

## How Hard Is Hard Water?

The water that comes out of the tap at home or school may be “hard” or “soft” depending upon what minerals it contains. Hard water refers to the presence of primarily two elements in water, calcium ( $\text{Ca}^{+2}$ ) and magnesium ( $\text{Mg}^{+2}$ ). Iron, aluminum, manganese and a few others may contribute to water’s hardness, but large amounts of these trace minerals are not usually found in natural waters. Most people use the words “hard” and “soft” associated with the lathering capacity of soaps. The harder the water, the less the lather!

The geology of an area usually determines the source and extent of hardness. Limestone that has been dissolved by slightly acid water (carbonic acid) is the usual source. Granite is not easily dissolved by acidic waters. Thus, areas rich in limestone generally have very hard water and areas that are mostly granite do not. Acidic water is formed when water absorbs carbon dioxide. Carbon dioxide ( $\text{CO}_2$ ) makes up approximately 0.03% of air and is a waste product of plant and animal respiration. Decomposition processes in soil and water also contribute to the carbon dioxide in the atmosphere.

When carbon dioxide combines with water it forms a weak solution of carbonic acid, which is found in most carbonated beverages. This acid reacts with limestone to produce calcium carbonate ( $\text{CaCO}_3$ ), which is a white compound that usually leaves a scaly deposit in pans and teakettles.

There is an important relationship between the amount of carbonates in water and the amount of “bicarbonates,” which are similar compounds. Bicarbonates work like Alka-Seltzer to buffer water against acids. If a water source has a high carbonate content (total alkalinity), it also has a good buffering ability and is much less likely to be affected by acid rain and acid wastewater. In the baking industry, very soft water produces sticky bread dough and soggy bread. On the other hand, hard water used for cooking toughens many vegetables and slows fermentation.

The tables below show common hardness values of water and the recommended hardness values for industrial uses.

There are two different methods used in testing for water hardness. The total hardness test is performed frequently in the water industry. It measures the total amount of calcium and magnesium in water and the results are expressed as *milligrams per liter* (mg/l) of calcium carbonate. The second method determines calcium content only. Water analysis kits can be purchased from various science supply companies (see appendix).

## **Total Hardness (mg/L CaCO<sub>3</sub>)**

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**0 to 60 = Soft water**

**61 to 120 = Moderately hard water**

**121 to 180 = Hard water**

**181 and up = Very hard water**

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## **Industry Comparisons**

<b><u>Industry</u></b>	<b><u>Total Hardness (mg/L CaCO<sub>3</sub>)</u></b>
<b>Brewing beer</b>	<b>200 to 300</b>
<b>Carbonated beverages</b>	<b>200 to 250</b>
<b>Washing clothes</b>	<b>0 to 50</b>
<b>Steel manufacturing</b>	<b>About 50</b>

#### Activity #4:

### “How Hard Is Hard Water?”

Water in Southern Nevada is often referred to as “hard” water. *Hardness* of water is usually caused by calcium ( $\text{Ca}^{+2}$ ) and magnesium ( $\text{Mg}^{+2}$ ). These two elements enter water mainly by the leaching of rocks. You might recall having visited other places and noticed differences in the water when used for certain activities such as drinking, bathing, shampooing or brushing your teeth. In this lab activity, students will test samples for hardness and compare the results.

**Teacher Note:** An explanation of how water softeners work can be found in the Resources section (in the appendix) of this unit.

**Objective:** Upon completion of this activity, students will be able to explain what is meant by water’s hardness property and demonstrate the ability to test water samples for this property.

NEVADA SCIENCE STANDARD 13:12.3

**Time:** One to two class periods

**Materials:** water analysis kits, samples of water (tap water, well water, commercial bottled water, water from local washes and Lake Mead), other liquids to be compared (carbonated beverages, milk, lotions or creams, fabric softeners), graph paper

#### **Procedure:**

- A. Teacher: Briefly review why water is termed “hard” or “soft.” Ask students to recall noting differences in water when shampooing or bathing. Discuss actions taken to reduce hardness.
- B. Students
  1. Follow instructions for using the water analysis kit to test the various samples of water and other substances. (See Appendix for list of companies that sell water test kits. Directions for use are included in each kit.)
  2. Record your data on the Data Sheet.
  3. Use graph paper to graph the data from samples tested.
  4. Write an analysis comparing your test results with that of other students.

**Research:** To strengthen student understanding of *hard* water, encourage students to use library or Internet resources to obtain hardness data from communities in other states or countries. Data may be obtained from state of Nevada or U.S. Geological Survey offices.  
— (Check: <http://www.awwa.org/govtaff/driwapol.html> )

# Water Hardness

## Data Sheet

Substance Tested

Hardness (mg/L CaCO<sub>3</sub>)

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