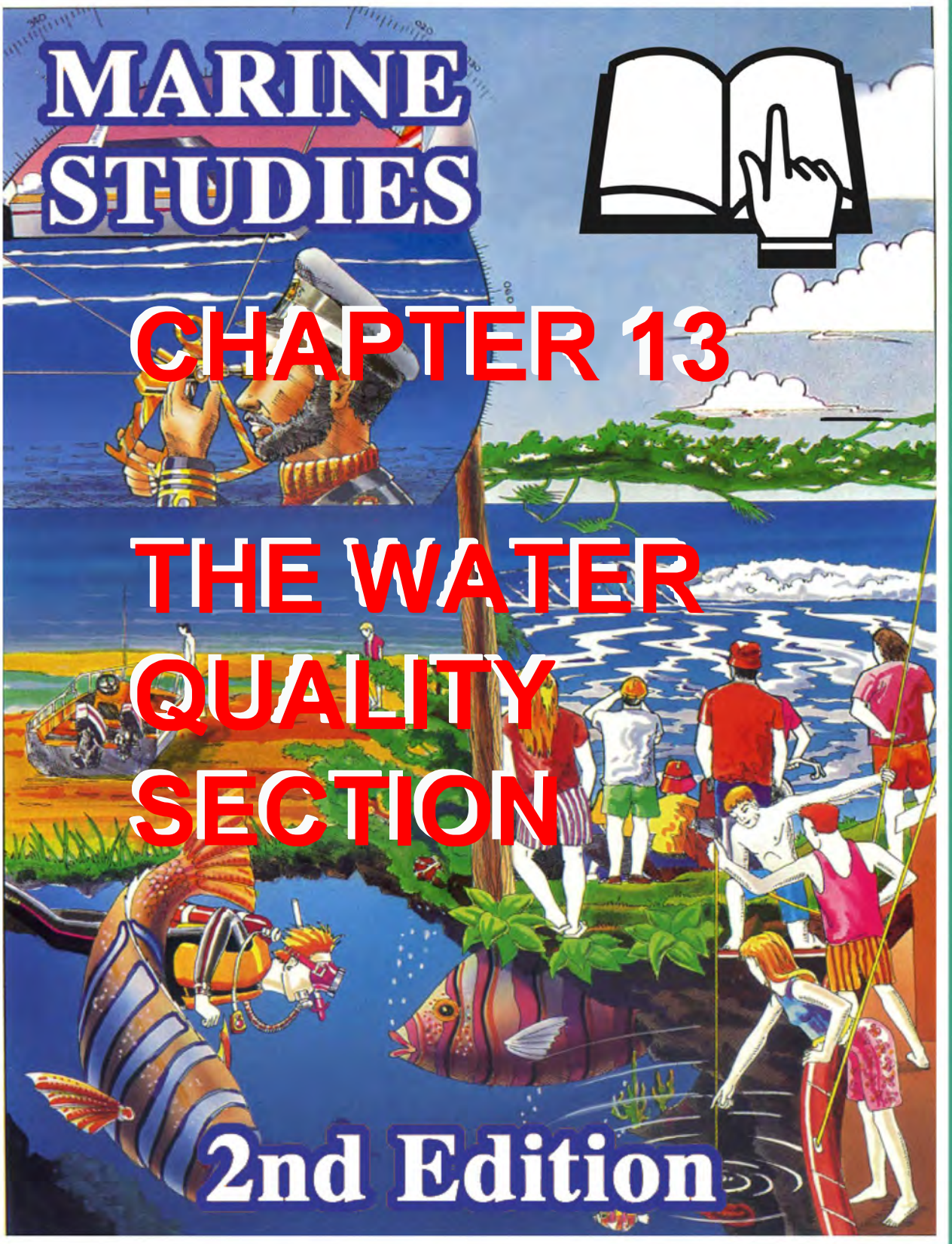

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January 1992

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Syllabus references

The table over shows how the book matches each of these syllabi. Addresses are as follows:-

Classroom objectives - Senior Secondary School Studies Syllabus, copies of which may be obtained from PO Box 1379, Spring Hill, 4000.

National Powerboat Training Scheme Topics - Australian Yachting Federation, Locked Mail Bag 806, Milsons Point, Sydney, 2000.

Commonwealth Department of Transport and Communications Handbook for Radiotelephone Ship Station Operators (Restricted certificate standard) copies of which can be obtained from State Offices.

NAUI National Association of Underwater Instructors syllabus on skindiving. Copies of which can be obtained from NAUI Australia 145 Old Cleveland Rd. Capalaba 4157.

GREEN - Global Rivers Environmental Education Network- water quality monitoring syllabus of Stapp and Mitchell available from 2050 Delaware Ave, Ann Arbor, Michigan, USA 48103 which is now widely used in Australian States.

Queensland University of Technology Kelvin Grove Campus Marine Education Materials Locked Mail Bag No 2 Red Hill 4059

Standards and chapter design

This book is designed for a two year course of study by students aged over 15 years, who have approximately 240 hours of programmed class time. Each chapter has a set of **classroom objectives,** centred around a set of **topics** that have been derived from either:-

- Community standards e.g. The national restricted radio operators certificate of proficiency
- University undergraduate courses in Marine Zoology and Botany
- Overseas Marine and Estuarine Courses e.g. The Global Rivers Project or University of Hawaii Curriculum Research and Development Group
- Government Department publications e.g. Green Paper on Coastal Environmental Protection

The *classroom objectives* are derived from the Queensland Board of Senior Secondary School Studies Marine Studies Syllabus, which based many of its ideas on National Curriculum Standards in Marine Education.

The terms content means - knowledge and its application, process means - analysing information, writing reports, data processing and reasoning. Skills refer to physical hands on skills such as "row a boat, collect a sample of plankton using a plankton net" and attitudes are self explanatory. The illustration below, shows how these are arranged four components have been arranged in the book.

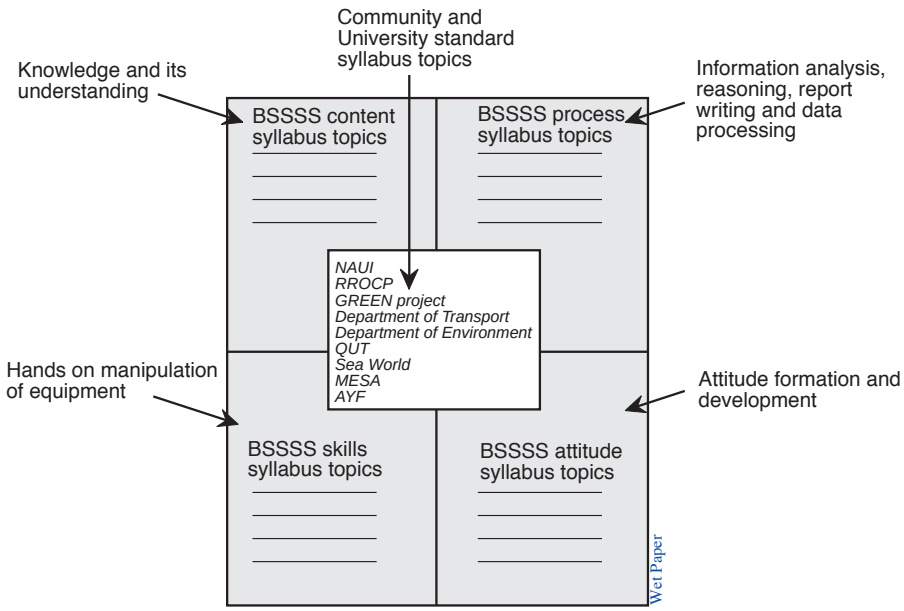


Fig 1: Textbook design

Syllabus matches

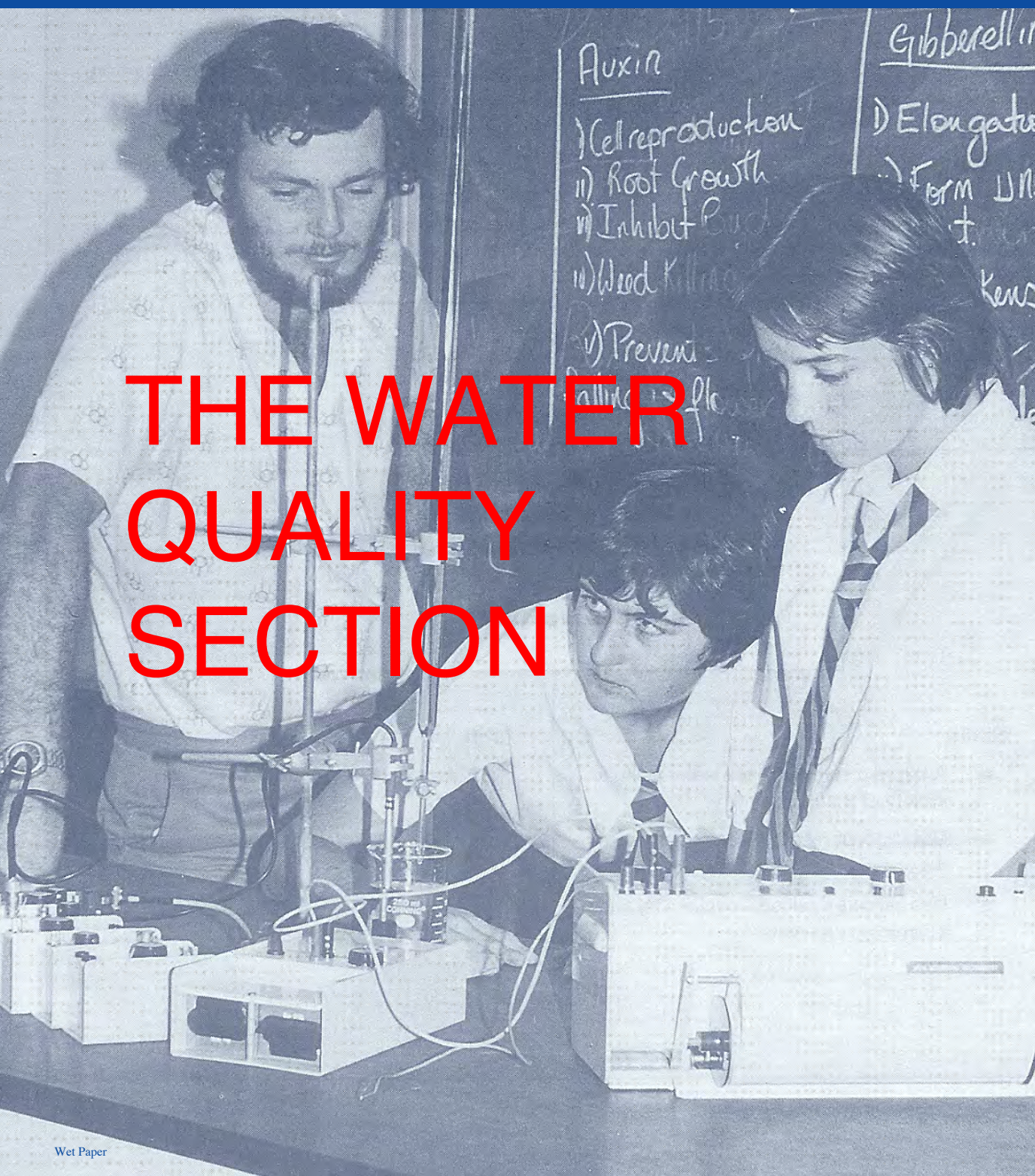
Wet Paper

		BSSSS - Board of Senior Secondary School Studies Syllabus	RROCP - Commonwealth Department of Telecommunications Radio Certificate	NAUI - Snorkelling certificate	AUF - Snorkelling certificate	TAFE - Inshore navigation course	AYF - Training level 3 powerboat handling certificate
Chapter 1	Boats and equipment	★					★
Chapter 2	Outboard engines	★					★
Chapter 3	Small craft safety	★	★				★
Chapter 4	Navigation	★				★	★
Chapter 5	Small craft handling	★					★
Chapter 6	Chartwork	★				★	★
Chapter 7	Tides and weather	★				★	★
Chapter 8	Marine communications	★	★				★
Chapter 9	Skindiving	★		★	★		
Chapter 10	Managing marine accidents	★		★	★		★
Chapter 11	Oceans	★					★
Chapter 12	Coastlines	★					
Chapter 13	Sea water quality and pollution	★					
Chapter 14	Plankton	★		★	★		
Chapter 15	Nekton	★		★	★		
Chapter 16	Benthos	★		★	★		
Chapter 17	Marine ecosystems	★					
Chapter 18	Aquaculture	★					
Chapter 19	Principles of conservation and management	★					
Chapter 20	Research projects and case studies	★					

In addition Chapters 19 and 20 address the issues raised by the green papers on coastal management and conservation.

Chapter 13

Sea water quality and pollution



Wet Paper

Content

- The composition of seawater
- Basic chemical and physical properties of sea water and some tests used to determine its quality.
- Some factors that can cause sea water pollution and some legislation intended to prevent that pollution

Process skills

- Interpret data concerning the quality and composition of seawater
- Recognise the potential for pollution of the coastal zone
- Predict the effects of pollution by currents, winds and waves discussing the methods used to combat them
- Research examples of water pollution in the local marine environment and present the results in a report
- Gather data on pollution from laboratory tests and present these in either graphical or tabular form.
- Interpret data in terms of the environmental tolerance of marine organisms
- Examine the processes involved in environmental decision making

Topics

The composition of seawater

Making seawater

Establishing a test for seawater

Water pollution and its measurement

What is water pollution

How is water pollution measured

Water quality tests

Research projects

Skills

- Analyse a sample of sea water using a variety of methods
- Use field equipment to measure and record data on major coastal processes
- Use various devices for collecting and examining sea water

Attitudes

- An awareness of the value of clean water

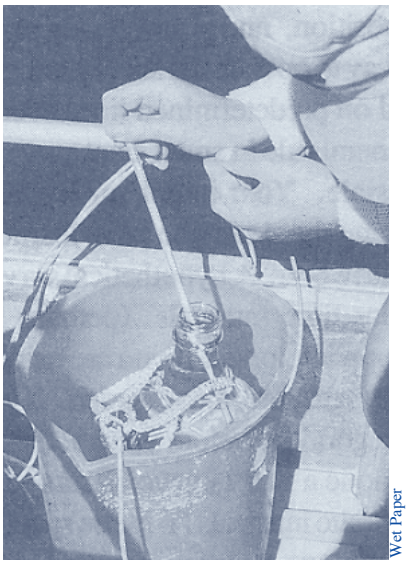


Fig 20 Using the "wine sampler" on board your boat.

