Chapter 4 **Water**

Water, water, everywhere . . .

Over two thirds of the surface of the Earth is covered by water, a remarkable combination of the elements oxygen and hydrogen. Life evolved in water and could not exist without it. Water comprises over 70% of our own body weight and in some plants this figure can be as high as 99%! In land plants water is used to transport nutrients from the roots, to provide support and to stimulate germination. Water, combined with carbon dioxide, is the basis for sugar production by photosynthesis.

Oxygen, which is vital for life, dissolves in water in minute quantities and its availability can limit the presence or activities of some animals. While over 20% of the atmosphere consists of oxygen, in normal conditions the maximum amount dissolved in water as a result of turbulence and photosynthesis is little more than 10 parts per million (ie. ten molecules of oxygen in a million of water!) and this amount declines further with rising temperature.

All three states of water influence the environment and our daily lives. When water freezes to become ice it expands and the continual freezing and thawing action is an important agent of weathering. A surprising **physical property** of water is that it is most dense at 4°C, and this prevents deep freshwater bodies, even in the coldest parts of the world, freezing completely. Water heats up and subsequently cools down very slowly, exposing animals and plants to far less severe temperature fluctuations than on land. The oceans have a major influence on the planet's energy balance and weather patterns. As a gas, water vapour is an important component of the atmosphere.

The **water cycle** ensures that water moves constantly through the environment. Any rainwater entering the soil moves down slopes to reach rivers or streams, or percolates down further to reach the water table. From the rivers, water flows to the sea. The sun's energy turns some of the liquid water into vapour, evaporating it into the atmosphere from rivers, lakes and seas and even tiny puddles. Some of the vapour carried high into the atmosphere cools and changes back into droplets of liquid, producing clouds. This completes the cycle which can then start again!

The salinity of sea water results from the ability of water to dissolve high concentrations of sodium chloride, together with smaller amounts of potassium and calcium salts. Some of the physical properties of water make it an attractive medium for living organisms. With the exception of fish, most aquatic vertebrates are thought to have returned to the water from the land, and may only stay there for part of their life cycle. **Freshwater ecosystems** are dominated by insects, which are almost excluded from the sea. Many static water bodies such as ponds are often temporary features, quickly silting up and drying out, but lakes may be deep enough to exhibit changes in temperature, light and oxygen with depth, as in the sea. In rivers and streams water currents bring both problems and opportunities for inhabitants as careful study will clearly show.

The most accessible **marine ecosystem**, the seashore, has tides, waves and currents affecting the conditions and the types of life. Many low-lying tropical coastlines at the outlets to rivers are dominated by salt-tolerant trees and shrubs such as mangroves. In other areas, where freshwater meets the sea to produce brackish water, salt marshes are found. There is, of course, a continuum between fresh and salt water; some areas are quite low in salts, and some inland lakes, especially where it is quite warm, can be very salty.

. . . but not a drop to drink

Despite the ubiquity of water, some human populations in less-developed countries have poor or no access to clean drinking water and millions die from water borne diseases. As well as drinking, cooking, cleaning and industrial uses, water is often used as a convenient waste disposal system. Many cities have rivers which are highly **polluted** and completely devoid of life. The lack of water of any kind is also increasingly a problem with prolonged **droughts** occurring in many parts of the world.

Wetlands are important wildlife habitats, which often regulate the flow of rivers and provide food for local populations, yet many are subject to threats from **dams, drainage and irrigation** schemes. In India, for example, 93% of water used is for irrigation. Whilst this can lead to increased crop productivity, poorly designed irrigation systems often lead to the soil becoming waterlogged, or land becoming too salty from rising minerals and subsequently abandoned. Where too much groundwater is pumped out, aquifers will become depleted often causing subsidence.

In many parts of the world, fish is often the most important source of animal protein. Three quarters of the world catch is used for food and the rest for animal food, oil and fertiliser. Modern developments such as the introduction of larger trawlers, monofilament nets and sonar detection systems frequently result in **overfishing** with consequent depletion of fish stocks in the long term for all.

Water

Basic concepts and issues

Composition

Physical properties

The water cycle

Freshwater ecosystems

Marine ecosystems

Pollution

Drought & abstraction

Irrigation & drainage

Overfishing

Activities

4.0 Safety Code

4.1 Water cycle in miniature

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4.0 Safety code for field work near water

When organising field work activities for any group of participants, safety and welfare must be paramount. These are achieved primarily through thorough preparation, adequate supervision and knowledge of the site. In the case of water activities, however, there are specific hazards and a code of conduct is suggested.

1. *Carefully inspect any site before taking a group out.*

☞ *Do you have legal and easy access?*

☞ *Are the edges of the pond or river safe from collapse?*

☞ *How deep is it? Decide the limit of entry for the group.*

☞ *If it is a river, how fast is it? A shallow but swift river could pose a threat.*

☞ *If working beside the sea, check tide times and ask about dangerous currents.*

☞ *How clean does the water appear to be? If it smells or has scum on the surface, decide whether it is really suitable for your purposes.*

2. *Ensure adequate supervision for the site, the activity and the age of the group.*
   Ensure that participants have the required clothing and footwear.
   Ensure that they are aware of any potential hazards.

3. *Ensure that the group stay in visual contact with you all the time you are at the site.*

4. *Ensure that nobody wades into the water unless asked to do so and that no-one splashes or pushes.*

5. *Cover any scratches or cuts with waterproof plasters. If the site is a possible health risk, consider issuing rubber gloves.*

6. *Ensure that participants do not put water, fingers, or any equipment that has been into contact with the water, into their mouths, nostrils or eyes. Don't allow eating or drinking while working beside study sites. Ask participants to wash their hands with soap and clean water as soon as work has finished, and before they eat.*

4.1 The water cycle in miniature

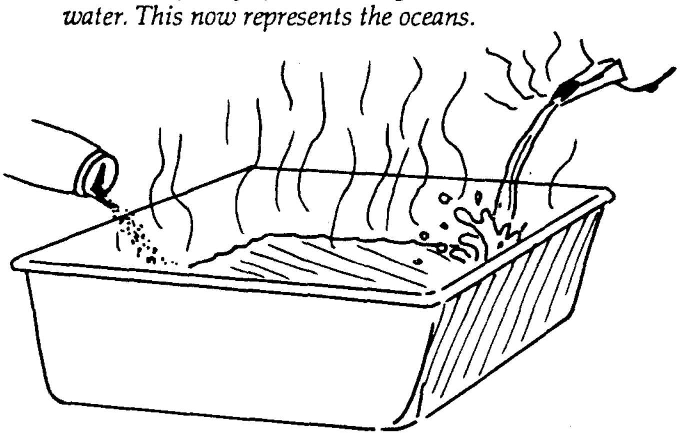
Concept
Without negative human interference, the water cycle constantly provides a mechanism for renewing freshwater and transporting it around the globe.

Context
Various models have been suggested to simulate the water cycle. The idea here is to demonstrate the importance of evaporation from the oceans, investigating the reasons for the lack of salt in rain.

Equipment
Hot water (best if near to boiling point . . . care!) - salt - ice cubes - clear plastic bag - two small glass jars - wire mesh - bowl (large enough to take one jar standing in the middle)

Making it
1. Pour the very hot water into the bowl, so that the participants can see steam rising.

