remain, add more soap one drop at a time until suds remain for one minute.
6. Record the number of drops added to each sample on the table below.
7. Repeat steps 1-6 with the same samples. Treat each by dissolving a few crystals or washing soda or borax in each sample before adding the soap solution.

UNTREATED SAMPLES

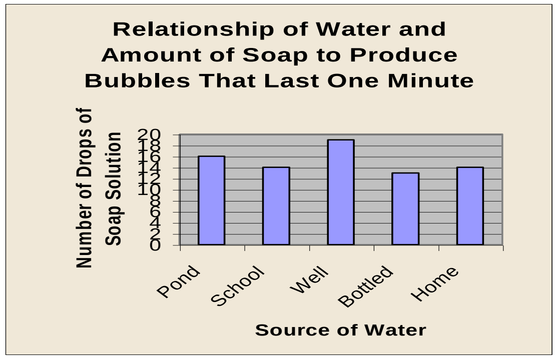
| Sample Type | # Drops of Soap Added | Description of Sample |
|---|---|---|
| 1. Distilled | | |
| 2. School Faucet | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |

TREATED SAMPLES

| Sample Type | # Drops of Soap Added | Description of Sample |
|---|---|---|
| 1. Distilled | | |
| 2. School Faucet | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |

STUDENT SHEET

# HOW HARD OR SOFT IS YOUR WATER?




Example of what your chart should look like. Results will vary.