Water quality

World health authority categories used for making recommendations on water uses are the following:-

1. Water supply for domestic and industrial use.
2. Recreation for total body contact like swimming, water skiing, skin diving, wind surfing or surfing.
3. Partial body contact like fishing and boating.
4. Protection of organisms like fish, wildlife and other aquatic life.
5. Agricultural uses like livestock watering, irrigation and spraying.
6. Commercial uses like navigation, hydroelectric and steam generated power or cooling.

The bottom line is that water is classified and signposted according to the categories above. We are going to have to get used to using **grey water.** This is recycled water from washing machines, sewage treatment plants or dams.

Water quality tests and pollution

The techniques described here are from Mitchell and Stapp (1990 with modifications by Bullocks 1991)

Once you have water samples you can now test them for water quality. Water is measured in terms of a water quality index or WQI based on the results of 9 tests. These tests are dissolved oxygen, faecal coliform, pH, biochemical oxygen demand (5 day), temperature, total phosphorus, nitrates, turbidity and total solids. After completing the nine tests, the results are recorded and transferred to a weighted curve chart to obtain a numerical value. This value is called a **Q value** for each test and is multiplied by a weighted value for each test according to its importance. Dissolved oxygen has a high value because it is important. The nine values are added together to give an overall value (WQI) - see Figure 21.

Some would argue that

"The attitude that we must use 100% clean water for everything need to change"

Variable	Results (Column A)	Column B	Factor (Column C)	Column D
1. Dissolved oxygen	130%	91	0.17	15.47
2. Faecal coliform	colonies 130/100ml	41	0.16	6.56
3. pH	8.8 units	58	0.11	6.38
4. B.O.D.	6.5 p.p.m.	48	0.11	4.28
5. Temperature	+0.5 Δ^{o}C	90	0.10	9.00
6. Total Phosphorous	0.3 mg/l	82	0.10	8.20
7. Nitrates	0.62 mg/l	98	0.10	9.80
8. Turbidity	90 cm	30	0.08	2.40
9. Total solids (-salinity)	430 mg/l	42	0.07	2.94
	Overall water quality index			**65.03**

Wet Paper

Fig 21 Water quality measurement table After Mitchell and Stapp 1988. (Reproduced with permission)

The overall water quality index is expressed as a value out of 100 and in the USA most state water quality ratings of 50-58 are acceptable levels for general use. WQI values and their significance are summarised below:

- 90 - 100 excellent
- 70 - 90 good
- 50 - 70 medium
- 25 - 50 bad
- 0 - 25 very bad

Immediately it should be recognised that a body of water may have a high faecal coliform (human bacteria) count and still come up with a 70 WQI. The results of individual tests should be considered independently as well as a whole when making decisions about the use of the water.

The chemical kits used to determine some of the Q values are manufactured by the HACH (pronounced haark) company and called HACH kits. Here are some safety suggestions to consider:-

- You should examine each of the chemicals used in these kits consulting your state safety manual as to their dangers. Refer also to the label.
- Safety goggles must be warn when using or shaking chemicals in bottles. It can be windy in the field or you can be bumped by accident and any splash in the eye could leave you with a serious injury.
- Wash your hands before and after all experiments.
- If possible work on a flat surface - a board or table to avoid spillage.
- Take a slop bottle with you to put all used chemicals in after use. It's no good studying pollution and then polluting the environment yourself. Take the slop bottle back to the lab and dispose of the chemicals as determined by your State safety manual. If in doubt ring your regional office or local city council for advice on how to dispose of chemicals.

Now you are going to complete nine tests to determine water quality, so draw up, or copy, a data table like the one shown in Figure 22 and read through the nine tests before starting.

Variable	Results (Column A)	Column B	Factor (Column C)	Column D
1. Dissolved oxygen	%		0.17	
2. Faecal coliform	colonies /100ml		0.16	
3. pH	units		0.11	
4. B.O.D.	p.p.m.		0.11	
5. Temperature	Δ^{o}C		0.10	
6. Total Phosphorous	mg/l		0.10	
7. Nitrates	mg/l		0.10	
8. Turbidity	cm		0.08	
9. Total solids (-salinity)	mg/l		0.07	
Overall water quality index				

Wet Paper

After Mitchell and Stapp 1988

Fig 22 Water quality data table (After Mitchell and Stapp 1988)

The kits described here is the HACH Dissolved Oxygen Kit and is available from your local Selby Scientific Agent. Addresses are appendixed.

1. Dissolved oxygen (D.O.)

See also page 540 in the Chapter on Aquaculture which discusses seawater, oxygen and temperature

The major gases dissolved in sea water are nitrogen, oxygen and carbon dioxide. Gases can dissolve in water from the atmosphere. How well these gases dissolve depends on three factors:

1. The temperature of the seawater and the solution
2. Depth of the water
3. The salinity of the solution

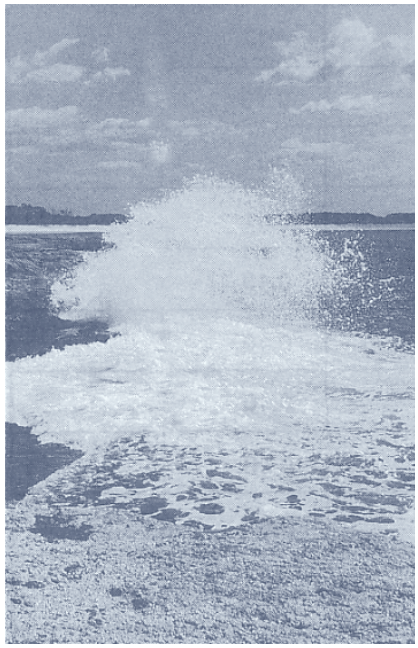
Oxygen concentration varies with depth and in surface waters it is related to temperature of the water.

As water temperature increases, solubility of oxygen decreases.

Waves mix oxygen with sea water as does water rushing over rocks in mountain streams. Water rich in oxygen creates an environment which has a distinctive odour. e.g. sea or mountain air has a different smell than air of an inner city street.

Plants are also responsible for providing much of the world's oxygen by photosynthesis. During sunny periods the green chlorophyll in microscopic floating sea plants, called phytoplankton, combines the carbon dioxide produced by the animals of the sea with their body water to produce oxygen and sugar. The sun's energy is trapped in the body sugar and provides food for the other animals in the sea. Photosynthesis takes place from dawn to dusk, and during the night the cycle is reversed and it is used up. It follows therefore that the greatest levels of dissolved oxygen should be found in the afternoon and the lowest sometime before dawn.

Dissolved oxygen is an essential element for the maintenance of estuaries because most aquatic plants and animals need oxygen to survive. In the ocean depths where dissolved oxygen is very low, animals and bacteria have evolved to function on very low levels. Environments with high levels of dissolved oxygen are usually able to sustain as high **species diversity**.



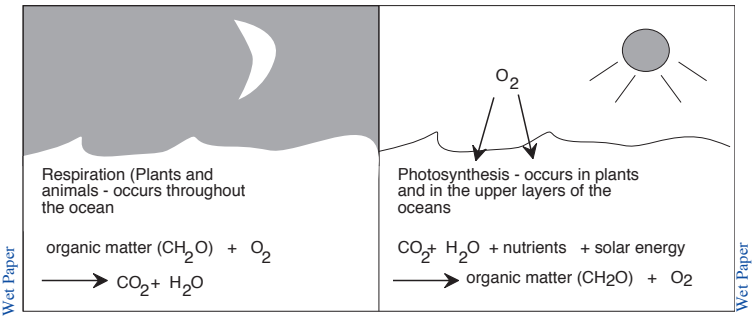


Fig 23 Oxygen dissolves in water in a number of different ways

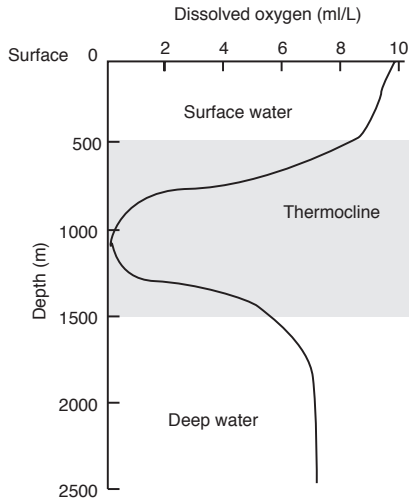


Fig 24 Typical graph of dissolved oxygen v's depth of marine waters (After Lerman 1986)
Wet Paper

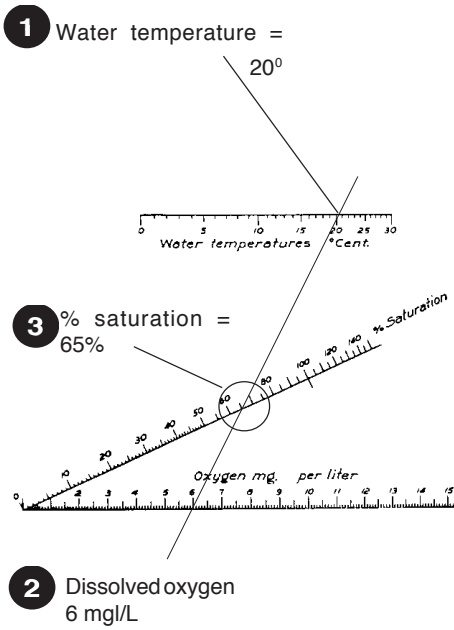


Fig 25 How to calculate % saturation
Wet Paper

Barrier reefs are bathed in oxygen rich waters. Shallow, warm sea conditions with high water clarity, low nitrogen and phosphorus levels, no human faecal pollution and very few suspended solids, make great places to develop a tourist facility. A few ways this could be changed are:-

- The accumulation of organic waste. The term **organic** means anything that contains the element carbon. Our living planet is based on this element. Plants, animals, bacteria and the wastes they produce all contain carbon. So any materials that contain carbon are called **organic**. Sewage is one form of organic waste.
- Discharges from food processing plants, meat packing works and dairies will contain organic materials.
- Leaves, twigs and dead plants can also contribute organic material. If the natural removal of these is inhibited by changes to natural river patterns like weirs or canals, they can accumulate causing a depletion of water quality.
- Places where the current is slow and wave action is reduced are places for low DO levels. Surf beaches with high currents would be places for high DO levels. Clear surface waters will have a high DO whereas deeper muddy waters will have a low DO. You may like to predict other places for high and low DO.

As mentioned earlier, the temperature of the water determines the solubility of the dissolved oxygen and % saturation levels.

A graph (Figure 26) must be used to change the figures of mg/L of dissolved oxygen into a % saturation level.

After you calculate your concentration (mg/L) of dissolved oxygen, you measure the temperature of the water sample and then draw a straight line connecting the two. You can now read the % saturation from the point where the line crosses as shown in Figure 25.

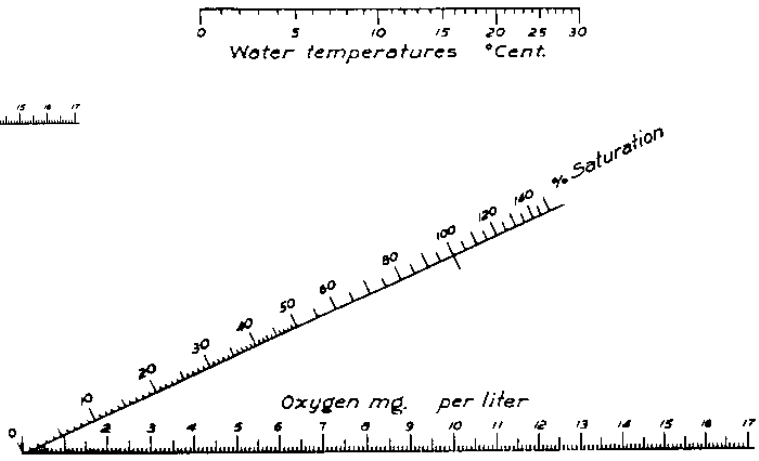


Fig 26 Percent saturation calibration graph - you use this graph after Step 8 on the next page (Reproduced from Mitchell and Stapp (1988)
Wet Paper

Other kits

There are other kits available to test oxygen. The instructions printed below are from the HACK kits but other kits also contain instructions too. The HACK instructions are reproduced with courtesy of the HACK corporation.

Safety warning

In addition to the instructions over you are to wear goggles and gloves for the rest of the exercise.

The dissolved oxygen test

The kit described here is the HACH Dissolved Oxygen Kit .

Wet Paper

Fig 27 Dissolved oxygen kit

This is the DO test described in the HACH kit. If you are using another kit or titration, use the instructions in it.