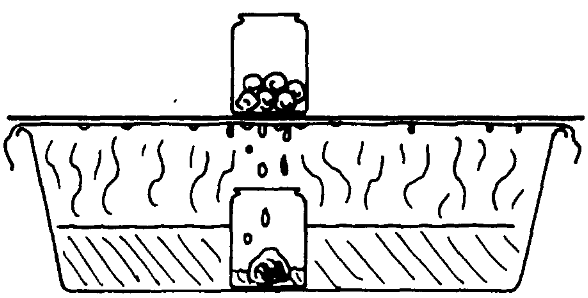
2. Mix in plenty of salt - enough to taste it in the water. This now represents the oceans.



3. Place one empty jar in the middle of the bowl (it may have to be weighed down).

4. Stretch the plastic over the top of the bowl to cover it completely and place the mesh on top.

5. Take some ice cubes and put them in the second jar, supported by the mesh over the empty jar below.



Using it
Water will condense on the plastic sheet (representing the 'clouds') immediately and this will be speeded up by the cold surface provided by the ice. Water will begin to collect in the empty jar.

1. Is the water salty? Taste the water in the jar and condensing on the sheet.

2. What is happening to the remaining water in the bowl?

3. Why does the water evaporate and then form water droplets again?

4. How does this model differ from what happens in the global water cycle?

Adapting it
Students might be able to think of improvements to this simulation; perhaps suggesting the inclusion of a 'river' to take the water back to the sea.

To illustrate pollution and how this remains in the sea:

Try adding a colour to the water in the bowl.
Is the water that falls as 'rain' clear or coloured?
(Care, as gases can be incorporated into rain; see information on acid rain 3.8).

4.2 Water coming down

Concept
Some falling rain is intercepted by plants; the surplus water seeps into the ground and helps to maintain soil moisture levels.

Context
A convenient point to investigate the water cycle is when water falls to the ground as rain. Simple rain gauges allow the measurement of water intercepted by different vegetation, and rates of infiltration into the ground can be recorded.

Equipment
Rain fall gauges: from bottles, see 3.2

For stem flow: nylon cord or similar - old inner tube (one from a bicycle is best) - a plastic bottle (square or rectangular in section)

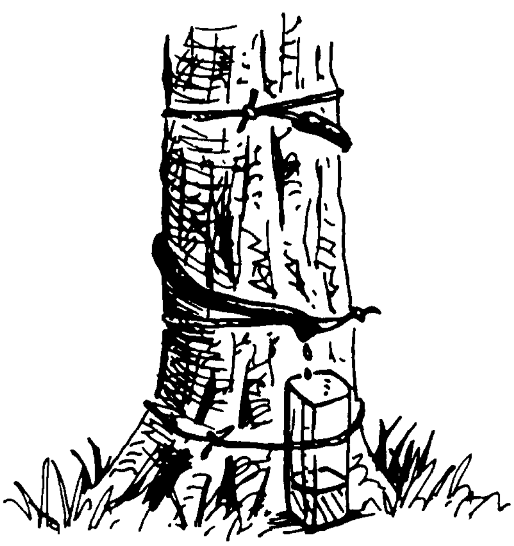
Infiltration rings: large coffee or other food tin - thick piece of wood (wider than diameter of tin) - hammer or mallet - ruler - stopwatch (or watch with second hand) - bucket of water

Making it
1. Prepare a number of standard rain gauges. If necessary secure them to wooden stakes with string to prevent them blowing over.

2. Attach the inner tube tightly to a tree by passing the cord through and winding the tube in a gentle downward spiral around the trunk. It must be long enough to go around the tree at least once.

3. Cut the top off the square plastic bottle and secure it with cord to the trunk, so that the end of the rubber spiral is just above the bottle .

4. Prepare the infiltration ring: remove the tops and bottoms of the tins, cleaning up any sharp edges.



Using it
The equipment can measure three different parts of the water cycle. They can be looked at separately or taken together to see the effects of the vegetation and of the soil.

1. Set out one rain gauge to measure the rainfall in the open and others under various different kinds of trees. The gauge in the open will therefore be collecting uninterrupted rainfall; the others will be collecting the water dripping off the leaves.

2. Measure the amount of water which trickles down the trunk of a tree.

3. Place the wood over the tins and knock them into the ground with the mallet so they are held firmly. Pick different soils and positions. Stand the ruler upright in the tin, and pour water into the top, timing how long it takes for the water to soak into the ground.

How do different trees and seasons affect the amount of water reaching the ground? Does less drip down when it is warmer? What would happen if the trees were removed? Does water always enter the ground at the same rate? What happens on a slope or on different soils? Does it soak in more quickly when it is dry or after it has been raining for some time?

4.3 Water going up

Concept

Much of the water absorbed by the roots of plants is eventually also evaporated from the leaves in a process called transpiration.

Context

While plants rely on transpiration to aid the transportation of water from the roots, they attempt to minimise the loss of water. Dyes can be used to illustrate this, and simple investigations undertaken to demonstrate water loss.

Equipment

Demonstration: *small plastic bottle - colourful dye (eg. red ink in water) - fresh leafy cut stick of celery (or leafy green shoot of a fast growing tree such as willow) - secateurs or vegetable knife*

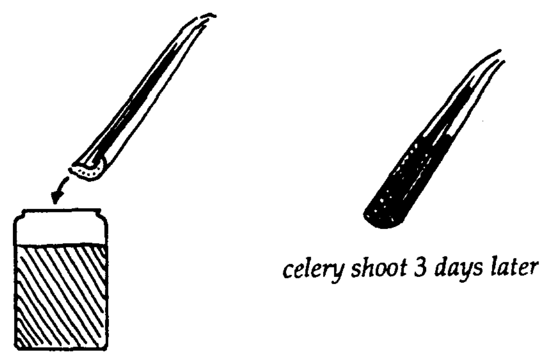
Transpiration in action: *large clear plastic bags - string*

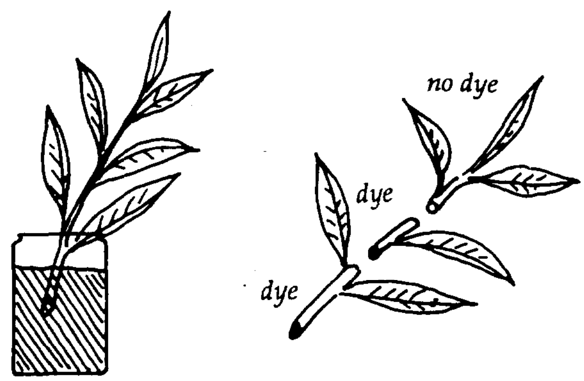
Demonstrating it

Whilst it is possible to measure accurately the actual rate of transpiration, the use of dyes provides a particularly effective way of demonstrating that transpiration is taking place.

1. Half fill the small bottle with the coloured water. Cut the stem or stalk of the plant and leave it in the water for a few days, keeping the plant well lit.

