Background information

The GLOBE water investigations help us to understand our natural environment and to what extent human activities are affecting the quality of our water. We can also develop a better understanding of our land and water resources to help make decisions about how we use, manage and enjoy water resources.

Water is one of the most abundant and important substances on Earth, yet despite its abundance we cannot use most of Earth's water.

97% is seawater, 2.7% is ice, leaving just 0.3% available as fresh water

Water sustains plant and animal life, plays a key role in the formation of weather and helps to shape the surface of planet Earth through erosion and other processes. Water continually circulates between the Earth's surface and its atmosphere in what is called the water cycle - one of the most basic processes in nature.

Water carries many impurities as it travels through the water cycle. These impurities give it a distinctive chemical make-up, or quality that is reflected in, and indicated by, water pH and many other measurable characteristics.

Water transparency
A measurement of how clear or transparent the water is.
Most natural waters have a transparency ranging from 1 metre to a few metres. A low value, under 1 metre denotes a high concentration of suspended solids, organic (e.g. algae) or inorganic (e.g. mud).

Water temperature
Temperature is largely determined by the amount of solar energy absorbed by the water. This energy, in the form of heat, moves through the body of water. However, without mixing, the surface is usually more influenced by the air temperature than the bottom. Therefore, in the summer, the surface is usually warmer and colder in winter, than the bottom.
Water temperature strongly influences what can live in it. The colder oceans on the earth are much more biologically productive than warm waters such as the tropics.
There is also a relationship between temperature and the amount of oxygen that can be dissolved in it. The lower the temperature, the more oxygen can dissolve. Conversely, at higher temperatures, less oxygen can be dissolved.

Dissolved oxygen
Water is a molecule made of two hydrogen atoms and one oxygen atom, hence H_2O. However, mixed in with the water molecules of any body of water are molecules of oxygen gas that have dissolved. This dissolved oxygen is essential for animal life as it is used in respiration. Without sufficient levels of oxygen in the water aquatic life suffocates. Dissolved oxygen levels of below 3 mg/L are stressful to most aquatic organisms.
All living things require oxygen and a healthy water body has a sufficient amount of oxygen dissolved to meet demand. Large amounts of organic materials such as human faeces, animal slurry and milk can reduce the oxygen content because of the additional increase in bacteria numbers needed to break them down. Bacteria respire using vast quantities of oxygen from the water.

Water pH
pH is a measure of the acid content of water. The pH scale runs from 1 (acidic) to 14 (alkaline). Distilled water, which has no impurities, has a pH value of 7. Water with an equal balance of acid and base content will also have a pH of 7 (neutral). The range found in most natural waters is approximately pH5.5 – 8.5

The pH scale is logarithmic, which means that a one unit change in pH represents a factor of ten change in the acid content of the water.

The pH of a water body depends on:

- The type of rock over which the water flows i.e. chalk releases calcium carbonate making the water alkaline
- The effects of human activity, especially acid rain

The pH of any water body has a strong influence on what can live in it. Most insects, amphibians and fish are absent in water bodies with pH below 4

Conductivity
Pure water is a poor conductor of electricity. It is the impurities in water, such as dissolved salts, that enable water to conduct electricity. This measurement gives a good indication of the total level of impurities in fresh water. The more the impurities, the greater the electrical conductivity.

Chemically, a salt is: The neutral compound formed by the union of an acid and a base

For agricultural and industrial uses we want water that has a total dissolved solids contents below 1000-12000 parts per impurity per million parts water by weight (ppm) or an electrical conductivity below 1500-1800 microSiemens/cm.
Above these levels crops can be damaged.
For household use we prefer less than 500ppm or blow 750 microSiemens/cm. Pure alpine snow has a conductivity of about 5-30 microSiemens/cm.

Salinity
Salinity is a measure of the saltiness of water and is expressed in parts impurity per thousand (ppt) parts of water. The average salinity of the Earth's oceans is 35 ppt. Sodium and chloride, the components of salt (NaCl) contribute the most to the salinity. The regions where freshwater and seawater mix (brackish water) has a salinity between that of freshwater, which averages 0.5oo/o, and seawater.

The salt content of a water body is one of the main factors determining what organisms will be found there. Thus fresh waters and saline waters are inhabited by quite different organisms. Plants and animals that live in or use freshwater generally have a salt content inside their cells that is greater than the water they inhabit or use. They tend to give off salts as waste products. Saltwater plants and animals have a salt content equal to or less than the salinity of the surrounding water, and thus have different mechanisms for maintaining their salt balance. In brackish waters we find plants and animals that can tolerate changes in salinity.

Alkalinity
Alkalinity is the measure of water's resistance to the lowering of pH when acids are added to the water.
Alkalinity is generated as water dissolves rocks containing calcium carbonate such as limestone. When a lake or stream has too little alkalinity (below 100mg/l), a large influx of acids for example from a high rainfall could (at least temporarily) consume all of the alkalinity and thus drop the pH to levels harmful to amphibians, fish or zooplankton.