1. Fill the Dissolved Oxygen bottle (round bottle with glass stopper) with the water to be tested by allowing the water to overflow the bottle for two or three minutes. (If you have sampled from depth, bring your water sample to shore and siphon off the water sample so that no air bubbles can enter the bottle. Allow the water to run out of the bottle for 30 seconds). To avoid trapping air bubbles in the bottle, incline the bottle slightly and insert the stopper with a quick thrust. This will force air bubbles out. If bubbles become trapped in the bottle in steps 2 or 4 the sample should be discarded before repeating the test.
2. Use the clippers to open one *Dissolved Oxygen 1 Reagent Powder Pillow* and one *Dissolved Oxygen 2 Reagent Powder Pillow*. Add the contents of each of the pillows to the bottle. Stopper the bottle carefully to exclude air bubbles. Grip the bottle and stopper firmly; shake vigorously to mix. A flocculant (floc) precipitate will be formed. If oxygen is present in the sample the precipitate will be brownish orange in colour. A small amount of powdered reagent may remain stuck to the bottom of the bottle. This will not affect the test results.
3. Allow the sample to stand until the floc has settled halfway in the bottle, leaving the upper half of the sample clear. Shake the bottle again. Again let it stand until the upper half of the sample is clear. **Note the floc will not settle in samples with high concentrations of chloride, such as seawater.** No interference with the test results will occur as long as the sample is allowed to stand for four of five minutes.
4. Use the clippers to open one *Dissolved Oxygen 3 Reagent Powder Pillow.* Remove the stopper from the bottle and add the contents of the pillow. Carefully re-stopper the bottle and shake to mix. The floc will dissolve and a yellow colour will develop if oxygen is present.
5. Fill the plastic measuring tube level full of the sample prepared in steps 1 through to 4. Pour the sample into the square mixing bottle.
6. Add Sodium Thiosulphate Standard Solution drop by drop to the mixing bottle, swirling to mix after each drop. Hold the dropper vertically above the bottle and count each drop as it is added. Continue to add drops until the sample changes from yellow to colourless.
7. Each drop used to bring about the colour change in step 6 is equal to 1 mg/L of dissolved oxygen (DO).

The following steps are now to be followed regardless of which kit or titration you used

8. When you have established the DO concentration in mg/L, measure the water temperature and use the "level of saturation" chart in Figure 26 on the previous page to determine the percent saturation of dissolved oxygen. Record this under Column A on the Table on Page 365.
9. Now use the chart in Figure 30 to determine the Q value. Record this on your data table under Column B and multiply by the weighted factor (0.17) and record the Q value in column D.

Fig 28 The kit contains chemicals in plastic pillows. Use the callipers to cut the top carefully so as not to spill any reagent or get it on your hands or in your eyes

Safety warning

Be very careful not to splash any chemical-ladened water and wash your hands immediately if spillage occurs. Dispose of all solutions used in your slop bottle and take it back to school

Fig 29 If oxygen is present a brownish- orange precipitate will form

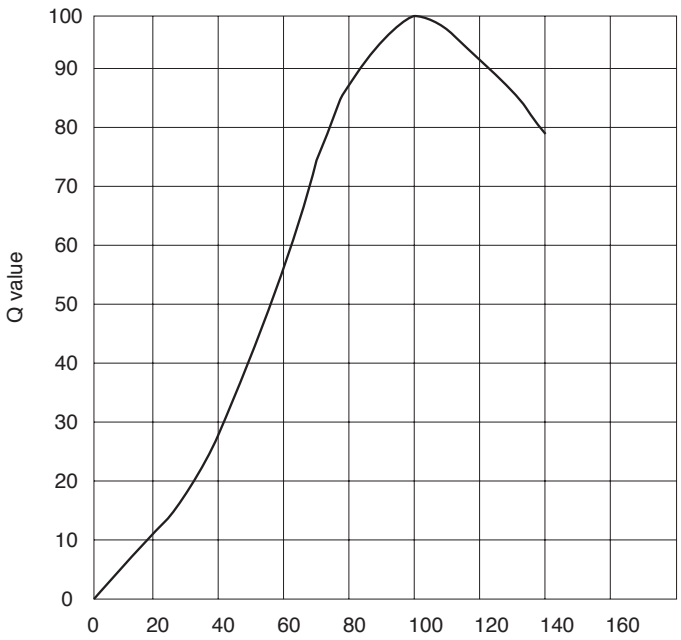
Percent saturation

To determine the quality of this result you must determine % saturation.

The saturation level is determined by the temperature.

Stapp (1988 says that "Rivers with a constant 90 percent dissolved oxygen saturation value or above are considered healthy. Rivers below 90 percent saturation may have large amounts of oxygen-demanding materials (organic wastes)

Table 1. Dissolved oxygen (DO) test results



After Mitchell and Stapp (1988) Page 66. Reproduced with permission.

Fig 30 Use this graph for step 9 to determine the Q value

2. Faecal coliform

Faecal coliforms are bacteria derived from the faeces of humans and other warm blooded animals. These bacteria can enter rivers through direct discharge from mammals or birds, from agricultural or storm runoff carrying bird or mammal wastes or sewage discharge into the water. These are microscopic bacteria which in themselves are harmless, but signify that there may be other harmful bacteria present such as those causing gastroenteritis, dysentery, typhoid fever, hepatitis or outer ear infections. The standards for these bacteria are summarised opposite. The faecal coliform count is also used as a indicator of water quality as shown in Figure 31.

Faecal coliforms	Safe colony numbers
Drinking water	1/100 ml
Swimming/ Surfing	200/100 ml
Boating/ Fishing	1000 / 100ml
Treated sewage effluent	No more than 200 / 100 ml

Data supplied Dept of Environment

Remember its not the coliform colonies that are harmful, its the indication that other more harmful pathogens can be present and alert the water control officer to begin serious testing for these.

Wet Paper

Aim

The aim of this test is to count the number of colonies present. This is done firstly by trapping them in a filter and then growing them under controlled conditions in a petri dish. The bacteria grow and multiply into colonies like those shown in Figure 31.

Sampling

- You can use the same sample bottle as for oxygen, but do not touch the inside of the bottle with your hands.
- Sample from below the water as the surface film contains coliforms in greater concentration than the actual river sample. Avoid sampling the bottom for the same reasons,
- Collect several samples and test within one hour. If this is not possible, keep the samples in ice to stop the bacteria from multiplying and so giving a false reading.

Method

The kit and procedure described here is the Sartorius membrane filter method which involves trapping the bacteria in a filter and then culturing colonies on a nutrient pad set.

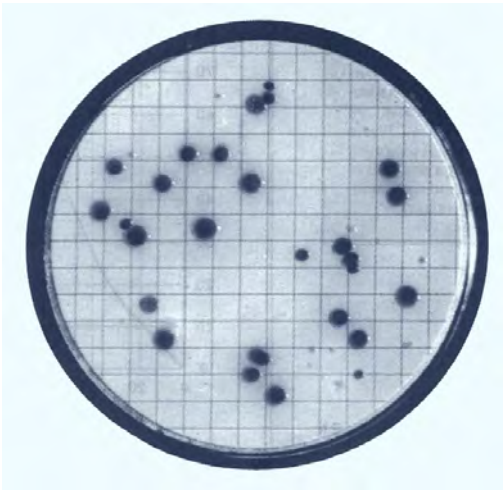


Fig 31 Photograph of E. coli colonies growing on a specially prepared nutrient pad that has been embedded with M-FC medium that only E. coli can grow on to produce a blue coloured colony of 1-2 mm in diameter. Colonies of different colours are not evaluated.
Wet Paper

Sartorius 14068047N Nutrient pad sets which include sterile petri dish, nutrient and membrane filter. The filter pores are small enough to trap the bacteria but big enough to let the water through. All equipment must be sterilised otherwise you will introduce more faecal coliforms than are actually present and obtain inaccurate results.

- A household pressure cooker can be used in the absence of a commercial autoclave. You will need a hot plate, the pressure cooker, forceps supplied, pipette and bulb, petri dishes and filtration system.
  Make sure the pressure cooker has an efficient gauge which should be run at 15 psi or 120 for 10 minutes. You can also sterilise forceps by passing them through a flame. When all equipment has been sterilised, you are ready to add your water sample. The membrane filter, nutrient pad and petri dish are all presterilised for immediate use.
- Unscrew the top half of the filtration system. Place a sterile polymer membrane filter on top of the support plate, in the filter holder with sterile forceps, grid side up. Be sure the filter is completely flat with no wrinkles. Screw on the top half of the filtration system.

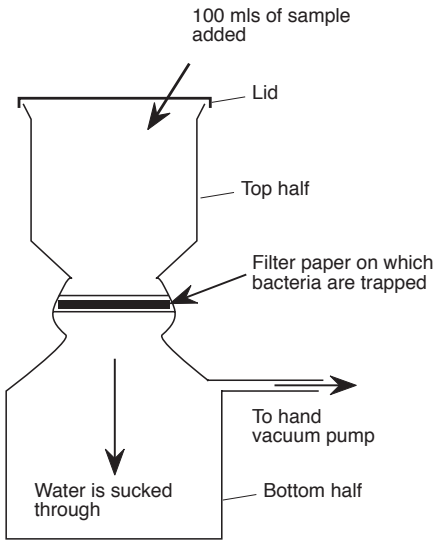
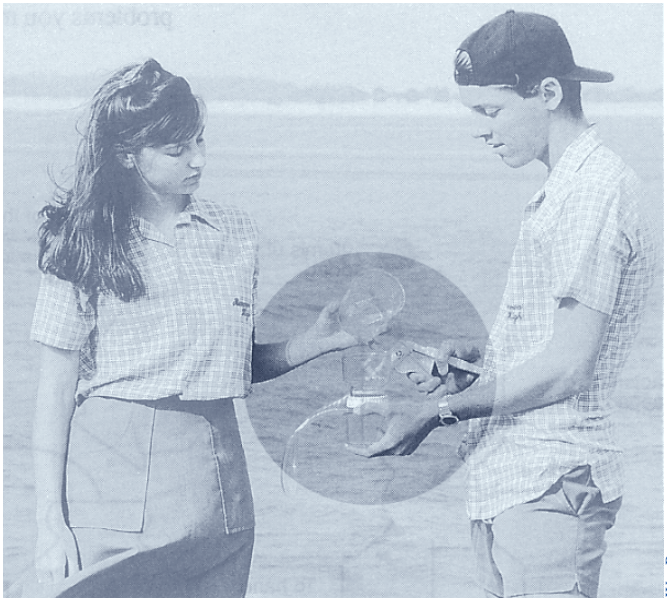


Fig 32 Membrane filter set
Wet Paper


Wet Paper

- Add your predetermined amount of water sample (This predetermined amount could be 1, 2, 5, 10 or 100 mLs. depending on the density of coliforms you suspect are present - in early attempts, this will be trial and error and it is suggested you start with 100 mLs).
  The ideal number of colonies to find are 20 - 60.
- Transfer the predetermined volume of water to the funnel though the top of the filter holder. If the water does not cover

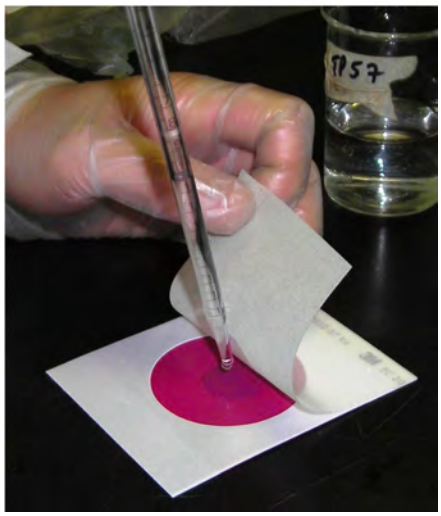
Autoclaving techniques

Consult with your local water control officers or science department to obtain details on correct sterilisation procedures.

Also instructions are usually contained in the filter holder box.

THIS IS THE NEW ONE
FROM THE POWER POINTS

GOOD PIC IN T36



the entire filter (i.e. where a small volume is used), add distilled water to the funnel so that the whole membrane filter is covered with water.

- Use the suction pump to suck all the water through the membrane filter. Take care not to suck the membrane right through and continue to squeeze until the membrane appears dry. Unscrew the top half of the funnel and carefully remove the membrane filter with the sterile forceps.
- Prior to transferring the membrane filter to the petri dish, the nutrient pad needs to be "wetted" with sterile distilled water using a sterile syringe or glass pipette so that the nutrient pad is wet but the petri dish is not awash with excess water. Approximately 3 mLs of water is required.
- Open the top of the petri dish and place the membrane filter onto the wetted nutrient pad with the grid side up. Ensure that no air bubbled are trapped beneath the membrane filter. Petri dishes should be incubated within 30 minutes of filtering the sample. The plates should be incubated at 37^{0}C for 24 hours.
- After incubation, carefully count the bacterial colonies on the filter using a magnifying glass or stereo microscope. Each dark blue spot is counted as one colony. Figure 34 shows some of the problems you may encounter.

The Petrifilm method

The Petrifilm method has been specifically designed for volunteer water monitoring purposes. The method is user friendly, relatively inexpensive and easily quantifies and identifies total coliforms and *E. coli*.

Equipment:
gloves
sterile Schott bottle or pre-sterilised disposable container
Petrifilm *E. coli* plates
disposable sterile plastic pipette or syringe
small glass (heat resistant) beaker
incubator

Test preparation

- Store unused Petrifilm *E. coli* plates in a sealed plastic container in the freezer.
- Collect your sample in a sterile Schott bottle or sterile disposable container.
- Turn on the incubator and ensure it has reached 44°C ± 1°C.
- Perform the test on a flat surface.

Method

1. Shake sample bottle vigorously.
2. Using 1 mL disposable plastic pipette or sterile syringe, draw up 1 mL of sample water.
3. Lift up the top clear film of the Petrifilm *E. coli* plate.



4. Hold pipette upright and dispense the 1 mL sample onto the centre (pink circle) of the bottom film.
5. Roll the top film back onto the sample quickly and gently to minimise bubble formation.
6. Allow the gel to set.
7. Place in an incubator clear side up.