2. The dye will rise through the plant and colour the veins in the leaves. If a young tree shoot has been used, cut it to investigate the distribution of the dye. In other plants it travels in the xylem vessels. Celery (if available) is one in which it may be easily seen. (NB: this experiment does not work well in all plants so it is as well to try out a few different shoots first to see which ones work best).



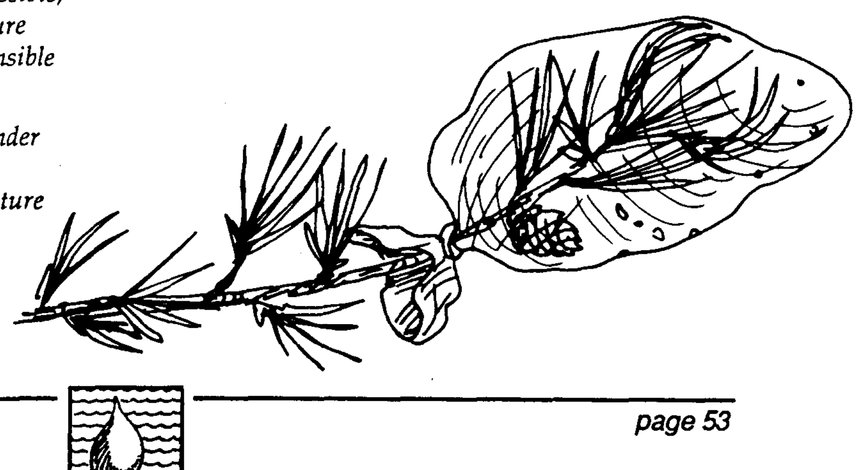


To demonstrate transpiration in action outside:
1. Tie large plastic bags over the growing shoots and leaves of trees. Carefully examine the bags some hours later (noting the build up of moisture inside).

Remove the leaves from one of the shoots and then try the experiment again. What happens this time?

If both evergreen and deciduous trees are accessible, try this in winter to show that it is the moisture evaporating from leaf surfaces which is responsible for the droplets of moisture in the bags.

2. Try to compare the rate of transpiration under different conditions (eg. in windy or sunny conditions) by comparing the amount of moisture in the bag.



4.4 Wonderful water

Concept

Water has a number of unique physical properties, including the change in molecular arrangement that means that it is densest at 4° C (which is why ice floats). Water, especially salt water, provides support to plants and animals through buoyancy.

Context

The phenomenon of surface tension provides a specialised habitat for many animals and the 'skin-like effect' that this produces can be illustrated. The difference between the buoyancy of fresh and sea water can also be investigated. The temperature should be measured since it affects the amount of oxygen dissolved in the water which in turn affects the fauna living in it.

Equipment

Surface tension: *small pot filled with water - tissue paper - pin or small paper clip*

Buoyancy: *two pots of water - salt - two fresh eggs*

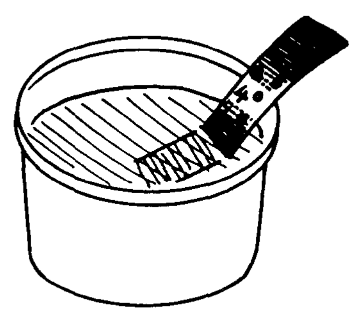
Temperature: *graduated liquid crystal strips*

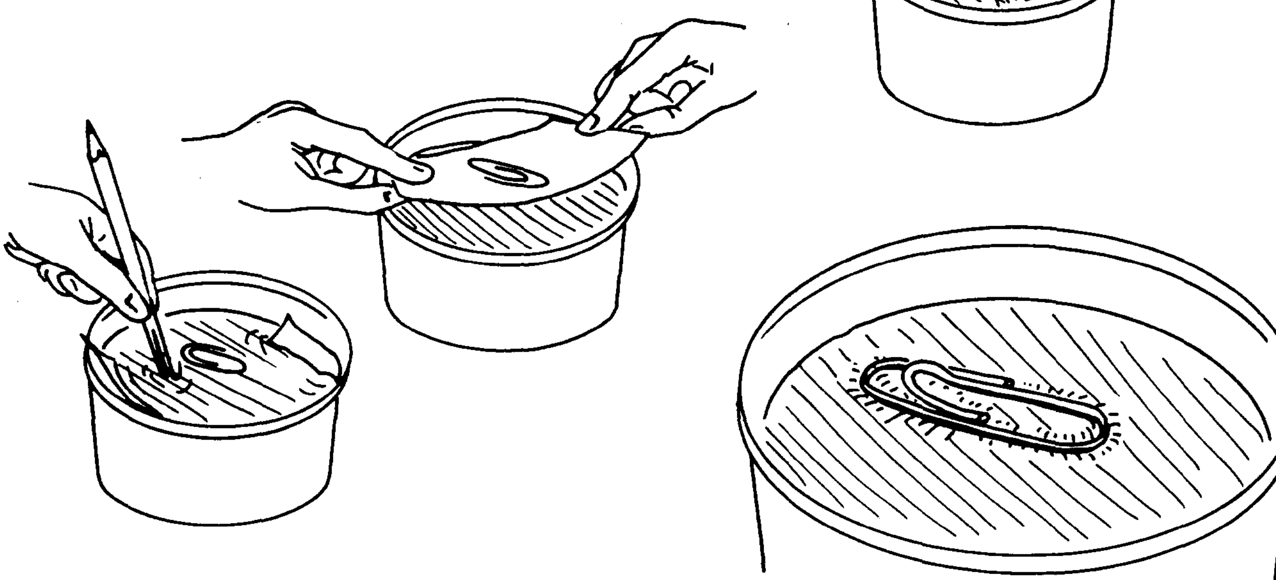
Using it

*1. **Surface tension:** put a piece of tissue onto the water and carefully place a pin or paper clip on the tissue. Gently help the paper to sink and watch what happens. Look carefully around the edges of the object; the 'skin' is visible. With a bent pin it is possible to lift the surface layer slightly on still water. What happens to the pin or clip if a drop of detergent is added?*

*2. **Buoyancy:** take two pots of water and add some salt to one of them and stir. Place one egg in each pot and see what happens. Swap the eggs around to check that it is in fact the water which is responsible.*

*3. The **temperature** can be taken using waterproof liquid crystal strips. These are graduated in °C, and can be bought relatively cheaply from pet /aquarium shops. They are more robust than thermometers and much cheaper.*





4.5 Measuring the flow

Concept

Fast flowing water can dissolve more oxygen and all sorts of other characteristics are affected. In comparing habitats, speed of current flow is therefore an important factor to measure.

Context

Most aquatic animals living in moving water have gill surfaces to extract oxygen. In comparison, many of those which live in standing water obtain their oxygen by coming to the surface. Animals also exhibit special adaptations for holding on to avoid being swept away, so that it is often possible to relate current measurements to the types of animals found. There are various simple methods of measuring flow which require little equipment.

