Hard Water – Soft Water

Topic

Composition of tap water

Introduction

Do you live in a hard water area or a soft water area? You can tell by checking how hard it is getting soap to lather. Hard water makes soap difficult to lather. In soft water, soap lathers very easily. Hard water leaves scale inside kettles and hot water pipes. Hard and soft water have the same chemical formula, H_2O. The difference lies in what is dissolved in this H_2O. Hard water contains lots of dissolved substances, most commonly compounds of calcium and magnesium. These compounds get into the water from rocks that the water flows through. For example, as water flows through limestone (calcium carbonate), there is a reaction between the limestone, water, and carbon dioxide (from the air). This results in calcium hydrogencarbonate becoming dissolved in the water. This compound and others stay dissolved in the water all the way through the purification process at your local water works. These compounds are soluble and safe to drink, and actually have some advantages over soft water – for example, the calcium present strengthens teeth and bones. However, it is the dissolved compounds that make it difficult to form lather with soap. The calcium or magnesium ions combine with the soap ions to form an insoluble compound, which you see as a scum floating on your water. If you keep adding soap, lather will form when all the calcium and magnesium have been precipitated. The soap will then act as a cleaning agent. In this experiment you will investigate which compounds cause hardness, and look at the hardness of your local tap water.

Time required

45 minutes

Materials

Samples of:
- distilled water
- distilled water with a little sodium chloride dissolved in it
- distilled water with a little calcium chloride dissolved in it
- distilled water with a little potassium chloride dissolved in it
- distilled water with a little magnesium chloride dissolved in it
- local tap water
- boiled tap water
- purchased bottled water (you could try several different brands for comparison)

purchased liquid soap solution
graduated cylinders (10 ml)
test tubes
stoppers
watch or clock

Safety note

Read the general safety guidelines given in the Introduction.

Procedure

1. Using a graduated cylinder, pour 10 ml of distilled water into a test tube.
2. Using a second graduated cylinder, pour 1 ml of soap solution into your test tube.
3. Put a stopper in the neck of the test tube and shake.
4. See if you get a good lather – that is, one that lasts about half a minute.
5. If you do not have a good lather, add a further 1 ml of soap solution and repeat stages 4 and 5.

6. Record the volume of soap solution that you had to add to get a good lather in data table 1 below.

DATA TABLE 1

What is dissolved in distilled water	Volume of soap to get a good lather (ml)	How much scum?
nothing		
sodium chloride		
calcium chloride		
potassium chloride		
magnesium chloride		

7. Look carefully inside the test tube. Has any scum formed? Record your observations in data table 1 above.
8. Repeat stages 1 to 7 using water with:
   a) sodium chloride dissolved in it
   b) calcium chloride dissolved in it
   c) potassium chloride dissolved in it
   d) magnesium chloride dissolved in it.
9. Repeat stages 1 to 7 using your local tap water and bottled water. You could try lots of different brands and compare them. Complete a second data table to compare these results.

DATA TABLE 2		
Sample of water	**Volume of soap to get a good lather (ml)**	**How much scum?**
tap water		
boiled tap water		
mineral water brand ...		

Analysis

1. Which water was the softest? Explain how you can tell from the results in your data tables.
2. Which water was the hardest? Explain how you can tell from the results in your data tables.
3. Which substances make water hard?
4. Is it the metal or the chloride ions that make the water hard? How can you tell?
5. Is your local tap water hard or soft?
6. What effect did boiling have on the hardness of your local tap water?
7. By looking at your local area rock types try to explain your answer to question 5.

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4.03 Hard Water – Soft Water

1. The softest water was distilled water, which is pure H_2O and contains no dissolved salts. It took the least volume of soap solution to form lather and no scum was formed.
2. The hardest water was the sample containing calcium chloride. It needed the greatest volume of soap solution to form lather and lots of scum was formed. Depending on the composition of your local water and mineral water, they may be even harder. When calcium ions react with soap an insoluble substance, scum, is formed. Until all the calcium ions have been removed as scum, the soap will not lather.
3. Calcium chloride and magnesium chloride made water hard.
4. It is the metal ion that causes hardness. The chloride ion has no effect – sodium chloride in water had no effect in the experiment, so the chloride ion is not guilty of causing hardness.
5. If your water supply has flowed through rock containing calcium or magnesium, such as chalk, limestone, and gypsum, it will be hard.
6. Boiling reduced hardness of tap water. Boiling water reduces temporary hardness by removing calcium ions from solution. The calcium ions are precipitated as calcium carbonate. This is the scale that forms on the heating element in a kettle or inside hot water pipes.
7. If your water supply has flowed through rock containing calcium or magnesium, such as chalk, limestone, and gypsum, it will be hard.

There are many ways of softening water. Boiling is one example. To remove permanent hardness, you can add water softeners such as sodium carbonate or use an ion exchange resin. Ion exchange is used for large-scale water softening. The calcium ions in the hard water are exchanged for sodium ions in the exchange resin. The water released from this process therefore contains fewer calcium ions and more sodium ions and so is no longer hard.