Nitrate
Plants in both fresh and saline waters require nutrients for growth. Nitrogen exists in water in numerous forms, of which nitrate (NO_3-) is usually the most important. This comes naturally from the atmosphere in rain, snow or fog, or from the decay of organic material in soil and sediments. It can also come from agricultural runoff: (fertiliser) and sewage: (human waste).

When an excess amount of nitrate is added – usually through anthropogenic (manmade) inputs – the water becomes enriched and further, luxuriant plant growth takes place. This is known as *eutrophication*. There are many problems associated with eutrophication from the physical nuisance to water users to the eventual oxygen depletion when bacteria break the plant matter down.

Most natural waters have levels of under 1 mg/l nitrate. Drinking water must not contain over 50mg/l

GLOBE activities

The study of water provides a valuable opportunity for pupils to generate data through measurement of their environment. Temperature, transparency and pH have been selected as straightforward measurements which give a great deal of information about the status of a water body, material that is being moved by the water and what can live in it. Other measurements included may be more appropriate for older students but they all help give an overall picture of the hydrology in your local area.

Your chosen water investigation site will ideally be within school grounds but can be anywhere within the 15km x 15km GLOBE study site. You may choose to use a pond, river, stream, canal, lake or a stretch of seashore. However, if you have a choice we have an order of preference

1. Stream or river
2. Lake, reservoir, bay or ocean
3. Pond
4. An irrigation ditch or other water body if one of the above is not available

There is no limit to the number or type of water sites..

For accuracy, all measurements must be taken more than once and an average result calculated for entry onto the record sheet. Testing for transparency, temperature and dissolved oxygen should be done on site, in this order, immediately after obtaining the water sample. pH, Electrical conductivity or salinity, alkalinity and nitrate should be conducted next, again, in this order.

Activity 1. Defining your study site
Many of the scientists that use the student's data become frustrated when it is not accompanied by a comprehensive site definition. It is the most frequently omitted yet most essential piece of student work.
Students should complete the recording sheet in as much detail as they can before entering the data onto the GLOBE database. Digital images can also be used to accompany the data. These should be taken from the hydrology site, facing north, south, east and west. The 4 images then give the scientists a clearer view and they can ask you questions directly, should they need to.

Activity 2. Collecting your water
Discuss with your students, Health and Safety and the specific problems that can be associated while working with water, prior to this exercise.

The aim is to collect a sample of water that can be used for testing immediately
If the bucket sits for more than half an hour before the measurements are taken, take a new sample.

Testing for transparency, temperature and dissolved oxygen should be done on site, in this order, immediately after obtaining the water sample. pH, Electrical conductivity or salinity, alkalinity and nitrate should all be conducted next, again, in this order.

Activity 3. Water transparency
Students measure how clear, or transparent the water is.
By measuring the transparency of water, pupils will have the opportunity to see water transportation in action as part of the erosion - transportation - deposition process.

Activity 4. Water temperature
Pupils measure the temperature of the water three times and average their results. Ensure that students do not remove the thermometer from the water while they read it. The temperature of the air will affect the thermometer very quickly and result in inaccurate readings.

Activity 5. Dissolved oxygen
Using an oxygen kit involves a titration with some hazardous chemicals, but can be very accurate. An oxygen probe is safer but is an expensive piece of equipment.

Activity 6. Water pH
Students measure the pH of the water.
Using pH strips to compare results with those obtained with the pen is a useful exercise. pH paper is simple to use and relatively inexpensive. However, the result given is a whole number (no decimal places) and relies on a colour choice. It is a personal interpretation. In addition, as the pH scale is logarithmic, should the paper be slightly inaccurate i.e. off by 1. It is actually off by 10.

Activity 7. Conductivity
Students measure the impurities within the water to derive electrical conductivity. The pen will need calibrating before use but is simple to use

Activity 8. Salinity
Note: This measurement is for salt and brackish waters only. For fresh waters measure conductivity instead. For the salinity protocols, you will need to know the times of high and low tide.

The density of water is related to the amount of salt dissolved in it. The hydrometer is used to measure this density. The salinity of the water is then determined from the density and water temperature using tables provided.

Activity 9. Alkalinity
Generally, an activity designed for older students as it involves a chemical titration

Activity 10. Nitrate
Generally, an activity designed for older students as it involves a chemical titration

GLOBE equipment

- A secchi disk or turbidity tube (simple instructions to make these are in the toolkit section of your manual).
- Thermometer (An ordinary spirit thermometer will be fine. It will need a length of string attached to it for immersion in the water.)
- A stopwatch or clock to time the length of immersion of the thermometer.
- Oxygen kit or probe
- pH pen.
- Beakers
- Conductivity pen (buffer solution)
- Hygrometer
- Cylinders
- Alkalinity kit
- Nitrate kit

Additional equipment if using a pH pen
- Buffer solutions, pH 4, 7 and 10
- Distilled water
- Mini screwdriver (depending on pen type)

Defining your site

Once you have selected your hydrology site(s), be sure to identify the co-ordinates of this site with the GPS receiver. Enter the location plus any site description information requested.
For salinity protocols, you will need to know the latitude and longitude of the location for which you will report the times of high and low tide.