Equipment

Float method: *1 orange - 10 metres of string - stopwatch (or clock with a second hand)*

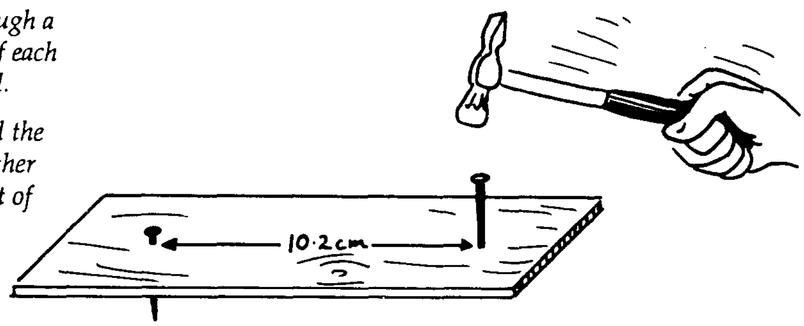
Thrupp's nails: *piece of wood approx 15cm long - 2 nails - a hammer - ruler*

Making it

With the float method the items listed are ready for use. To test the speed of flow with the nails proceed as follows:

1. Use the hammer to knock the two nails through a piece of wood (one at each end) so that the tip of each projects the same short distance above the wood.

2. To produce an accurate instrument to record the velocity of the stream (in metres per second, rather than as a simple comparison) the distance apart of the two nails needs to be 10.2 cm.



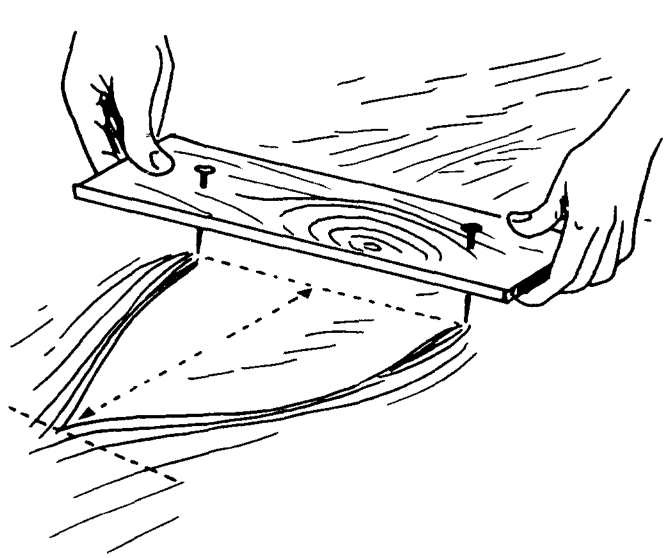
Using it

Use the wood and nails as follows:

1. Hold the wood above the stream so that the nails both just touch the surface of the water. If the speed of flow is above about 22cm. per second, ripples will form on the water surface.

2. The ripples will converge at a point downstream. The faster the water flow, the further away they will come together. Measure the distance from the wood to this point and compare this with other sites.

3. The speed of the current can be calculated if required, although this may be too complex for younger children.



Now a convenient method for determining speed has been decided, various problems can be approached:

1. *Where in a stream is the flow the fastest?*

2. *Is the bed of the stream different in slow and in fast areas?*

3. *Do animals prefer to live in fast or slower parts of the stream?*

4. *Is the speed constant through the year? If not, what will affect it?*

Using an orange:

Any object which floats without obstruction, such as a small stick, can be used to observe and then to measure the speed of water flow of a stream or river. The advantage of using an orange is that it is easy to see and floats just below the water's surface (and so is less affected by the action of the wind).

1. *Lay out the string along the river bank, picking a section where the flow is unobstructed by plants, debris etc. Drop the orange into the water above the upstream end of the string.*

2. *Start to time the orange as soon as it passes the start and record the time taken to reach the other end of the string. If the orange can be retrieved with a net (care!), or if you have another one, try again.*
(Do not eat the orange after this test.).

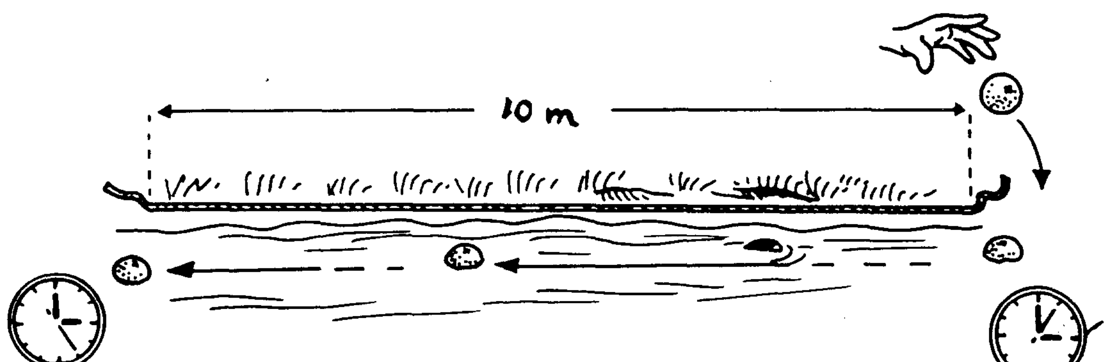
3. *To calculate the speed, first find the average time. Then divide 10 by this number of seconds to give the speed in metres per second.*

Adapting it

With a cork borer (or a fruit knife), the peel from one orange can be cut into many small circular or square pieces. Each will float well and can be clearly seen from the bank, so for the price of one orange, many tests can be carried out (and, if the orange is peeled before setting out for the river, it can be kept for eating!).

Both these methods measure the current speed at the surface, and yet students usually find more animals at the bottom of the river where the flow may be different. Can they devise a variation to measure the flow rate lower in the water?

The speed of flow can be related to the volume of water (the discharge) by multiplying by the cross-sectional area. A more direct, rough measure of this value is obtained by recording the time to fill a large, strong plastic bag. Hold the bag, crushed up to remove all the air, just under the surface. Now open the top and time how long it takes to fill.



4.6 Cardboard aquarium

Concept

Minibeasts exhibit adaptations of structure and behaviour to equip them for life in freshwater.

Context

*Participants should **not** be encouraged to take samples of aquatic animals and plants away from their habitats, but close observations are necessary for identification and to record behaviour and adaptations. A simple field aquarium can easily be constructed on site.*

Equipment

Cardboard box (the ideal size is one used to take reams of A4 paper) - large plastic bag (needs to fit into and fill box) - scissors - marker pen - adhesive or masking tape

Making it

1. Ensure that the bottom of the box is secure by using tape.

2. Cut any flaps off the top.

3. Mark two large windows on the sides of the box. Leave a reasonable amount of the cardboard in place all the way around the window as a strengthening frame. This is especially important at the top.

4. If the cardboard is not very thick it will be necessary to reinforce the bars along the top. You can do this by either taking additional card from the discarded lid, or by leaving a central pillar of cardboard vertically in the centre of each window.

5. Fit the large bag so that it fills the box, leaving the open end to fold over the top of the box. Tape the bag into position.

6. Carefully add water to test that it can take the weight and that there are no leaks!

Using it

Beside a freshwater pond or river, or when investigating a seashore rock pool, fill the aquarium with the clearest water you can get. The sides of the bag will bulge out through the windows, removing any creases and giving a good view. Plants or stones can be added as appropriate. Animals can now be introduced.