Setting the incubator

1. The incubator needs to be turned on and brought up to 44°C ±1°C.
2. A small beaker of water should be placed into the incubator to act as a humidifier.
3. It is important that the incubator maintains this temperature for 24 hours ±2hr as fluctuations in temperature, or temperatures outside of this range, may inhibit the growth of *E. coli*.

The number of colonies should be recorded in your note pad and use Figure 35 to determine the Q value. Now record this in column B of the table in Figure 22, Page 365 or your data table and multiply by the weighted factor of 0.16 to obtain the Q value for Column D

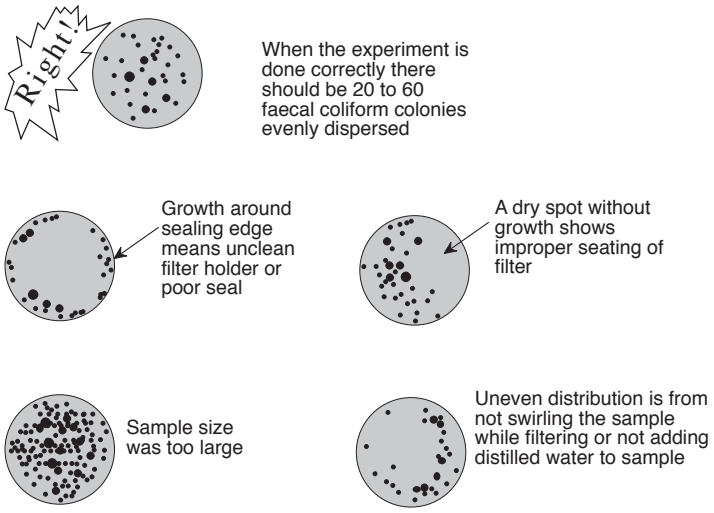
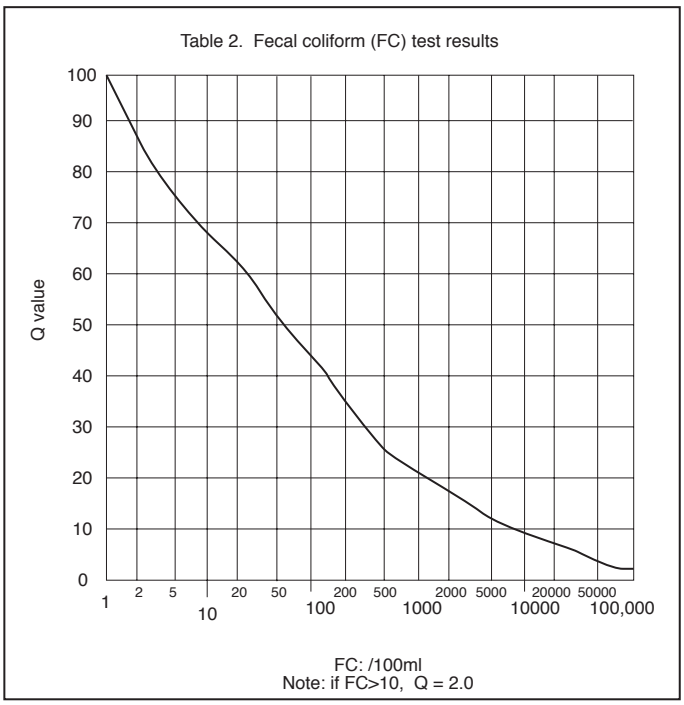


Fig 34 What to look for (After Stapp and Mitchell 1990)
Wet Paper

Safety warning - disposal of plates

A common method of disposal of petri dishes is to burn them, however schools or institutions are to follow the disposal methods recommended by their local safety officer or regional office



After Mitchell and Stapp (1988) Page 67. Reproduced with permission.

Fig 35 Faecal coliform Q graph (After Stapp and Mitchell 1990)
Wet Paper

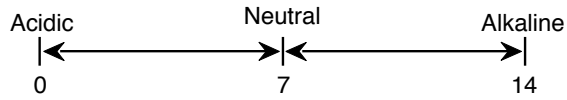
3. pH

We saw how salt in water can ionise into sodium and chloride ions. pH is a measure of the concentration of hydrogen ions (H^+) in water.

These ions are measured on a 0 to 14 scale as follows.

$H_2O \quad \rightarrow \quad H^+ + OH^-$

The definition of an acid is where a substance ionises to form hydrogen H^+ ions in solution.



As the pH value decreases, the hydrogen ion concentration increases.

Natural waters will have a pH of approximately 7. Sea water has an average pH of 6.5 to 8.5.

At extremes of pH ranges, organisms diversity decrease. Ranges of 5 and below have been recorded in many places overseas which affects the larval stages of fish and other small invertebrates.

pH is measured here with a pH metre.

- The metre must be calibrated first with the solution supplied by pouring it into a beaker and immersing the bottom of the metre in the pH 7 buffer solution. Stir and wait till the reading is stable, then adjust the metre to read pH 7.0.
  The metre shown in Figure 37 has a calibration screw located at the back.
- The metre is then placed in the water and the pH read off the digital display. With some water samples the metre may take up to a minute to stabilise.

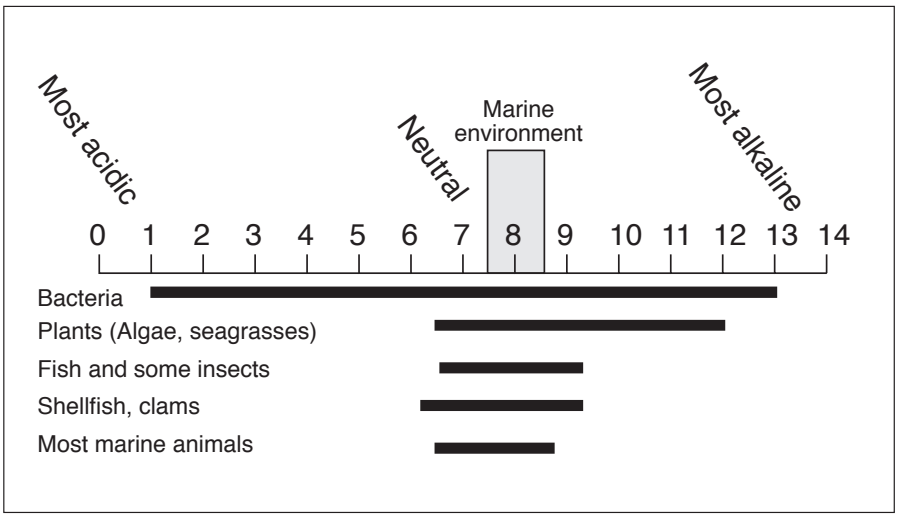
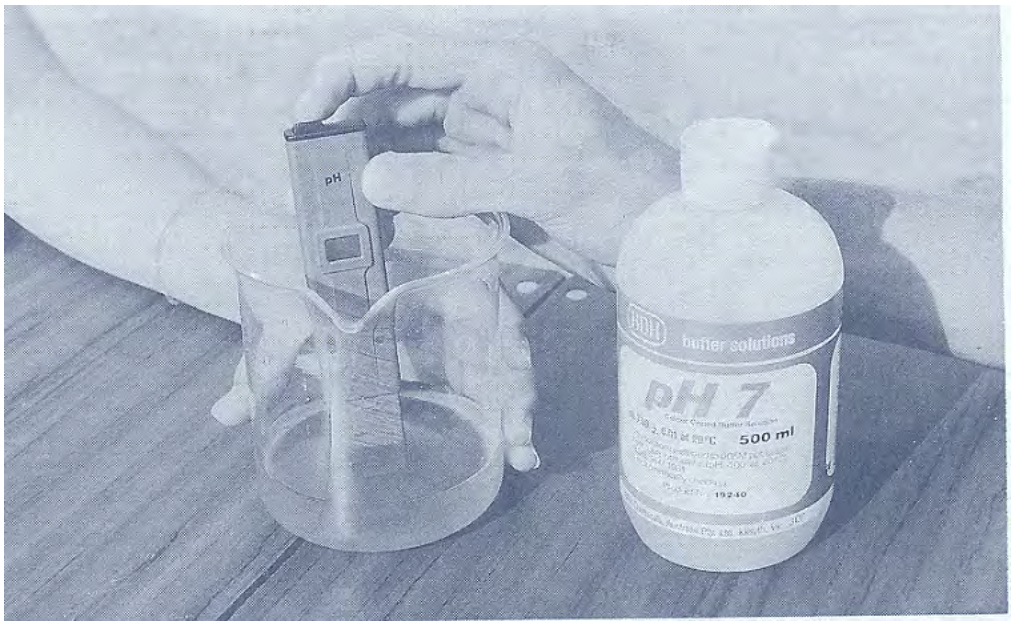


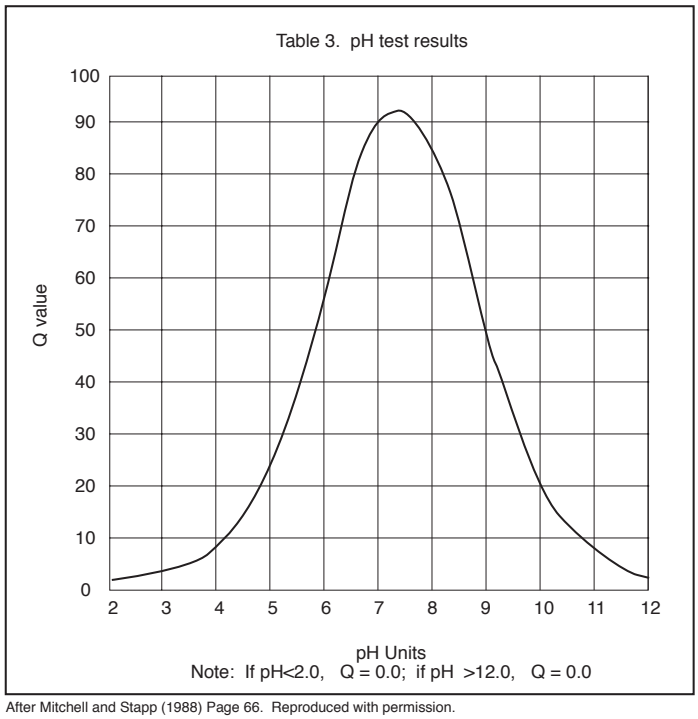
Fig 36 Some animal and plant tolerance to pH (After Stapp and Mitchell 1990)
Wet Paper



Wet Paper

Fig 37 The metre must be calibrated first with the solution supplied by pouring it into a beaker and immersing the bottom of the metre in the pH 7 buffer solution. Stir and wait till the reading is stable, then adjust the metre to read pH 7.

Read off the Q value from the graph in Figure 38 and record it in Column B in Figure 22 on Page 365. Then multiply this by the weighted factor of 0.11 to obtain your Q value which you write down in column D.



Wet Paper

After Mitchell and Stapp (1988) Page 66. Reproduced with permission.

Fig 38 Q value determination of pH (After Mitchell and Stapp 1990)

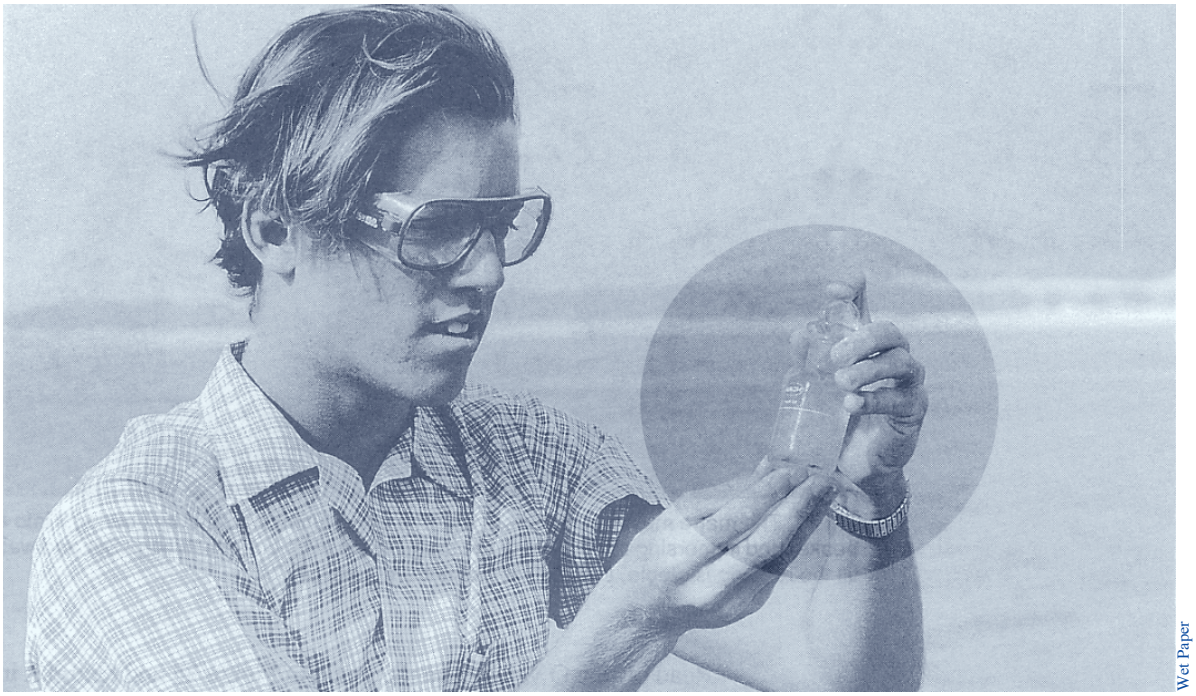


Fig 39 Adding reagents for BOD test

4. Biochemical Oxygen Demand

The BOD test (Biological Oxygen Demand) measures the amount of organic material in water. Organic matter is fed upon by aerobic (able to live only with oxygen) bacteria. In this process the organic material is broken down and combined (or oxidised). Single celled animals called Protozoans, prey upon the growing population of bacteria and also require oxygen.

