Scottish Schools Equipment Research Centre
SSERC

Primary Science & Technology Bulletin

For Primary Schools and Teachers of S1/S2 courses

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Water, water everywhere

"When the well is dry, we know the worth of water."
Benjamin Franklin (1706-1790).

Figure 1 - Global warming - is it a reality?

As more and more is found out about the effects of global warming on the Earth, the influence that water in the oceans and in the air can exert on weather patterns becomes more apparent . The finite amount of water in, on and around the planet can, if its location or state changes, cause problems for mankind. Scotland has had a very wet Autumn, with more than twice the expected level of rainfall from October to December. This led to widespread flooding, traffic disruption and school closures. At the same time, Australia has suffered from its worst drought since records began.

Antarctica is the driest continent, and its Polar region only receives about the same amount of moisture as a hot desert. However, the snowflakes that fall there have been accumulating undisturbed for hundreds of thousands of years. Each flake contains information about the dust, gas and chemicals that were in the atmosphere at the time it was created, so it can provide scientists with information on environmental conditions from long ago.

Water is unusual because the three states of matter (solid, liquid and gas) can be shown to children at easily achievable temperatures. They will be familiar with the solid (ice), the liquid (water) and can detect the presence of the gas (water vapour) if they breathe on a cold window or mirror and the invisible gas condenses into liquid water droplets. If you look at the emissions from a boiling kettle, invisible water vapour occupies the space close to the spout. We often think of steam as a cloudy, white "gas," but that white mist is actually just tiny liquid droplets suspended in the air.

Did you know?

If all the Polar ice melts, sea level would rise by 60 metres. Many of the world's major cities are near the coast and would be devastated by such a change. Witness the terrible effects on New Orleans by Hurricane Katrina. This had a storm surge of "only" 8 metres.

97% of the world's water is salty or otherwise undrinkable; 2% is locked up in glaciers and the ice caps so only 1% is available for all the needs of the world's population.

Although it is possible to live without food for more than a month, a person can only live without water for about a week.

Water makes up 75% of your brain, 83% of your blood and 25% of your bones. As may be expected, most fruits and vegetables have substantial water content. However, there is a surprising amount of water in many other foods.

Food	% water
Strawberry	91
Apple	86
Grapes	83
Melon	93
Banana	76
Cucumber	96
Lettuce	97
Carrot	88
Tomato	97
Pasta	72
Turkey (cooked)	62
Eggs (raw)	74
Bread (wholewheat)	35
Butter	20
Cheese	37

(see http://www.thefruitpages.com/contents.shtml and http://waltonfeed.com/self/h2ocont.html)

Dinosaurs may have drunk the same molecules of water that are in your cup of tea or can of cola today.

You can find other interesting water related facts at www.freshwater.org & www.njawwa.org/kidsweb/waterfacts/waterfacts.htm & http://witcombe.sbc.edu/water/waterfacts.html

Water related activities

These can be a source of fun at the same time as being educational. If you are trying to find a topic with cross-curricular potential, water may well just fit the bill.

Salty and fresh

To demonstrate the relative amounts of salt and fresh water on the planet Earth you can use a 2 litre clear plastic bottle, add 1940 cm^3 water with a little green food colouring to represent salt water, and on the top layer, 60 cm^3 oil to show the amount of fresh water.

Figure 2 - Relative proportions of salty:fresh water on Earth

Food colouring is water based so will not mix with oil but you may be able to buy coloured oil intended for use in oil burners at home.

Salt water tester

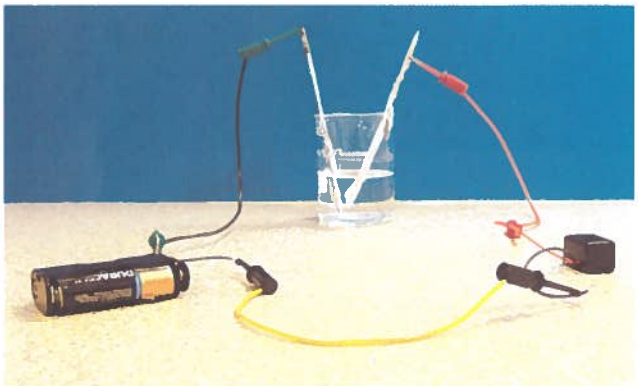


Figure 3 - Testing salt/fresh water to see if they conduct electricity

Why not construct a tester to see if salt and/or fresh water conduct electricity? If electric circuits are familiar then connect a buzzer into a circuit (Fig. 3) made with two lolly sticks covered with aluminium foil (test probes). Check the buzzer is connected correctly in the circuit with the battery (black wire to black wire and red to red) by touching the two foil sticks together and listening for the buzz. The battery shown is made up of two 1.5 V cells in a battery holder (SSERC Stock No. 835, battery holder only, 20p). A light bulb can be used but needs more electricity than a buzzer to function. Hold the probes in the test liquid (salty or fresh water) about 2-3 cm apart. If the test liquid completes the circuit and allows the current to flow, the buzzer will operate. If the buzzer sounds then the test liquid conducts electricity.