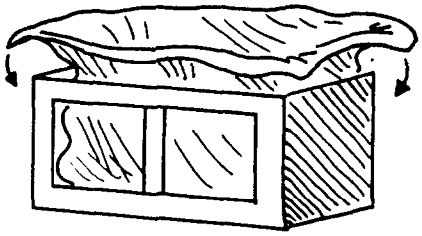
1. Add all the animals you find and carefully watch for interactions . . or

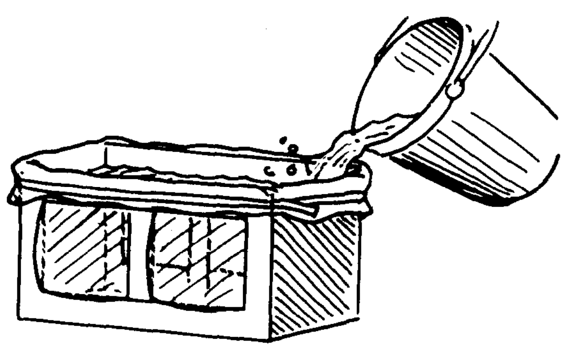
2. Add a few animals of the same type and observe carefully. Can you see how they move, how they hang on, how they obtain their oxygen, how they feed and what they feed on etc? Are there any observable adaptations which allow them to be successful in this habitat?

3. The aquarium could be used to keep animals in for a longer time. However, a balanced mini-ecosystem is difficult to achieve, and it might be better to keep a few carnivores such as dragonfly nymphs on their own (they are easy to rear and fascinating to watch). Make sure that there is a stick put into the box when the nymphs look nearly ready to emerge .

Adapting it

An alternative to the box and bag aquarium is to use a large clear plastic bottle, or better still, a large sweet jar.





4.7 Netting your catch

Concept

Life began in seawater, where dissolved salts roughly balance the composition of the internal fluids of living organisms. About 2.5% of all the world's water is freshwater which lacks this high salt concentration.

Context

In fresh water, animals and plants find conditions more difficult than in the sea, since they need to maintain internal concentrations in excess of their surrounding medium (an osmoregulatory problem which only a few groups of animals have successfully solved). To observe the relative diversity of minibeasts from freshwater and marine habitats, simple sampling equipment including nets can be constructed.

Equipment

Small hand net: *a plastic kitchen sieve - or an aquarium net*

Long handled net: *broom handle or cane - jubilee clips (or plastic cable clips or strong string)*

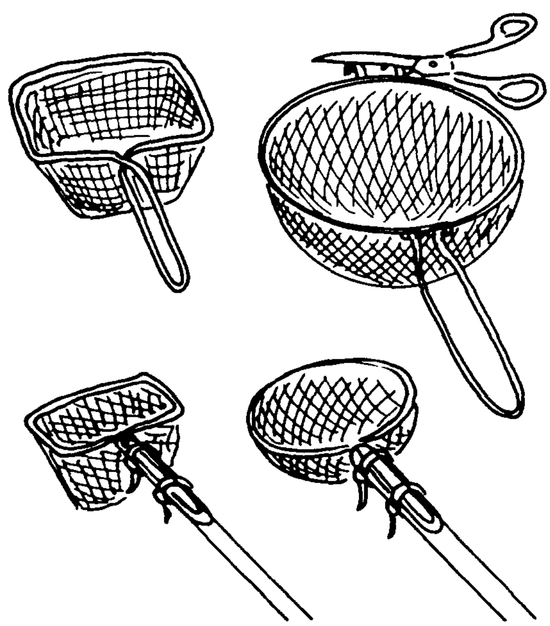
Home made river net: *wire coathanger - old net curtain - thread and needle*
(Also use the containers, viewers and sorting equipment described in 4.10)

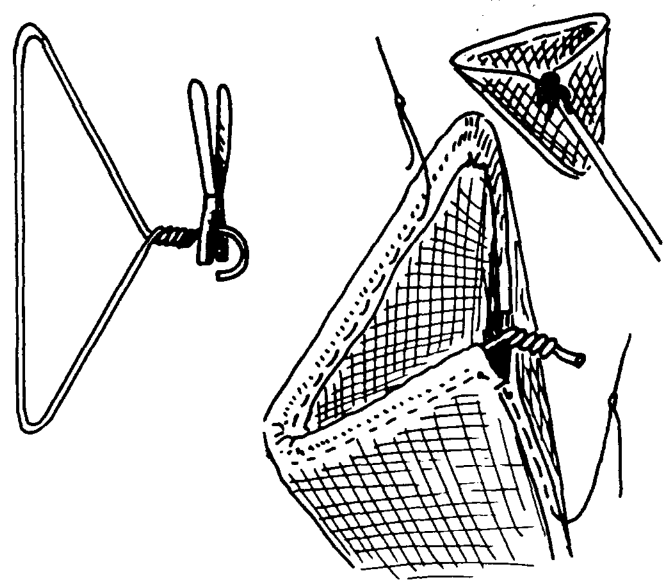
Making it

1. *If sampling in a shallow pond or a rock pool a strong plastic sieve or an aquarium net may be adequate. Sieves often have two projections (to support them over a bowl) but these are easily removed with a knife or sharp scissors.*

2. *To increase the length, attach the net or sieve to a broom handle or stiff cane. Mark the handle every 5 or 10 cm with a waterproof pen so that it can also be used as a depth measurer. The net can be fixed permanently with cable clips, firmly with jubilee clips (or, most cheaply, bound on tightly with string).*

3. *A flat bottomed net bag more suitable for work in a stream or river can be made from old net curtain material. Measure the circumference of a wire coat-hanger, adding on a few centimetres. Cut this width of material. Sew the two sides together then sew up one end and sew onto the hanger. Snap off (or straighten) the hook. The bag can be attached to a handle as shown.*





Using it

Before sampling at any water site first read the safety information (4.0) and take the necessary precautions.

Nets can be used to introduce participants to life in water, to illustrate the diversity of animals living in different habitats and to carry out a variety of investigations. What you can do will depend on the aquatic habitats that you have available.

1. Empty the contents of your catch into a water filled white dish each time and sort. Transfer your catch temporarily to the aquarium (4.6) and ensure it is carefully returned to the water before leaving the site.

*2. In **slow** or **standing** water, approach slowly and quietly. Sweep your net through the open water and past submerged plants fairly swiftly and quickly lift out and empty the net. Wash the net bag carefully checking that nothing is left on the sides.*

*3. In **shallow running** water it may be possible to stand in the water. Check the depth carefully first with the net handle (a long handled net is needed here). Try sweeping different areas, but also try collecting by disturbing the bottom with your foot. Hold the flat bottom of the net on the stream bed, standing down stream so that the water flows through. Another student kicks the bottom with their heel, turning the stones and disturbing the minibeasts which are washed into the waiting net.*

*4. Seashore **rock pools** can be sampled as in ponds. Often the water is still and clear and it is possible to 'hunt' individual animals as they swim out from seaweeds, so that random sweeping may not be as necessary. Many of the sedentary animals clinging to rocks can easily be collected by hand.*

Now that animals can be found and studied, various ideas can be tested. For example:

1. Do different animals live in freshwater and salty water? Which has the greatest diversity? Are some animals more common than others? Does this vary at different times of the year? Do they spend all their time in the water or do you only catch one stage of the life cycle?