Collect data at roughly the same time each day, on a weekly basis. If your sampling site freezes over in winter or runs dry, be sure to enter this information on the data sheet each week until you again have a free flowing surface water to measure.

Extra activities

Related to:

Field studies
Students should draw a labelled field sketch of their site. It should include geographical features, land use, vegetation. Digital pictures can also be used

pH

- Aim: To allow students to use pH paper and pen in preparation for data collection in the field.

Make up 5 beakers containing 250ml of tap water and one of 250ml rainwater.
Add 2 tsp. the following to different beakers containing the tap water and stir until dissolved:
Lemon juice, baking soda, vinegar, washing powder.
This leaves a beaker of tap water and one of rainwater.
Students should use both the strips and the pen to determine the pH of each solution.
Discuss the results both in terms of accuracy of the equipment and pH values of solutions.

Salinity

- Fresh eggs will sink when placed in water (stale eggs contain gas and so float). Place an egg into a beaker of water to demonstrate that it does sink. Remove the egg and add 10 tablespoons of salt to the water. Mix thoroughly. Place the egg back into the water. It should now float, as the salt has made the water more dense than the egg.

- Half fill a beaker with salty water. Carefully tilt the beaker and pour cold, fresh water on top of the salty water. When the glass is full place the egg in it. The egg will start to sink but only until it reaches the salty water which it sits on top of.

Further investigations

Comparing different locations

Try comparing your water data with a school in a **contrasting** location.
Compare your data with a nearby urban school if you live in a rural area or with a nearby rural school if you live in an urban area. Alternatively, compare freshwater results with those taken in the sea

River study

Compare your local river data with schools situated on other UK rivers or even schools along the same river.

Coastal study

Compare your coastal water data with schools elsewhere in the UK. See if you can build up a picture of the water chemistry around the UK

Effect of rainfall upon the pH of water

Does rainfall amount or its pH affect the pH of a water body? This study would be most effective using data from a period of changing weather, e.g. spring or autumn. What else might cause changes in water pH over short periods?

Effect of air temperature upon the temperature of a water body

How quickly does the temperature of water change in response to air temperature? Look at data over a year from a single school. What is the temperature difference? Can you predict the weekly temperature of water given the air temperature data from the previous week or month?

Useful contacts and publications

www.ofwat.gov.uk
The economic regulator for the water and sewerage industry in England and Wales. The web site contains the addresses, Tel/fax numbers and web sites for all UK water companies.
Direct link below
http://www.ofwat.gov.uk/aptrix/ofwat/publish.nsf/Content/watercompanyaddresstelephone

http://www.water-education.co.uk/
National Curriculum Educational Resources and Materials with a background to many of the issues surrounding our most vital resource, with links to some of the leading web sites

http://www.e4s.org.uk/
Environmental Teaching Resources E4S provides teachers with lesson planning materials on the sustainable use of water and issues surrounding waste management.
Printable worksheets are available for use in National Curriculum Science, Geography

www.environment-agency.gov.uk
Wallcharts, worksheets, teachers' notes, activities and CD-ROM's with an environmental theme for school children key stages 1-3

GLOBE curriculum links

THE GLOBE PROGRAMME

Geography Encourages geographical enquiry and skill development through the collection and of data and appropriate use of fieldwork

Key stage 2	1 a-f	2a-g	3d-g	4a-b	5a-b	6a-e	7a-c

Key Stage 3	1a-f	2a-g	3c-e	4a-b	5a-b	6c-e, j,k	7a-d

Science Promotes scientific investigation of living and nonliving things, using equipment, materials and language appropriately whilst collecting firsthand data

Key Stage 2	1.1a-b	1.2a-m	2.1a-c	2.3a-b	2.4a-c
	2.5a-f	3.1c	3.2a,c,e	3.3b	4.3b-c

Key Stage 3	1.1a-c	1.2a-p	2.3a,c	3.1a-g	3.2b-e,i	3.3d-g

ICT Uses computer technology to convey information; to interpret, analyse and check data required for specific purposes. Purposeful use of data-logging equipment.

Key Stage 2	1a-b	2b+c	3a	4a-c	5a-b

Key Stage 3	1a+b	2b	3a-c

Mathematics Uses appropriate measuring instruments to observe, record and interpret numbers and scales with a high degree of accuracy. Opportunity for data handling skills.

Key Stage 2	2.1(a-k)	2.2(b,f,k)	2.3(l)	3.4(a,b)	4.1(b-h)	4.2(a-d)

Key Stage 3	2.1(g,h)	2.2(e)	3.4(a)	4.1(a)	4.2(d)	4.3(a-c)

Literacy Finding and selecting information from various sources; use electronic communication to describe observations.

Key Stage 2	2.5(f,g)	3.1(e)	3.2(a-f)