The process by which plants die is a major cause of high BOD's.

When the oxygen runs out this process of decomposition uses sulphurous compounds forming sulphides, giving the characteristic rotten egg smell.

Biochemical oxygen demand is a measure of the quantity of oxygen used by these microorganisms in the aerobic oxidation of organic matter. Organic matter comes from pulp mills, meat packing plants, food processing industries and waste water treatment plants. Natural sources include twigs, leaves, dead animals and plants.

These sources come from one point and are called point sources. However much pollution comes from non point sources like playing fields where lunch scraps, dog droppings, leaves, fertilisers, car wash detergents, bottles, cans, oil, topsoil, garden scraps, to name but a few, enter the system.

The influx of chemicals such as nitrates and phosphates stimulates plant growth. More plant growth leads to more decay and nutrients can be the major force in the BOD in rivers. Waste accumulates where the water slows, such as mangrove swamps, causing bacteria numbers to increase with the large amount of available food. Percent saturation of oxygen will therefore fall.

So much of the available dissolved oxygen is consumed by the aerobic bacteria leaving very little for mud crab larvae or fish larvae. As most of these larger order consumers live out to sea, stocks are reduced by a depletion of the immature stages in the mangroves. The diversity of the rich mangrove swamps is decreased by the deaths of the smaller animals on which the larger ones feed.

Testing for BOD

Use the same HACH kit you used for oxygen.

- This time however two samples are taken. One tested immediately and the DO recorded as before.
- The other is wrapped in aluminium foil and incubated in a dark cupboard for 5 days at approximately the same temperature as you recorded for the first bottle. After five days determine the DO using the appropriate method.
- Now subtract the two DO readings. This value = BOD. Now use the table below to compute the Q value.

Take this Q value and record it in the Column B in Figure 22 on Page 365. Now multiply this value by 0.11 to obtain the weighted Q value which is recorded in column D of the same table.

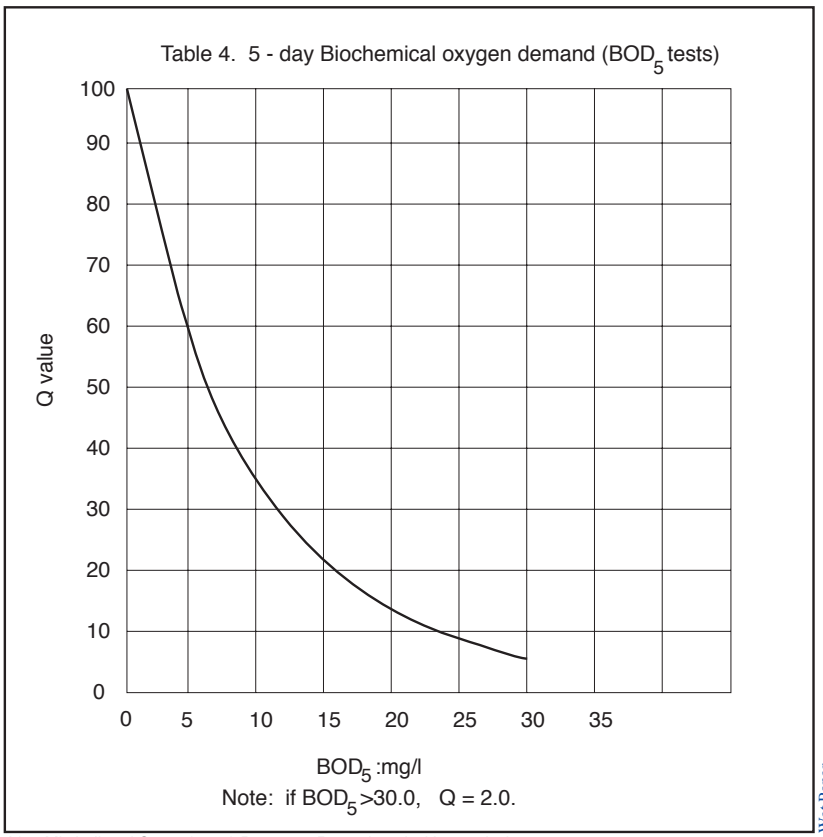


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Fig 40 Q value determination of BOD (After Mitchell and Stapp 1990)

5. Temperature changes

The effect of temperature is also discussed in Chapter 18 Aquaculture

Temperature affects many physical, biological and chemical characteristics of sea water.

- The solubility of oxygen, the rate of photosynthesis, the metabolic rate of most organisms and the sensitivity to toxic wastes and disease are all controlled by temperature.
- Gases are more soluble in cool waters. As temperature increases, the rate of photosynthesis increases causing more algae to grow, which in turn uses more oxygen causing fish to die. As the temperature increases fish metabolism slows down making them easy prey.
- The hot summer months in the cities heat roads, buildings and footpaths. Rain falling in summer storms absorbs this heat and storm water run off .
- Water that is slowed down by the building of marinas, jetties, or waterways that are clogged by tress or other organic matter, is heated rapidly.

Pollution of water by heat is called thermal pollution and can have a number of effects:-

- Fish die or move to other environments since certain fish can only live within certain temperatures e.g. Rainbow trout (15˚C), Perch (24˚C), Carp (32˚C). Each of these species can only tolerate a temperature rise of 5 degrees C
- Warmer water tends to lie on top of cooler water because it has a lower density. Consequently the cooler water is prevented from coming into contact with the atmosphere reducing the dissolution effect.
- Poisoning by other elements is greatly accelerated by an increase in temperature

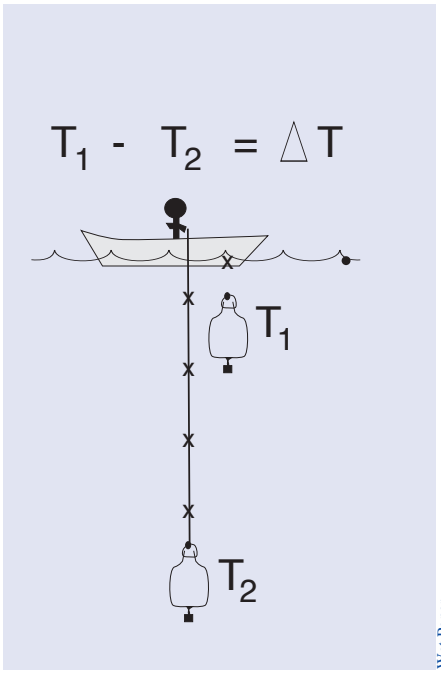

Fig 41 The determination of Q value is from the temperature change. This can be depth as shown above or comparing two sample sites as shown in Figure 42

The water sampling bottle and a bucket can be used to measure surface and shallow subsurface temperatures. As soon as the bottle is hauled on board, place the bottle in the bucket and read the temperature directly. Temperatures from a variety of depths can be determined in this way and used in conjunction with salinity, and oxygen can be used to draw a profile of the water column.

Alternatively, you can measure water temperature from the side of the estuary. Ideally the thermometer should have a temperature range of about 2˚C + 35˚C but it must have at least a minimum range that will not be exceeded in the field.

Measurement of temperature

The measurement is the difference from one point to another so you have to select two regions of the river or estuary. Lower the thermometer 200 mm into the water and read the thermometer direct to the nearest ˚C. Proceed immediately one kilometre upstream to a point with similar conditions.

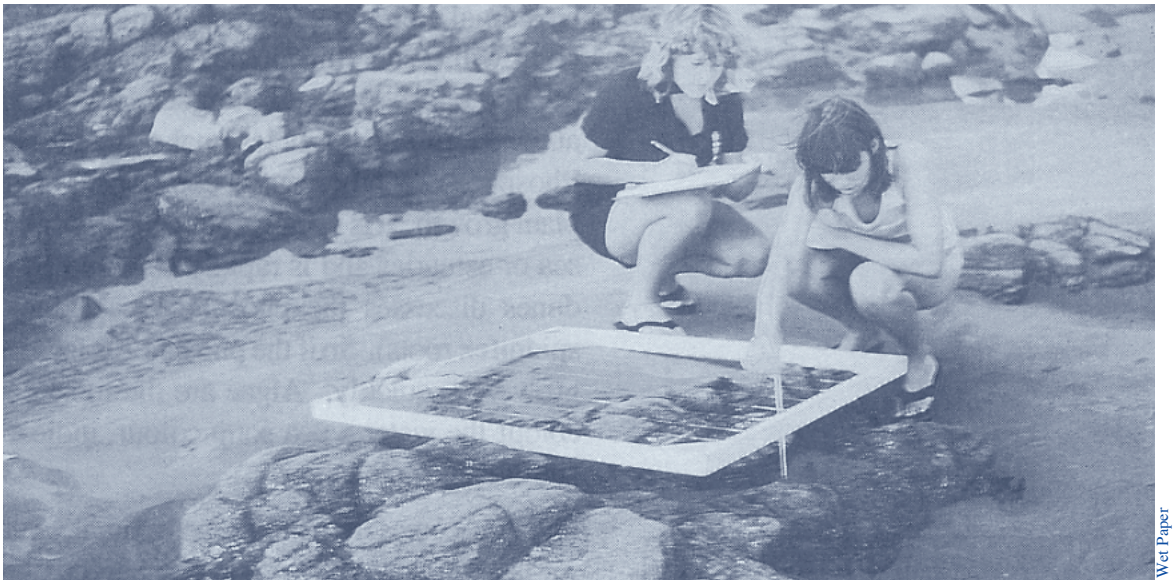

Fig 42 The temperature should be measured with the thermometer bulb in the water and comparing two sample sites

Repeat the test with the same thermometer and record the temperature in ˚C. Now record the difference and read the Q value from the table below. Record this Figure in column B in Figure 22 on Page 365. Multiply by 0.10 and record in Column D.

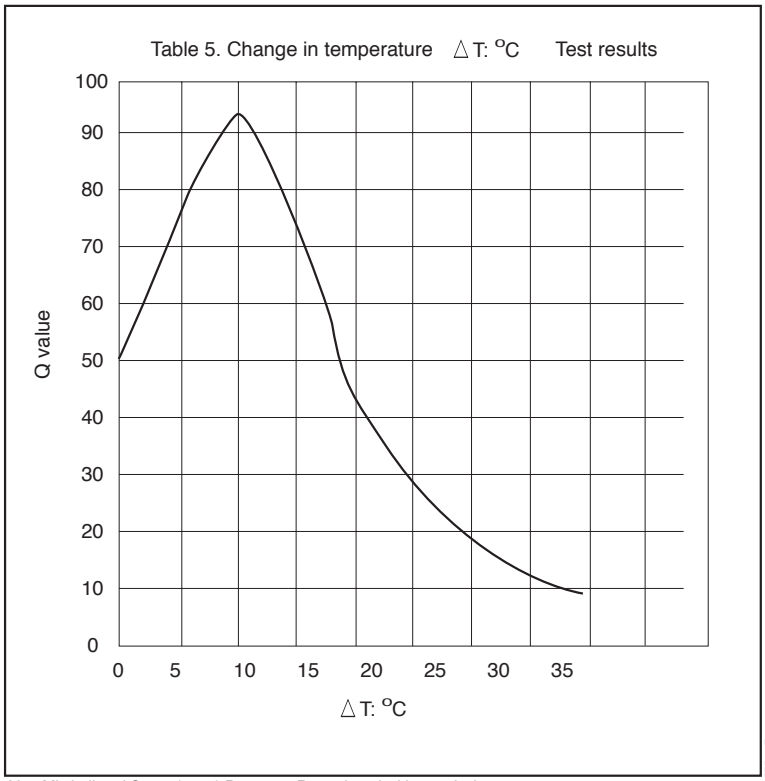

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Fig 43 Q value determination of BOD (After Mitchell and Stapp 1990)

6. Total phosphorus

This test includes organic phosphorus and inorganic phosphorus. If an animal dies and gets washed into the sea, the phosphorus in its body will be combined with other chemicals. So it is classed as organic phosphorus. Detergents and inorganic phosphorus ions attached to soil particles make up the inorganic components. Phosphorus is an essential component of life and is required for plant growth. It is usually found in very small concentrations in the sea or estuaries and is rapidly taken up by plants (the section on dunes discusses the phosphorus seeking behaviour of coastal spinnifex roots). So if the phosphorus increases rapidly, plants will grow very quickly. Algae are the most common form and they colour the water a pea soup colour, indicating a condition called cultural eutrophication.

Cultural eutrophication

Cultural eutrophication is an enrichment of the water, usually by phosphorous and usually by human pollution. Natural eutrophication is caused by fallout from volcanic eruptions, forest fires or natural underwater springs.

Pollution comes from human and animal wastes Inadequately treated sewage can cause increases in phosphorous levels. With this increase in phosphorus, plant growth is rapid. Massive amounts of oxygen will be produced during the day, however, decomposition will also occur at night. The plant bloom will actually destroy itself in the advanced stages of cultural eutrophication and dead organic matter flows to the bottom of the estuaries and marshes choking itself along with fish and other larger consumers. Anerobic conditions occur now in the bottom sludge and the characteristic rotten eggs gas, hydrogen sulphide, can be smelt in these backwater marshes.