2. In a pond or lake try sampling different mini-habitats. For example, are there differences between the animals on the surface, in the open water and in amongst the plants?

3. Are the animals in rivers and streams different from those in still freshwater? Is it possible to see how they are adapted to life in running water?

4. Are there any differences between the animals living in large and smaller rock pools? Do the inhabitants differ on different parts of the shore?

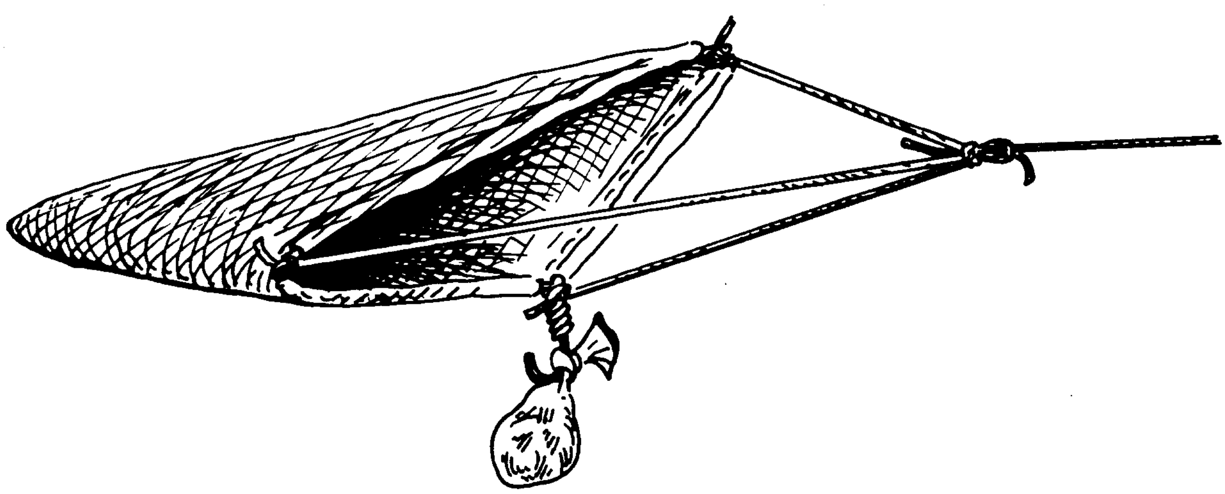
***Note:** it is not essential to put names to all the animals found; it is important, however, to be able to see and describe differences. Further identification will depend on the age of the group, what the investigation is all about and the availability of resource material.*

Since there will be relatively few types of animals in any one habitat, it is quite simple to collect together pictures of the most likely creatures and to 'laminate' them with sticky clear plastic, so that sheets can be taken out.

Adapting it

Where the water is deep or when working by a large pond or lake, a drag net is useful. Take the river net without the handle and tie strong string as shown so that the net bag is open as it is dragged. To weigh it low down in the water, suspend a bag of stones from the coathanger hook.

Throw the drag net out and allow it to sink. Then pull it back to the bank or shore. By allowing it to sink deeper or by pulling at different speeds, it is possible to sample at different depths.



4.8 Mud, glorious mud

Concept
Within aquatic ecosystems there are different habitats affected by different environmental factors. Alternative sampling methods will be required for some of those habitats.

Context
Scoops and sieves are useful if collecting animals from aquatic habitats with silty or muddy substrates. Passive collecting devices can also be left in place to allow animals to catch themselves. Underwater viewers allow observations of ponds and rock pools with the minimum of disturbance.

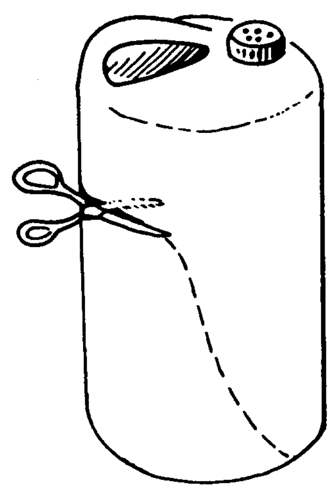
Equipment
Mud scoop: *thick plastic bottle or container with handle and top - scissors or sharp knife - felt pen*

Artificial substrate: *rough old bricks or building blocks - string (best if waterproof) or net bag (eg. from vegetables) - collection of small pebbles*

Underwater viewer: *old food tin or thick plastic bottle - thick clear plastic, cling film or plastic bag - strong rubber band.*

Making it
1. To make a mud scoop

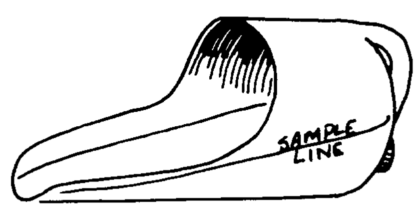
Mark out the area to be cut away from the plastic bottle, as shown. This includes all of the base. Carefully cut along the line. Leave the top screwed on tightly. A second line can be made on the scoop to mark a standard sample.



Using it
Before sampling at any water site, first read the safety information in 4.0 and take the necessary precautions.

*1. The **mud scoop** can be used in conjunction with the nets (4.7) to investigate the diversity of life in the stony or muddy bottom of a stream or pond. It can lift out the same quantity of material to sort through each time.*

Adapting it
A ready made scoop is provided by a plastic kitchen sieve with the projections removed. This can also be used to sort through the sample, looking for life. With a sample of mud in the sieve, 'pan for gold' by agitating it backwards and forwards in the water so that the fine particles fall through, leaving dead leaves and the animals.

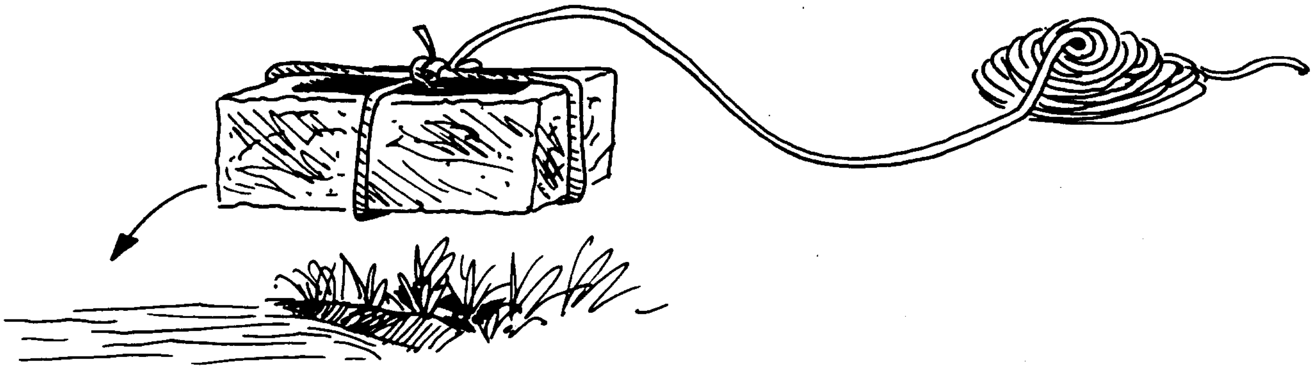


With the scoop suggested above, punch small holes in the lid before securing it, so when filled with a sample, it can be propped up to allow the water to drain through, before looking at the catch.

