

HARD & SOFT WATER



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This factsheet was written for teachers and a general audience as part of the BBC 'Terrific Scientific' schools initiative. A factsheet for primary school students aged 9-11 is also available on the website:

www.geolsoc.org.uk/waterhardness



Image Left: Soap bubbles in soft water

Image Right: Limescale crust in a kettle after repeated boiling of hard water (© Henna /Wikimedia)

Have you ever noticed that tap water tastes different depending on where you are? Have you ever seen a white coating inside your kettle or the shower head, or found that the shower gel won't lather up?

All these effects are caused by differences in the 'hardness' of the water.

Hard and soft water – the chemistry

Hard water is water that contains dissolved **minerals** (the materials that make up rocks). Water containing less dissolved minerals is known as **soft water**. In the UK, both hard and soft tap water is safe to drink.

Rainwater is naturally soft, but dissolved **carbon dioxide** gas from the atmosphere makes it slightly acidic. (This should not be confused with 'acid rain', which is much stronger and is caused by different gases). Rainwater soaks into the ground after it falls and then flows slowly through the soil and rocks beneath. **Carbonic acid** in the rainwater dissolves soluble minerals in the rocks, increasing the water's hardness. Other minerals are less soluble so don't increase water hardness.



Hard water: good or bad?

The good:

- Some minerals in hard water have health benefits, such as those containing **calcium**, (good for bones and teeth).
- Some people think it tastes better.

The bad:

- When some hard water is boiled, the dissolved minerals solidify to form a hard white coating of **limescale**. This blocks pipes and stops kettles working so well.
- Hard water forms '**soap scum**' instead of lather when soap is added. This makes washing more difficult, and uses more soap.



Cracks in the rocks grow as soluble minerals dissolve, and may form caves after many years.

Photo: Marble Arch Caves, County Fermanagh, Northern Ireland © Robert Mulraney

Temporary and Permanent hardness

A common mineral which dissolves to form hard water is **calcium carbonate**. This is less soluble in hot water, so becomes a solid again to form '**limescale**' in your kettle. It is known as '**temporary hardness**'. Other minerals (e.g. **calcium sulphate**) cause '**permanent hardness**' which cannot be removed by heating, but can be removed using commercial water softeners. Where water softeners are used it is usually to prevent mechanical problems related to limescale (such as blocked pipes or damage to heating systems).

DID YOU KNOW?

Calcium carbonate is a common mineral which dissolves to form hard water (along with smaller amounts of magnesium carbonate and other minerals). Calcium is found in animal shells and, as **calcium phosphate**, in bones and teeth. Some rocks contain calcium minerals because they are formed from the **fossils** of ancient animals, whose skeletons are usually all that remains after they die. Water found in these rocks often contains lots of dissolved calcium.



Image: Calcium carbonate crystal © Sailko / Wikimedia

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Testing for hard water

- A simple way is by gradually adding soap. The more soap needed to make bubbles the harder the water.
- Water hardness can also be tested using test kits which measure the dissolved calcium carbonate. The map below shows how tap water hardness varies across the UK and Ireland.



KEY

Dissolved calcium carbonate in tap water in milligrams per litre (mg/l):

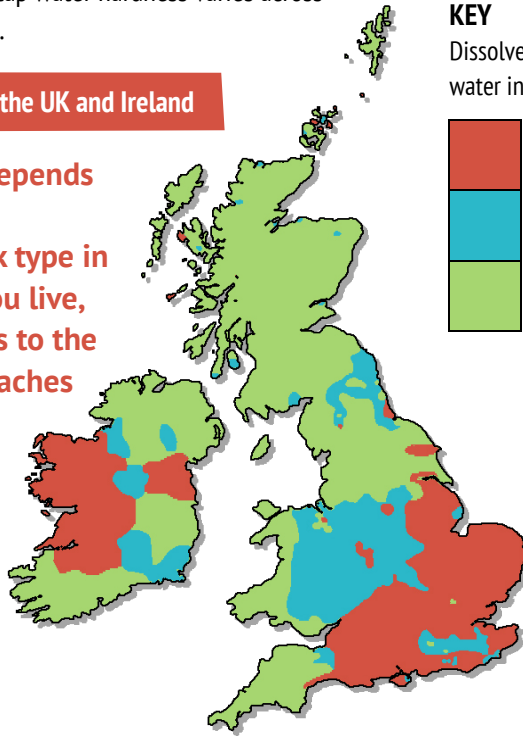
	Hard water areas (more than 200 mg/l)
	Medium hard water areas (100-200 mg/l)
	Soft water areas (less than 100 mg/l)

Map © Waterwise 2006

- If you compare this map with a **geological map** of different rock types in the UK and Ireland, the patterns are similar but not identical. This is because the hardness depends on where the tap water in an area comes from, not just the local geology.

Hard and soft water in the UK and Ireland

Water hardness depends on several things, including the rock type in the area where you live, and what happens to the water before it reaches your tap.



Hard water areas

In much of England and Ireland tap water is pumped out of underground **aquifers** (rocks storing water in cracks and spaces). This is known as '**groundwater**'.

The rocks in some areas are **chalk** (south east England) and **limestone** (Yorkshire), which are made up of soluble carbonate minerals. The water is soft when it falls as rain, but often stays underground for long enough for minerals to dissolve, forming hard water.

Soft water areas

In other areas, such as much of Scotland and Wales, most of our drinking water comes from rivers, lakes and reservoirs, and doesn't collect underground. This is known as '**surface water**'. This water is **soft** because it has not been in contact with rocks for long enough for the minerals to dissolve.

Some rock types are less soluble, so even where drinking water comes from groundwater it may be softer because less minerals have dissolved. For example, the groundwater is often softer in areas like Nottingham where the main rock is **sandstone**, which is made up of less soluble mineral grains.

Chalk, limestone and fossils

Hard water areas get groundwater from chalk or limestone rocks.



Chalk cliffs at Seven Sisters, Dover, UK

- **Chalk** is a soft rock which forms the 'white cliffs of Dover'.
- **Limestone** is a stronger grey rock which can form spectacular caves such as those in South Wales.

Both these rocks are made of the soluble mineral **Calcium Carbonate**, which formed millions of years ago from the skeletons of sea animals. After the animals died they sank to the seabed and the soft parts of their bodies rotted away. Their hard skeletons were buried and eventually turned into **fossils**.



Fossil Ichthyosaur (marine reptile) skull found on the Jurassic Coast, UK

Why was part of the UK underwater?

Millions of years ago, the Earth's climate was warmer than it is today. Ice at the north and south poles had melted, so the sea level was higher. Chalk and limestone formed when parts of the UK were at the bottom of a shallow sea that covered much of Europe!

Sometimes it's not that simple!

Why you might get unexpected results if you test your water...

The water in your tap could have come from groundwater nearby, or a reservoir further away. The source could also change throughout the year depending on rainfall. So even in a 'hard water area', the water could be softer than expected. One example is Birmingham, where water comes from reservoirs in Wales!



FIND OUT MORE...

- **100 Great Geosites**
www.geolsoc.org.uk/100geosites
- **The Rock Cycle (KS3)**
www.geolsoc.org.uk/rockcycle
- **Fact Sheets**
www.geolsoc.org.uk/factsheets