Tip all solutions into the slop bottle for return to school and disposal according to Departmental Safety Instructions

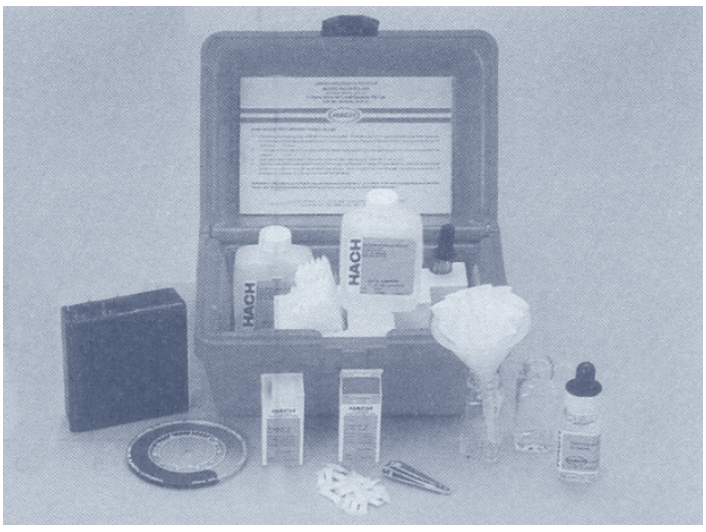
The amount of phosphorus can be reduced by reducing the amount of fertilisers we use in housing estates, encouraging a decrease in the amount of phosphorus used in farm fertilisation, preserving natural vegetation wherever possible near shorelines, requiring industry to pre-treat wastes.

Safety warning

Safety goggles to be worn during this experiment.

This kit contains dangerous chemicals and wands should be washed after the experiment and all solutions disposed of according to Departmental Safety Instructions.

The chemicals contained in the pillows are listed in the kit.



Wet Paper

Fig 44 Total phosphorus kit

Fig 45 Before you do the Phosphorus test, sit down and read the procedures carefully. It takes about 40-50 minutes to complete and is the longest of the nine tests

Testing for phosphorus

All equipment should be acid washed by soaking in dilute hydrochloric acid and rinsed with distilled water. Use protective gloves and goggles when working with acids.

Safety warning

The hexamine burner will get hot so be careful not to burn yourself when packing up the equipment.

If this test is done in a laboratory, a bunsen burner can be used. Again be careful when packing up to let the heating equipment cool before packing up.

Fig 46 The test involves the use of a haxamine burner kit. If the test is done in a lab, this may be replaced by a bunsen burner

Which Phosphorus range to choose?

At first you may not know how much phosphorus is preset in your sample. Start with the 0-50 mg/L range and from this result select a more appropriate range.

The kit consists of a small hexamine burner, square mixing bottle, 50 mL conical flask, potassium sulphate power pillow, 5 N sodium hydroxide solution, phosVer 111 Phosphate Reagent powder pillow, one black box and colour comparator.

TOTAL PHOSPHATE

1. Fill the square mixing bottle to the 20-mL mark with the water to be tested. Pour the sample into a clean 50-mL erlenmeyer flask.
2. Use the clippers to open one Potassium Persulfate Powder Pillow. Add the contents of the pillow to the flask. Swirl to mix.
3. Add 2.0 mL of 5.25*N* Sulfuric Acid Solution by twice filling the dropper to the 1.0-mL mark and discharging the contents into the flask. Swirl to mix.
4. Set up the boiling apparatus as shown in Figure 3. The use of a boiling aid is recommended to prevent violent boiling of the sample. *See Replacements.*
5. Boil the sample for 30 minutes. Add a little demineralized water occasionally to keep the volume near 20 mL. Do not bring the volume above the 20-mL mark near the conclusion of the 30-minute period. Do not boil to dryness.
6. Allow the sample to cool.
7. Add 2.0 mL of 5.0*N* Sodium Hydroxide Solution by twice filling the dropper to the 1.0-mL mark and discharging the contents into the flask.
8. Return the sample to the square mixing bottle. If the volume is less than 20 mL, add demineralized water to return the volume to 20 mL.
9. Proceed with the orthophosphate test of the appropriate range, except read the mg/L phosphate as total phosphate (PO_4).
10. At this point three values are known: ortho, total inorganic and total phosphate. Other values may be obtained as follows: total phosphate less total inorganic phosphate equals organic phosphate; total inorganic phosphate less orthophosphate equals meta (poly) phosphate.

High Range 0-50 mg/L Phosphate

1. Rinse the square mixing bottle with demineralized water.
2. Add 2.0 mL of the water to be tested by twice filling the dropper to the 1-mL mark with the sample and discharging the contents into the mixing bottle.
3. Add demineralized water to the mixing bottle to the 20-mL mark. Swirl to mix as shown in Figure 1.
4. Use the clippers to open one PhosVer 3 Phosphate Reagent Powder Pillow. Add the contents of the pillow to the bottle and swirl to mix. Allow at least two minutes but no more than 10 minutes for color development. If phosphate is present a blue-violet color will develop.
5. Follow Steps 2 and 3 of the Medium Range Procedure.
6. Hold the comparator up to a light source such as the sky, a window or lamp and view through the openings in front. Rotate the disc to obtain a color match. Read the mg/L phosphate (PO_4) from the scale window.
7. To obtain the value as mg/L phosphorus (P), divide by 3 the value obtained in Step 6.

HACH

ORTHOPHOSPHATE

Low Range, 0-1 mg/L Phosphate

1. Fill the square mixing bottle to the 20-mL mark with the water to be tested.
2. Use the clippers to open one PhosVer® 3 Phosphate Reagent Powder Pillow. Add the contents of the pillow to the bottle, and swirl to mix as shown in Figure 1. Allow at least two but not more than 10 minutes for color development. If phosphate is present, a blue-violet color will develop.
3. Insert the lengthwise viewing adapter into the comparator as illustrated in Figure 2.
4. Fill one sample tube to the line underlining "Cat. 1730-00" with the prepared sample. This will be approximately 15 mL. If not using 1730-00 tubes, fill to the line found at approximately 1 inch below the top of the tube.
5. Place the tube containing the prepared water sample into the comparator opening labelled Prepared Sample Position in Figure 2.
6. Fill the other sample tube with untreated water or a reagent blank to the line underlining "Cat. 1730-00". Insert this tube into the comparator opening labelled Clear Sample Position in Figure 2.
7. Orient the comparator with the tube tops pointing to a window or light source as in Figure 2a. View through the openings in the front of the comparator. When viewing, use care to not spill samples from unstoppered tubes.
8. Rotate the disc to obtain a color match. Read the concentration of the measured parameter through the scale window on the scale applicable to endwise or long path viewing.
9. Divide the reading from the scale window by 50 to obtain the mg/L phosphate (PO_4). To obtain the value as mg/L phosphorus (P), divide by three.

Medium Range, 0-5 mg/L Phosphate

1. Perform Steps 1 and 2 of the Low Range Procedure.
2. Fill one of the color viewing tubes to the mark with the prepared sample. Insert it into the right top opening of the color comparator (Prepared Sample Position in Figure 4).
3. Fill the other tube to the mark with the untreated sample. Insert this tube into the left top opening of the color comparator (Untreated Sample Position in Figure 4).
4. Hold the comparator up to a light such as the sky, a window, or lamp and view through the openings in front. Rotate the disc to obtain a color match. Divide the reading from the scale window by 10 in order to obtain the mg/L phosphate.
5. To obtain the value as mg/L phosphorus (P), divide by 3 the value obtained in Step 4.

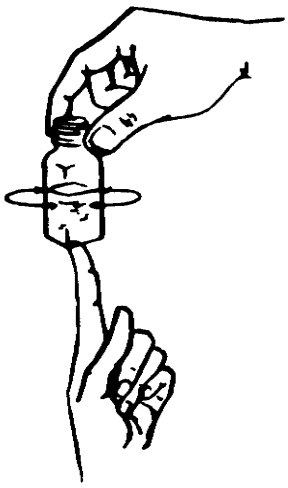


Figure 1
Swirling technique

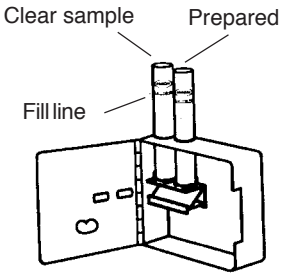


Figure 2

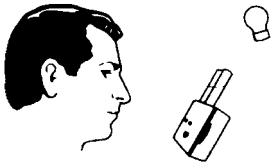


Figure 2a

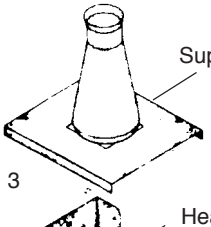
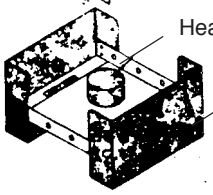


Figure 3



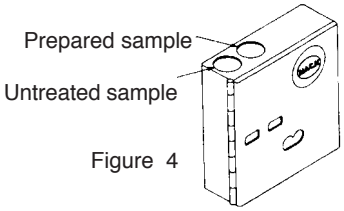
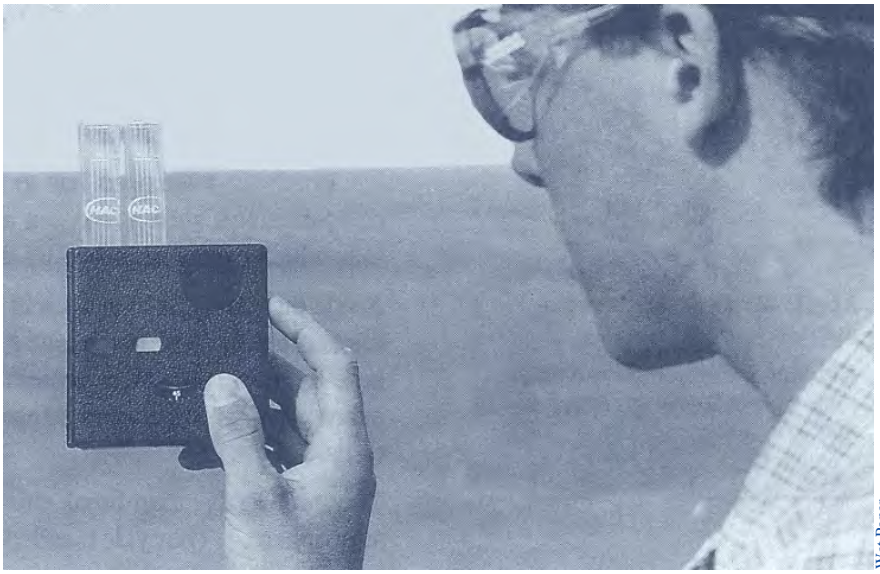


Figure 4

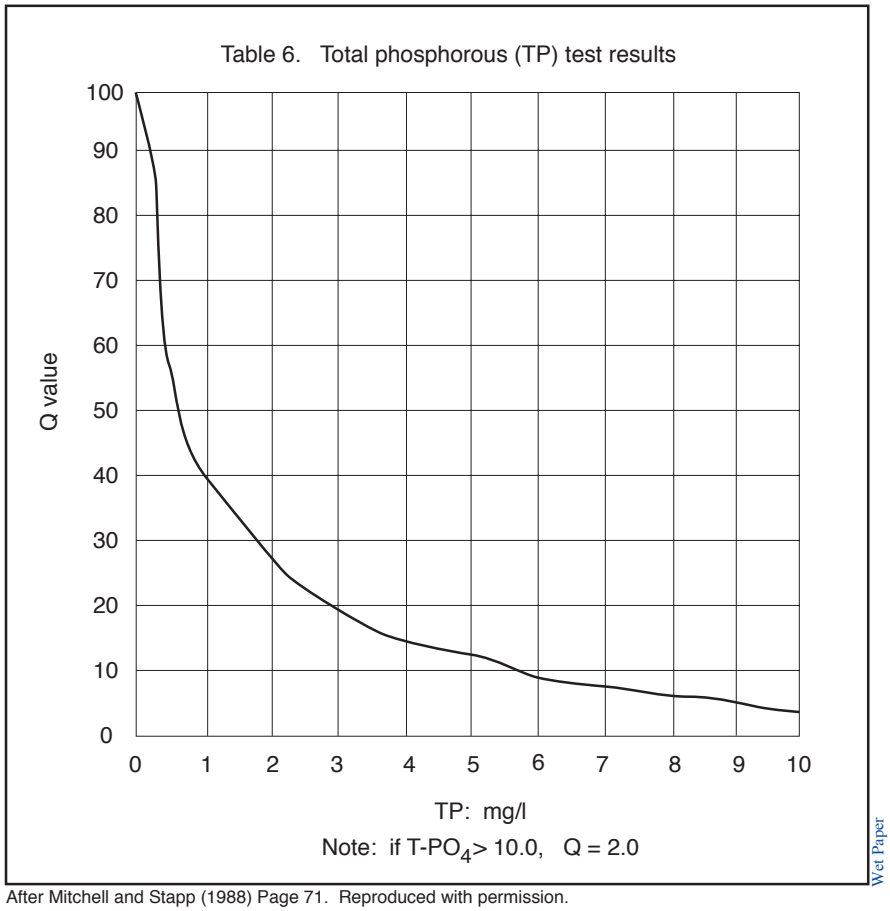
Fig 47 Sample instructions from the Hach kit. If you are using a different kit follow the instructions in that kit
Wet Paper



Wet Paper

Fig 48 Hold the comparator up to the light and rotate the disc until you get a colour match.

When the concentration in mg/L has been determined use the table below to obtain the Q value. Record this Figure in column B in Figure 22 on Page 365. Multiply by the weighted factor of 0.10 and record the value in Column D.



Wet Paper

After Mitchell and Stapp (1988) Page 71. Reproduced with permission.

Fig 49 Total phosphorus Q graph (After Mitchell and Stapp 1990)

7. Nitrates

Nitrogen is important for plant and animal growth. It makes up approximately 79% of the air we breathe. In water, nitrogen is in the form of nitrates (NO_3^-), nitrite (NO_2^-), ammonia (NH_3^+), and in organic matter. In the air it exists as a molecule N_2.

This molecular nitrogen has to be broken apart, combined with other elements such as oxygen and hydrogen to form the smaller ions which can be absorbed by the roots of plants.

Inside the plants this nitrogen is taken up by the root systems and transported to cells which take the ionic nitrogen forms and combine them to form plant proteins. As animals and plants die or excrete wastes, this combined nitrogen re-enters the waterways and estuaries.