2. *Making a passive sampler*

An artificial substrate can be provided by tying string to a stone or block. An alternative is to fill a net bag with clean pebbles, sew up the top with string and attach to a length of string.

*Carefully lower the **passive sampler** into the water (this is especially useful where the water is deep and difficult to sample with a net). Secure to the bank and leave for at least two weeks so that animals can enter and colonise. Then remove the sampler and brush the animals from the crevices on the bricks or blocks (or the stones tipped from the bag) to reveal the catch.*

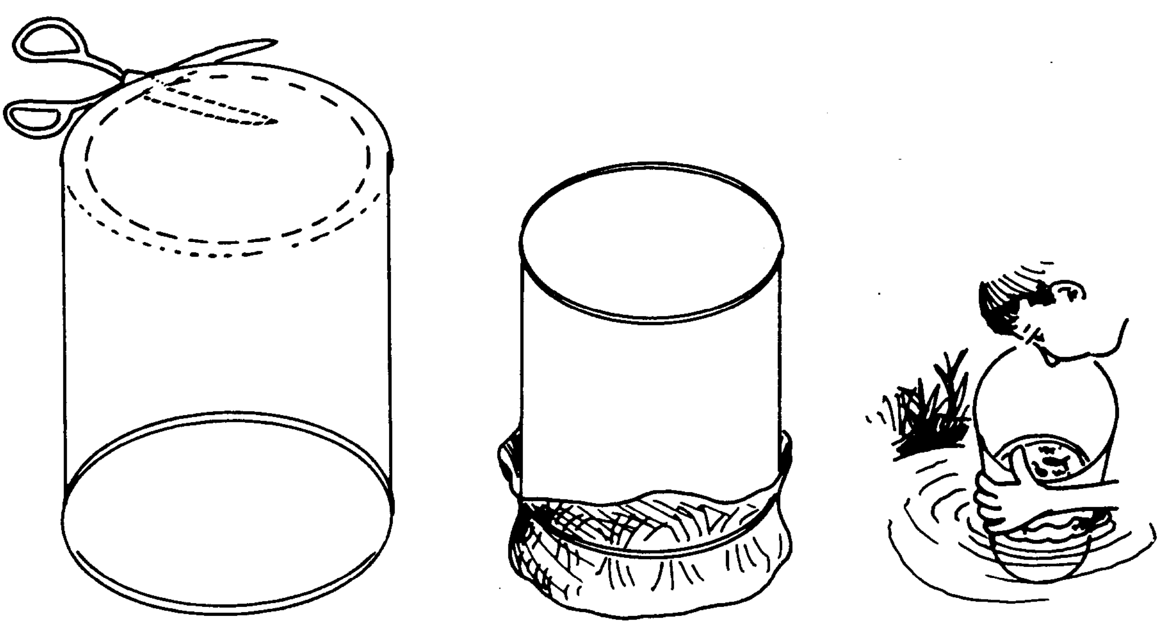


3. *Making an underwater viewer*

Carefully take the top and bottom off the tin or bottle. Ensure that there are no sharp edges. Fix the clear plastic lid tightly with the band.

Make a more robust water viewer by sealing a disc of perspex to the end of a plastic drain pipe. The view can also be improved by fixing a disc of card to the other end, with a small hole in the middle, like a pin-hole camera, through which to look.

***Using the underwater viewer**, you can discover much about life under water without catching any animals. Use the **underwater viewer** pushed just below the surface of the pond, stream or rock pool to cut out distracting reflections and peer down into the water rather like being in a boat with a glass bottom!*



4.9 Pollution detectives

Concept

The enrichment of rivers and streams by nutrients or organic pollution leads to changes in the minibeast community. The diversity of these invertebrates can be used to monitor pollution.

Context

The presence or absence (or better, the relative abundance) of minibeasts in rivers can be recorded. The diversity and composition of the community sampled, used in conjunction with a biotic index, allows the monitoring of pollution levels in water and a comparison between the different sites and seasons.

Equipment

Appropriate nets or samplers *(see 4.7 & 4.8)*

You will also need: *a white sorting dish (a large margarine or ice cream tub is ideal)*

Items for handling the catch: *plastic spoon - small brush - pipette made from wide plastic tube*

To make sorting and observation of different creatures easier, try to find moulded plastic containers with a number of sections (some food packaging may be suitable, or plastic egg cartons or ice cube trays from fridges). Animals can now be taken from the main white tray and separated.

Using it

Before sampling at any water site, first read the safety information in 4.0 and take the necessary precautions.

Identify several running water sites to compare. It is important to have some idea of the freshwater minibeasts (invertebrates) likely to be present in good, clear water in your area. There are some standard 'scoring systems' available, but it is possible, and perhaps better to construct your own. As a generalisation a list can be made with the animals most susceptible to organic pollution at the top and those most tolerant to pollution at the bottom ie.

5 ***Insect nymphs*** *eg. stone fly, mayfly, damsel fly*
4 ***Adult insects*** *eg. beetles and bugs*
Some insect larvae eg. caddis fly larvae
3 ***Crustacea*** *eg. amphipods*
2 ***Molluscs & Crustacea*** *eg. isopods*
1 ***'Worms'*** *including leeches, and worm-like larvae eg. bloodworms.*

1. It is important to use the same technique in each area (eg. a kick sample for a minute in each, or the same sized bag of stones left in each site; see 4.7 or 4.8). Remember to compare 'like with like' so that stony streams can be fairly compared (but not a stony section with a slow muddy section since the animals will differ anyway).

2. Record the presence or absence of each animal or type of animal. It is not necessary to identify every species accurately but useful to know for example the number of types of mayfly.

3. The greater the diversity, the better the water quality. Also the higher the score (the more of the types towards the top of the list) the better. You might record one stream as a '5' and another as a '3'. Or you could take into account all the groups found on the highest scale. So a stream with two '5' animals would score 10 while a stream with a greater diversity of clean water animals (eg. four in category '5') would score 20.

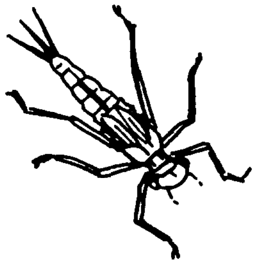
Adapting it

To make the assessment more realistic, take into account the relative abundance of each animal or group scoring each into a broad category such as:

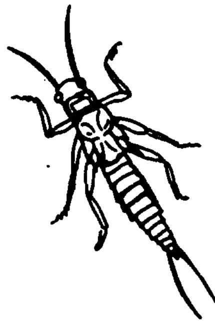
1 = one animal only
2 = between 2 and 10 animals
3 = between 11 and 50 animals
4 = between 51 and 100 animals
5 = over 100 animals found in the sample.

So two streams each scoring 'category 5' animals could be '5/1' and '5/5'. Clearly the one with the greatest total number of insect nymphs is likely to be cleaner.