Sticky water

A water molecule consists of one oxygen and two hydrogen atoms bonded together. These are arranged in a way that makes them "attractive" to other water molecules. It may seem strange to think of water molecules as being "sticky" but they do have this interesting quality, which can form the basis of simple investigations.

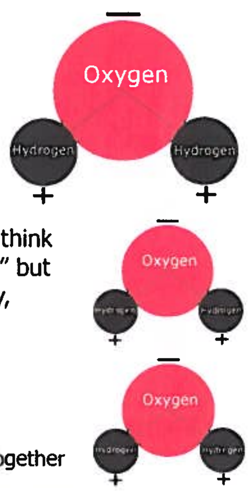


Figure 4 - Water molecules 'stick' together

Surface tension

Figure 5 - Water beads on polished surfaces

A very simple way to demonstrate the "stickiness" of water (surface tension) is to drip one drop of water on to a hard, polished surface . You can see it forms a little mound as all the molecules try to cling to each other (Fig. 5), rather than spreading out over the surface. You will be familiar with this phenomenon when rain falls on to glass, or when you see dew drops on a leaf or a blade of grass.

Figure 6 - Dome of water on coin caused by surface tension.

An interesting challenge for children is to see how many drops they can fit on the surface of a coin, before the water spills over the edge. They should be able to see that the liquid forms a mound on the coin. If they start with a one pence piece, they could try and predict how many drops a two pence would hold. To extend the activity further, they could try using other liquids e.g. milk, juice, washing up liquid, vinegar etc. Glass or plastic eyedroppers can be bought from your local chemist.

Figure 7 - How many coins can you add before it overflows?

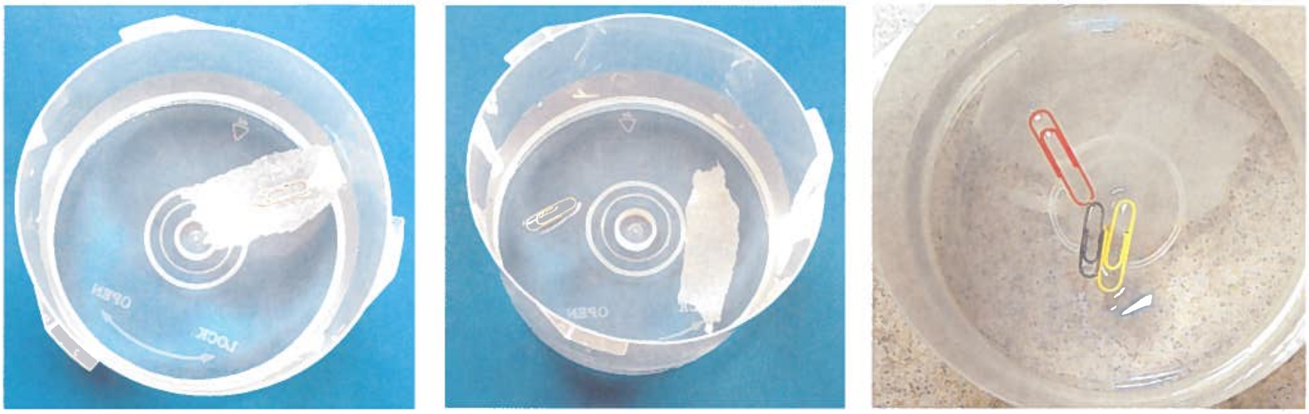
Pupils can also see surface tension at work if they fill a container (plastic cup, yoghurt carton) right to the top with water, and then add coins to see how many can be slipped in before the water spills. Make sure the rim of the container is dry at the start. There should be an obvious bulge of water above the top of the container as the coins are added.

Floating insects and metal

Pond skaters (common water-strider or *Gerris lacustris*, Fig. 8) are insects (2 cm long) which use surface tension, in combination with their sensitive water repellent hairs, to move over the surface of ponds to catch other insects which fall in the water.