Decomposer bacteria break this down and release it back to the atmosphere. The cycle is called the **nitrogen cycle.** Ryan, (1991) describes this process in greater detail and its relation with pollution, in the Book, "Pollution - Issues in Marine Conservation".

When nitrogen is combined with hydrogen in the form (NH_3^+) and (NO_3^-), it can stimulate plant growth. Blue green algae thrive on this form and rapidly multiply causing eutrophication.

This increases plant growth and finally causes a decrease in available oxygen.

Applications of the nitrogen cycle

A further discussion of the nitrogen cycle can be found on Pages 494, 495 and 508

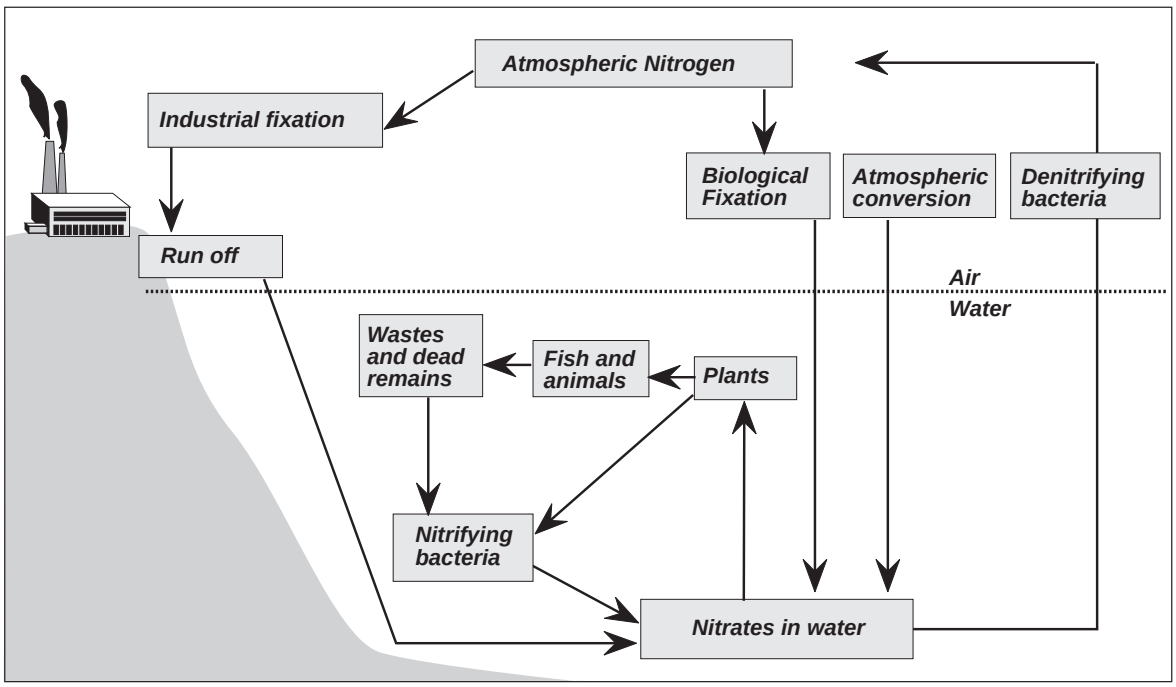


Fig 50 The nitrogen cycle (After Ryan 1991)

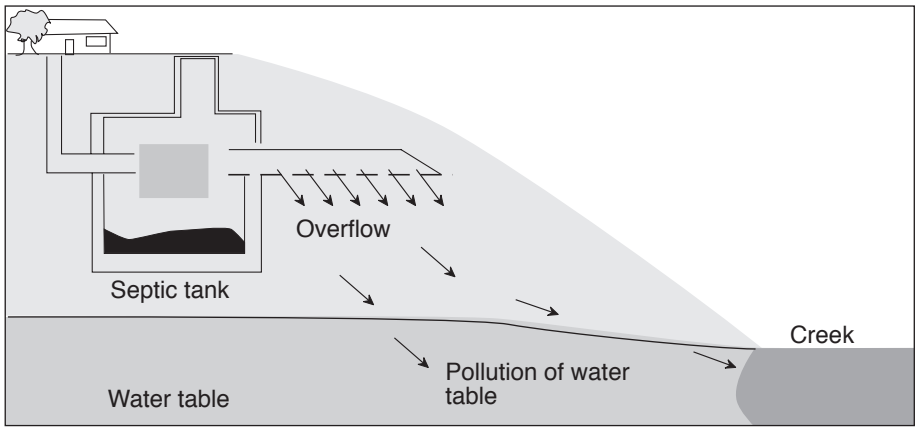


Fig 51 Septic tank (After Mitchell and Stapp 1990)

Sewage and septic systems are one large contributor to the nitrogen ions. Septic tanks are just a pit in the ground with an overflow pipe into a trench. This usually drains into a field where plants absorb the nitrates. Storm water runoff also will contain nitrates from fertilisers and pet droppings, or from farms and feed lots.

Testing nitrates

The kit again is the HACH kit using a colour comparator. Because nitrates vary so much in water samples there are two tests - a low and high range. Note :- All glassware should be washed in dilute acid and only demineralised or distilled water should be used.

Cadmium warning

The NitraVer reagent contains cadmium metal which should be disposed of in accordance with your local safety officer's recommendation. Some suggestions are given on Pages 66 and 67 of Mitchell and Stapp (1990)

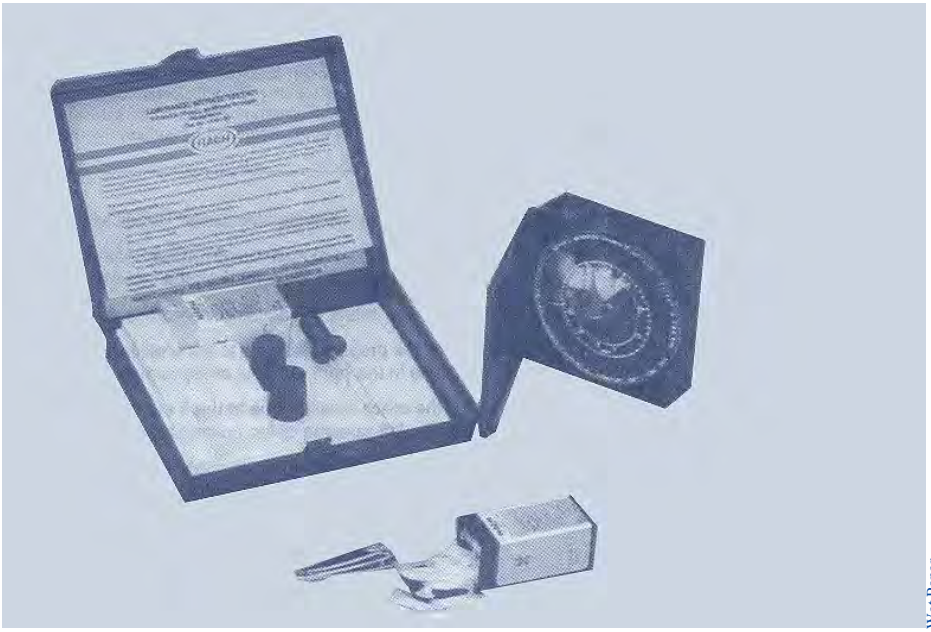


Fig 52 A nitrate testing kit

Nitrate - nitrogen 0 - 1 mg/L

Low range

NITRATE NITROGEN (0-1 mg/L)

1. Fill one of the color viewing tubes to the mark with the sample to be tested. Stopper the tube and shake vigorously. Empty the tube and repeat this procedure.
2. Fill the color viewing tube to the mark with the sample (if nitrite is not present) or with the pretreated sample (if nitrite is present).
3. Use the clippers to open one NitraVer® 6 Nitrate Reagent Powder Pillow. Add the contents of the pillow to the sample to be tested. Stopper the tube and shake for three minutes. Allow the sample to stand undisturbed for an additional 30 seconds. Unoxidized particles of cadmium metal will remain in the sample and settle to the bottom of the viewing tube.
4. Pour the prepared sample into a second color viewing tube carefully so that the cadmium particles remain in the first tube.
5. Use the clippers to open one NitriVer® 3 Nitrite Reagent Powder Pillow. Add the contents of the pillow to the sample. Stopper the tube and shake for 30 seconds. A red color will develop if nitrate is present. Allow at least 10 minutes, but not more than 20 minutes, before completing Steps 6 through 8.
6. Insert the tube of prepared sample into the right top opening of the color comparator (Prepared Sample Position in Figure 1).
7. Rinse the unoxidized cadmium metal from the color viewing tube used in Step 2. Fill to the mark with the original water sample and place in the left top opening of the comparator (Untreated Sample Position in Figure 1).
8. Hold the comparator up to a light source such as the sky, a window or lamp and view through the openings in front. Rotate the disc to obtain a color match. Read the mg/L nitrate nitrogen (N) through the scale window. To obtain the results as mg/L nitrate (NO_3) multiply the reading on the scale by 4.4.

Nitrate - nitrogen 0 - 10 mg/L

Middle range

NITRATE NITROGEN (0-10 mg/L)

1. Fill one of the color viewing tubes to the mark with demineralized water. Stopper the tube and shake vigorously. Empty the tube and repeat this procedure.
2. Rinse the plastic dropper with the sample or with the pretreated sample. Fill to the 0.5-mL mark. Add contents of the dropper to the rinsed color viewing tube.
3. Fill the color viewing tube to the mark with demineralized water.
4. Use the clippers to open one NitraVer 6 Nitrate Reagent Powder Pillow. Add the contents of the pillow to the sample to be tested. Stopper the tube and shake for three minutes. Allow the sample to stand undisturbed for an additional 30 seconds. Unoxidized particles of cadmium metal will remain in the sample and settle to the bottom of the viewing tube.
5. Pour the prepared sample into a second color viewing tube carefully so that the cadmium particles remain in the first tube.
6. Use the clippers to open one NitriVer 3 Nitrite Reagent Powder Pillow. Add the contents of the pillow to the sample. Stopper the tube and shake for 30 seconds. A red color will develop if nitrate is present. Allow at least 10 minutes, but not more than 20 minutes, before completing Steps 7 through 9.
7. Insert the tube containing the prepared sample into the right top opening of the color comparator (Prepared Sample Position in Figure 1).
8. Rinse the unoxidized cadmium from the color viewing tube used in Step 2. Fill to the mark with the original water sample. Place this tube in the left top opening of the comparator (Untreated Sample Position in Figure 1).
9. Hold the comparator up to a light source such as the sky, a window or lamp and view through the openings in front. Rotate the disc to obtain a color match. Read the mg/L nitrate nitrogen (N) through the scale window. Multiply that reading by 10 to obtain the mg/L nitrate nitrogen (N) present in the sample. To obtain the results as mg/L nitrate (NO_3) multiply the mg/L nitrate nitrogen (N) by 4.4.

Nitrate - nitrogen 0 - 50 mg/L

High range

1. Rinse a colour viewing tube several times with the water to be tested, then fill to the 5 mL mark.
2. Use the clippers to open one NitraVer 5 Nitrate reagent Powder Pillow. Add the contents of the pillow to the tube. Stopper the tube and shake vigorously for exactly one minute.
3. An amber colour will develop if nitrate is present.
4. Allow the prepared sample to set undisturbed for one minute, then place the tube of prepared sample in the right opening of the comparator.
5. Fill the other viewing tube to the 5 mL mark with some of the original water sample and place it in the left opening of the comparator.
6. Hold the comparator up to the light and view through the openings in front. Rotate the disc until a colour match is obtained. Read the mg/L nitrate nitrogen (N) through the scale window.
7. Test results can be converted from mg/L nitrate nitrogen (N) to mg/L nitrate (NO_3) by multiplying by the scale reading of 4.4.

Fig 53 A nitrate testing set of instructions (After HACH 1990)

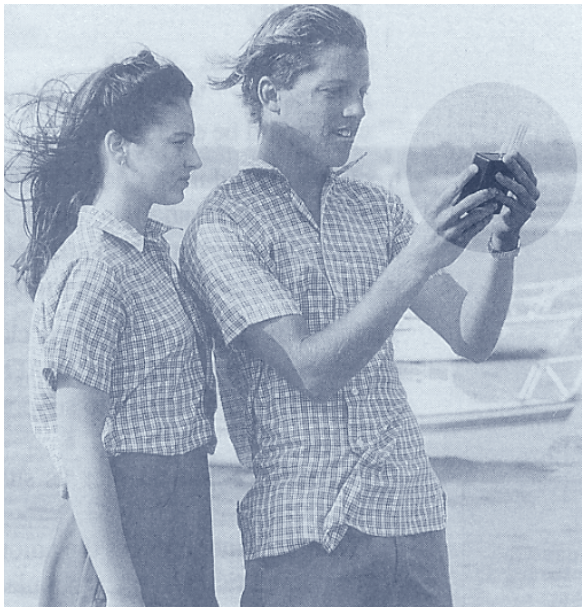


Fig 54 Colour comparison is again used to determine nitrates
Wet Paper

Record this in Column A in the table on Page 365. Now use the table below to compute your Q value which you record in Column B of the same table and then multiply by the weighting factor of 0.10 . Record this weighed Q value in Column D.