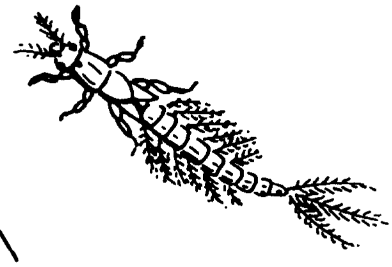
Such studies lead on to asking about the sources of pollution. Where there is intensive agriculture or sewage pollution, the levels of nitrate will be high. You can measure this with chemically impregnated dipping sticks. As these are relatively expensive, try cutting them vertically down the middle to double the sticks (it will still be possible to read the colour changes against the graduated scale).



Damsel fly nymph



Stone fly nymph

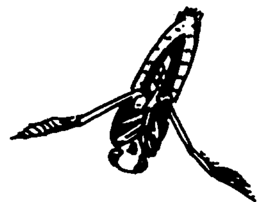


Mayfly nymph

5

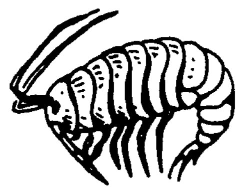
Diving beetle

Caddis fly larva



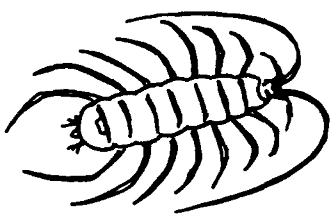
Water boatman

4

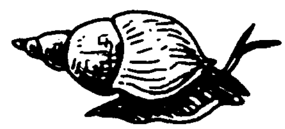


Amphipod Crustacean

3



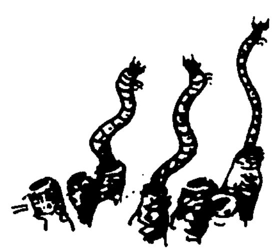
Isopod Crustacean



Mollusc (pond snail)

2

Leech



Bloodworms

1

4.10 Water filters

Concept

Flowing water has the ability to clean itself through natural biological processes and the physical filtration of the bed. Filtration is also used as one part of the treatment of water polluted by sewage.

Context

The effect of filters on cleaning up dirty water can be demonstrated in a simulation in which a filter bed is constructed and a sample of murky water monitored. The turbidity or cloudiness of the water can also be measured. Light is absorbed with increasing depth in water and will disappear even more quickly if there is a suspended load of sediment.

Equipment

For each filter bed: *washing up detergent bottle (or flower pot) - scissors and marker pen - collection of small washed stones - washed gravel - sand - two containers (eg. small lemonade bottles) - muddy water*

Turbidity: *lemonade bottle - scissors and ruler - clear plastic bag and a rubber band - card and black pencils and pens*

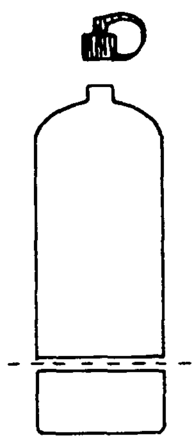
Making it

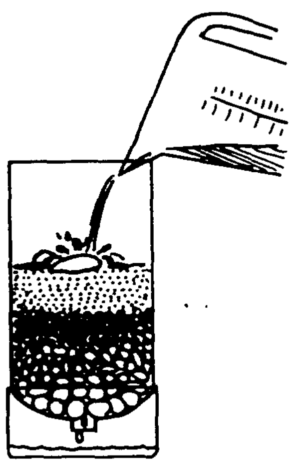
1. *Mark the detergent bottle about three quarters of the way down and cut it in two.*

2. *Remove the cap and reverse the top which should now fit neatly into the smaller bottom section. Alternatively a flower pot with a small central hole will act in the same way.*

3. *To prepare for measuring the turbidity or cloudiness cut the top off a large plastic drinks bottle so that at least 25cm of water could be added.*

4. *Cut a small piece of card which can fit in the bottom of the bottle. Mark numbers, 1, 2, 3, and so on, on the card, making each the same size but gradually increasing the shading; start with a very faint 1 and then use progressively darker shading.*





Using It

To simulate the effect of a filter bed, or the natural cleaning effect of a river bed:

1. *Put the small stones into the bottom of the pot (or reversed top of the bottle) so that the hole is covered but not completely blocked.*

2. *Add gravel on top of the stones and then the sand. Put a small stone right at the top.*

3. *Pour murky water onto the stone so that it can trickle down through the bottle or pot. (If using a flower pot, it will need to be supported so that the water can be collected at the base). If the detergent bottle is used, the water will collect in the removable bottom section.*

4. *What effect has the filter had on the water? Will the stones or the gravel do this on their own?*

To measure the cloudiness or turbidity of water:

1. *Place the card in the bottom of the bottle and fix the large plastic bag in place with a band.*

2. *Add water from the study site to a fixed level (25 or 30cm) and leave to settle for ten minutes.*

3. *Now look from above and see which numbers are visible. The cloudier the water, the fewer numbers can be seen.*

4.11 Rock pool chase

Concept

Overfishing has resulted in the depletion of many important fish stocks and caused a decline in some whale species. The complex food web which interlinks all the members of an ecosystem becomes disrupted as a result.

Context

Ecosystems have an inbuilt ability to compensate for minor natural changes like the temporary decline of a species. Most aquatic animals have a large potential for rapid increases in population when conditions are favourable. However, humans can interfere in the cycle by over-exploitation, upsetting the balance and making recovery difficult.
This game illustrates some of the problems associated with overcollecting or overfishing, using as an example a community living in a rock pool.

Equipment

Home bases for each animal type: *eg. games hoops - a bucket to store the seaweed cards - card and coloured pencils (or card and cut out pictures of the animals) - a large open space.*

Making it

1. Prepare cards to represent seaweed and detritus; (four are needed for each grazing 'snail').

2. Prepare four picture cards for each animal such as:

Grazing 'snails' & detritus feeders:
topshell - winkle - limpet - barnacle

Predators: *starfish - dogwhelk*

3. Put all the seaweed cards in the bucket and four cards for each animal in each hoop.

Using it

There are two phases to the game; at high tide when the rock pool is covered with water and at low tide when humans can collect from the pool.

At high tide:

1. Give the participants a limited time to run and gather four 'food' cards to survive, and return them (only one at a time) to the home base (hoop).

2. The 'snails' collect seaweed cards; the predators collect 'snail' cards and there can be a top predator such as a large fish which collects cards of the starfish and dogwhelk. All the animals should be able to survive.

At low tide:

3. A human can wander around the pool and 'collect' the animals. You may decide that the top predator is unable to operate in the tiny pool. Restrict the human to collecting just one card from each hoop at a time.

4. Some of the animals might survive but clearly others will no longer be able to collect all four cards. If the game is played again the effect on the rest of the food chain will be illustrated eg. there may not be enough cards for the fish to survive at high tide.

Adapting it

Clearly this game can be adapted for other ecosystems and not just other aquatic ones (although the problems of overcollecting are so acute in the sea that the livelihood of local fishermen may be threatened).

Similar approaches can be taken to illustrate the build up of toxic materials like pesticides within the food chain eg. food cards collected can be 'tainted' with residues which can build up to unacceptable levels before the animal can complete collection of sufficient food.