Figure 8 - Pond skater

Try floating a paper clip on the water surface in a beaker of water. Most children would expect, from previous experience, that such a metal object would sink. To achieve this, lay the paper clip on a small piece of tissue or kitchen



Figures 9, 10 & 11 - Float paper and paperclip on the surface, the paper absorbs water and sinks & how many can you float at once?

roll. Carefully lower the paper on to the surface of the water. In a short time the paper should get soggy and sink, leaving the paper clip floating (Figs. 9, 10 & 11). (You can push the paper down with a pencil if it is taking too long and your audience is getting restless!) How many paper clips can you float at once? Try adding a drop of washing up liquid or soap to the water. What happens to the surface tension and therefore the paper clip?

Water zip-wire

Figure 12 - Water hangs on to the string as it follows it down.

Because of its sticky properties, water can be persuaded to bridge a gap by travelling along a string. Tie a piece of string round the end of a tap (Fig. 12) and slowly drip water on to the top end. Have a container at the other end of the string to prove that the water has travelled and has been collected. As you have already seen, water molecules will stick to each other (cohesion); they can also stick to other materials, like string (adhesion). You can experiment with different kinds of string, wool, threads etc. Try using two or more strands close together. It helps to wet the string first.

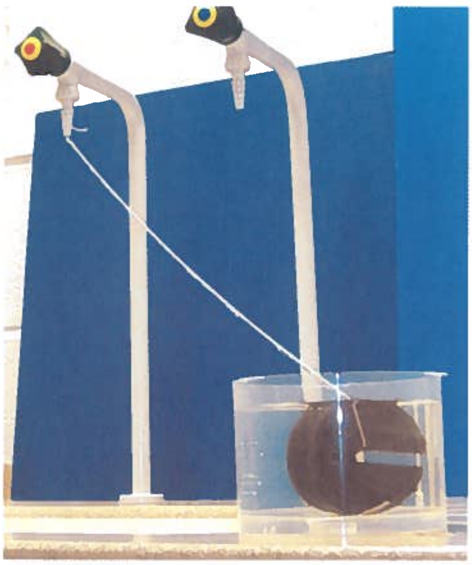


Figure 13 - Reservoir fills up at the end of the line.

Simple syphon

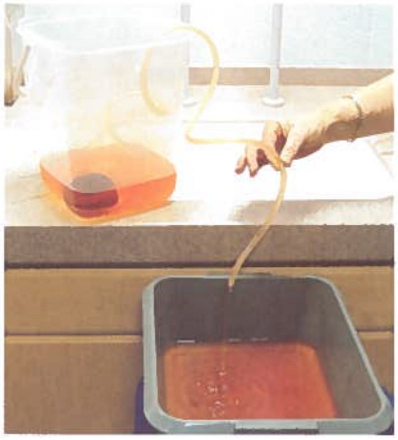


Figure 14 - Syphon at work.

Another way to move water is to use a syphon. By using a piece of tubing, water can be transferred from a higher container to a lower one. Fill a bucket with water. Put one end of a flexible tube into the water and slowly lower in the rest of the tube so that it fills with water and there are no air bubbles. Holding one end of the tube firmly under the water, close the other end by putting your thumb over it and lift this over the edge of the container. Have a suitable container down below and guide the closed off end into it. When you release your thumb the water will flow uphill and out of the higher container to the lower one. Syphons work because atmospheric pressure acts on the surface of the liquid. In fact, if you had a long enough tube, you would find that atmospheric pressure would support a column of water 9.75 metres (32 feet) high!

Bending a stream of water

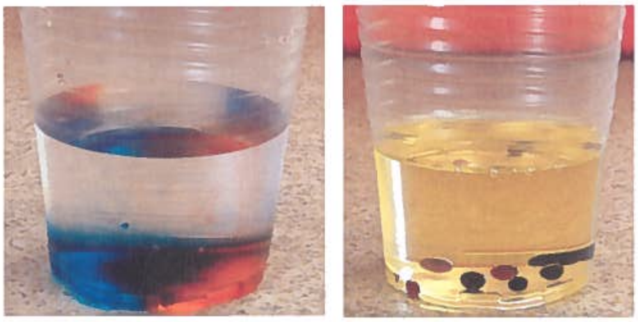
Figure 14 - Stream bend

Pupils can try bending a stream of water using static electricity. If they charge a plastic rod or ruler by rubbing it on their clothing or hair and then hold it near a steady stream of water from a tap, they will find that water is pulled towards the plastic object.

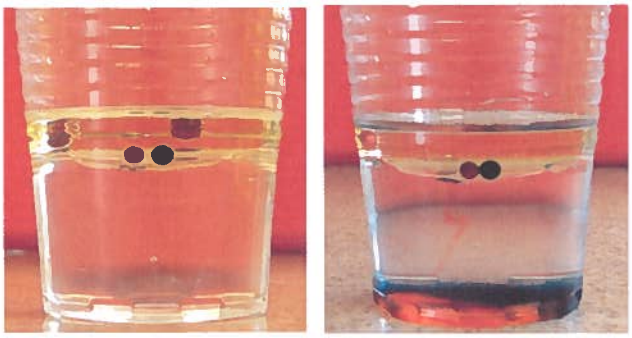
Pouring oil on troubled waters

Water and oil do not mix easily and there are a number of activities which show this. Fill a plastic cup one third full of water and another one third full of cooking oil. Let a few drops of food colouring fall on separate areas of the liquid surface in the two cups. Observe that the drops fall to the bottom of the water and start to spread out (Fig. 15). The drops on the oil also fall to the bottom of the cup but stay as discrete little balls (Fig. 16). When the children have seen what happens, fill a another cup one third full of water and add enough oil to make a thin layer on the top of the water.

Ask the pupils to predict what might happen if you drop on food colouring as before. You will see that the coloured droplets come to rest at the base of the oil layer (Fig. 17). However, if you poke them down with a pencil point, into the water below, they lose the tight ball shape and spread out in the water (Fig. 18). Left long enough, they will eventually fall down by themselves. Food colouring is mostly made of water, so it mixes easily in the cup with water but does not mix with the oil. This can be relevant to classes studying properties of materials.



Figures 15 & 16 - Food colouring into water (left) and oil (right)



Figures 17 & 18 - Food colouring balls sit in the oil layer then sink through and disperse into the water layer after a while.

Acid rain

Your pupils may have heard of acid rain. This can damage rivers, lochs, and thereby affect plant and animal life. Atmospheric pollution occurs when gases such as sulphur dioxide and nitrogen oxides are released into the atmosphere. This can be from natural sources, such as volcanoes and rotting vegetation or by human activity, such as industrial processes or the burning of fossil fuels. These gases can dissolve in the water vapour in clouds and fall as very dilute sulphuric and nitric acid rain.

You can use the following activity to demonstrate the weathering effect of dilute acids on rocks such as limestone

Figure 19 - Looking at the effects of vinegar, lemon juice and water on three samples of chalk.

(calcium carbonate). Some white blackboard chalk is made of the same material. Coloured and some makes of white chalk are made of calcium sulphate and will not work.

Figure 20 - Results

Set up three containers (e.g. plastic cups, Fig. 19). Label each cup, water *W*, lemon juice *L* and vinegar *V* and fill each about a third full of the appropriate liquid. Put a stick of chalk in each one and observe what happens. You should see bubbles forming in the vinegar and lemon juice cups, which shows that there is a chemical reaction taking place. There will be an observable change to the stick of chalk after quite a short time (Fig. 20). Lemon juice and vinegar, although weak acids, are considerably stronger than acid rain but they will show a speeded up version of what happens to rocks subjected to acid rain over a long period of time.

Flushed away

Because of the increasing numbers of people on the planet, who must all service their water needs from the finite amount of water available, it should encourage all of us to conserve water where possible. It has been estimated that families in America could save up to 50% of the water they use by implementing simple conservation measures.

Pupils could try and calculate how much water may be wasted, for example, from a dripping tap. Put a small container in a sink and turn a tap so that it is dripping slowly. After a suitable time interval, measure the water collected and calculate how much water would be lost after a day, a week, a year etc. (One drip a second can use up as much as 10,000 litres in a year.)

They can also work out how much water they use when taking a shower. Using a bucket, collect water from the showerhead, running at the rate they use when showering, for a short time (maybe 10 s?). Measure the amount collected using cupfuls or other small containers). If they time how long they normally take for a shower, then they can calculate how much water was used.

The study of water as a topic would not be complete without some consideration of where water goes after we have used it for various purposes and it leaves our homes by way of drains. Wastewater, including sewage, going to water treatment plants is, in fact 99.9% water, with only 0.1% impurities. An entertaining and helpful explanation, of various aspects of water treatment, including what you put down your toilet, can be found at :-

www.sandiego.gov/mwwd/kids

It is important that children are aware that certain substances should not be put down drains. Best practice may not always be followed in their homes, so a discussion of the problems which may be caused by fat/grease clogging up pipes, the pollution caused by excessive use of detergents and bleach, inappropriate disposal of paint or oil down street drains etc might help to make them more environmentally conscious citizens in the future.

You can get a free game from the Institution of Civil Engineers called *Flushed Away* which "encourages creativity, problem-solving and invention":-

www.ice.org.uk/education/homepage/flushed_away_form.asp