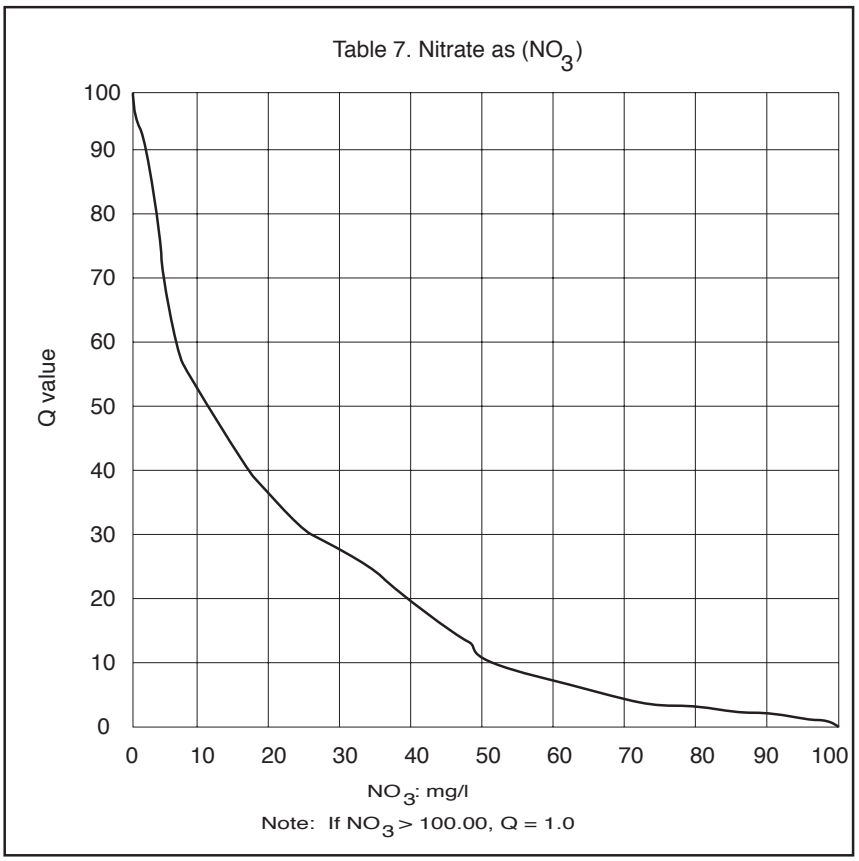


Fig 55 Nitrate Q value graph (After Mitchell and Stapp (1990)

After Mitchell and Stapp (1988) Page 72. Reproduced with permission.

8. Turbidity

As can seen from the diagram on Page 306 , wind and water are largely responsible for what is blown offshore or cannot dissolve. The list could be endless.

Look in a river during flood. There will be branches, twigs, mud, topsoil and dead animals, apart from the pollution caused by humans. This particulate matter goes to form the suspended solids in the sea which is called the **turbidity**.

Turbidity is a state of reduced clarity in a fluid caused by the presence of suspended matter. At higher levels of turbidity:-

- Water loses its ability to support a diversity of aquatic organisms.
- Waters become warmer as suspended particles absorb heat from the sun.
- Warmer water reduces the amount of dissolved oxygen which can affect fish and plant populations.
- Less light can penetrate water depths which effects photosynthesis.
- The suspended particles can sink and cover fish eggs or the burrows of crabs and prawns in the larval or sub adult stages.
- In areas where coral reefs are close to land, sediment can cover the corals causing death and subsequent loss of habitats for other reef creatures.

To measure turbidity, simply lower the disc until it disappears. Take care with the disc so that it does not bend out with current. (If it does, add weights). Note the depth D1.

Lower the disc even further and raise it again. Note the depth D2. Add D1 and D2, divide by two and read off the Q value from the table below. Now multiply by 0.08 to give the weighted Q value.

How to use the disc

A Secchi, or visibility, disc is used to measure the transparency of the water column.

The usual procedure is to lower the disc over the sunny side of a vessel that is motionless in the water, and then to note the depth when it reaches the point at which you can barely see it.

This measurement is especially important for your collection of biological samples, and it may also give you some information on currents and sediment transport.

A simple secchi disc can be made as illustrated in Figure 56

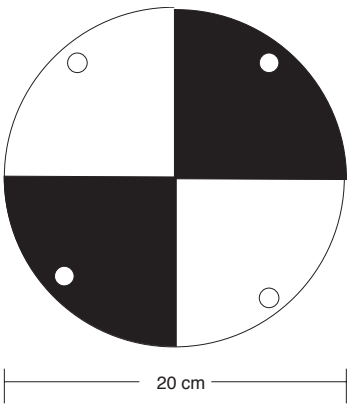


Fig 56 A secchi disc is made at school by your manual arts department
Wet Paper

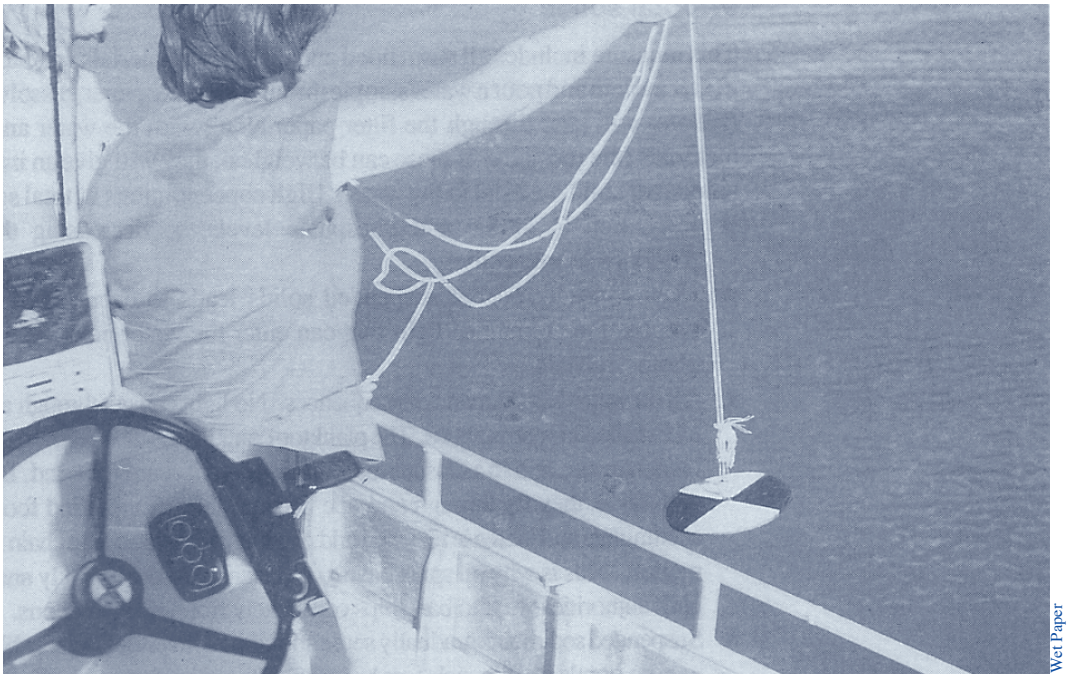


Fig 57 A secchi disc

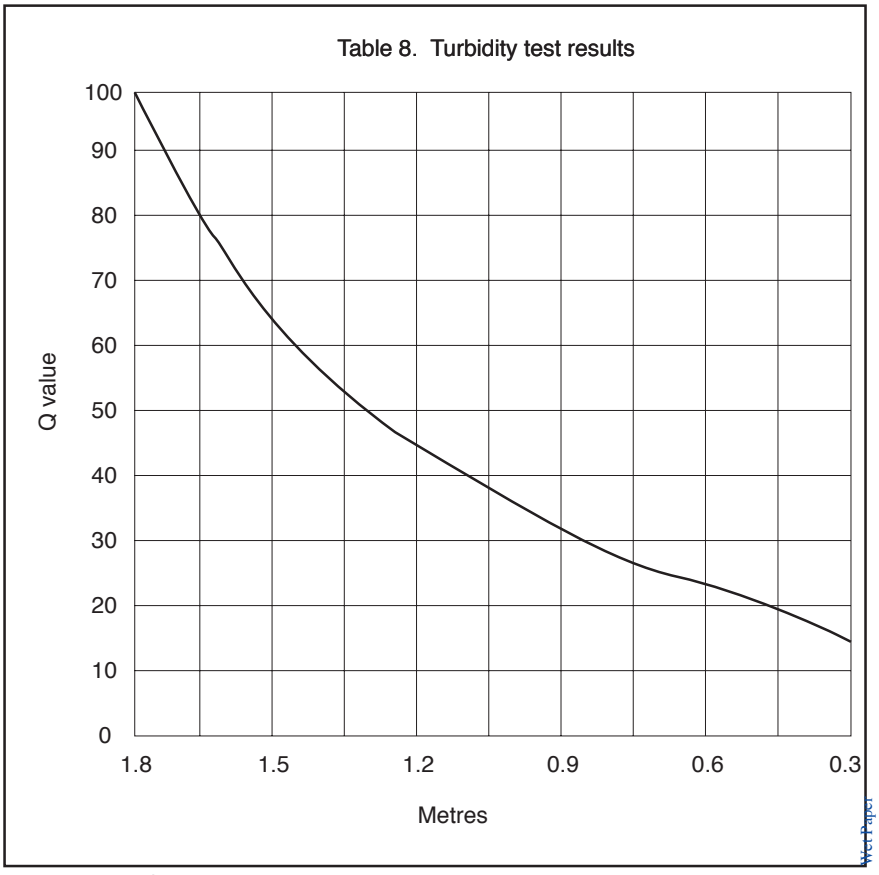


Fig 58 A secchi disc Q table

After Mitchell and Stapp (1988) Page 73. Reproduced with permission.

9. Total solids

This measure includes all suspended and dissolved materials in water. If we set up a filter system and pour a water sample through the filter paper, dissolved substances (filtrate) will pass through the filter paper along with the water and undissolved materials (the residue). If these can be weighed, they will give an indication of the amount of solid material in the water. High concentrations of total solids leads to:-

- Reduction in nitrate and phosphate levels, so decreasing the amount of phytoplanktonic activity.
- High concentration of suspended solids leads to decrease in water clarity, reduces the amount of light that can enter the water column, and so reduces photosynthesis.
- Oil on water has dramatic consequences. No light can get through and planktonic life is killed in vast qualities. The plankton contains the next generation of fish, crabs, barnacles etc., and so a seasons reproductive activity can be wasted. Birds are coated with oil as they fly through and die because they cannot find food. Dead birds accumulate and increase nitrogen and phosphate levels and the chain reaction sets in motion. This is why oil spills have to be cleaned up very quickly and some marine park authorities want to ban ships completely from certain regions.
- Suspended sediments gradually settle and stop all invertebrates that filter feed. Tube worms, corals and barnacles are but a few of the animals that are affected by mud that settles as a result of storms or flood.

Measurement

To measure the total solids simply collect a sample of water and boil off all the water and weigh what remains.

- To do this you will need a good balance that weighs to 1/1000 of a gram. This is called a milligram balance and is very expensive. Usually the science section will have one such balance but if not you will need to use plan B. Here you just use a larger volume and divide by 10)
- Collect 100 mLs of water sample (1000mLs if you are going to use plan B)
- Take a 300 mL (1.5l) beaker and dry it for one hour in a 103^0C oven. Remove the beaker with tongs, allow it to cool and weigh it to the nearest .0001g (0.01g). Record the weight as W1.
- Add the sample (100 or 1000mLs) to the beaker. Make sure all materials have been transferred. To do this you use a wash bottle containing distilled water and squirt water into the bottle so that the sample bottle is clean.
- Evaporate the sample, dry the beaker overnight and the resulting residue in the 103^0C oven. Don't touch the beaker with you hands or anything that may give a false reading. Now weigh the beaker and record as W2.

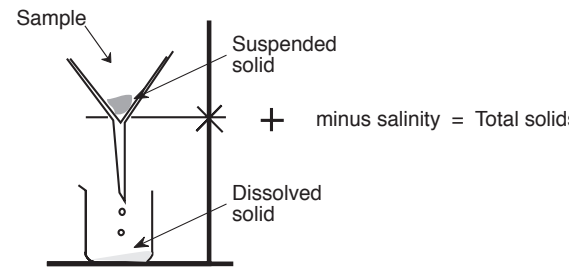
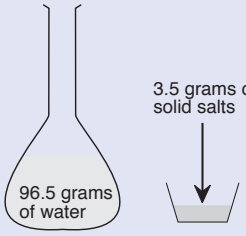


Fig 59 Total solids are the suspended solids plus the dissolved solids minus the salinity
Wet Paper



Remember that in seawater there is approximately 35 grams of salts and these occur naturally.

So don't forget to take these away.

One suggestion is to take 1 litre of very clean unpolluted seawater and boil it all away. Then take one litre of your sample. Boil all this away and subtract the two to obtain the mg/L.

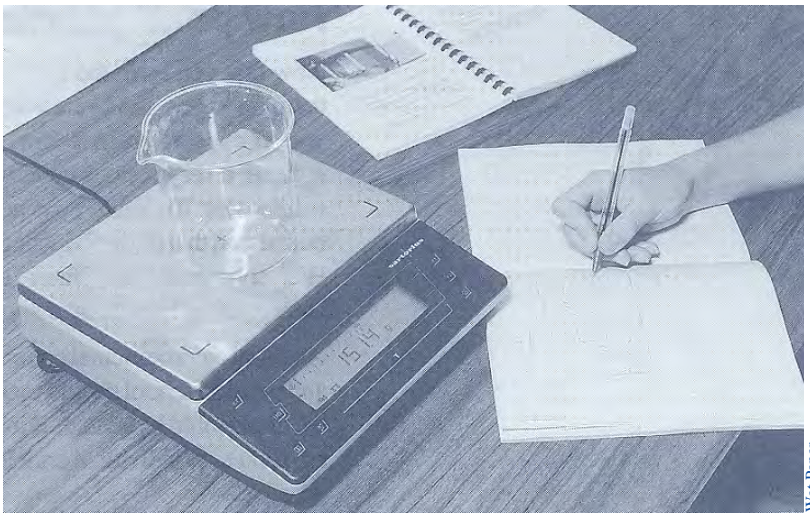
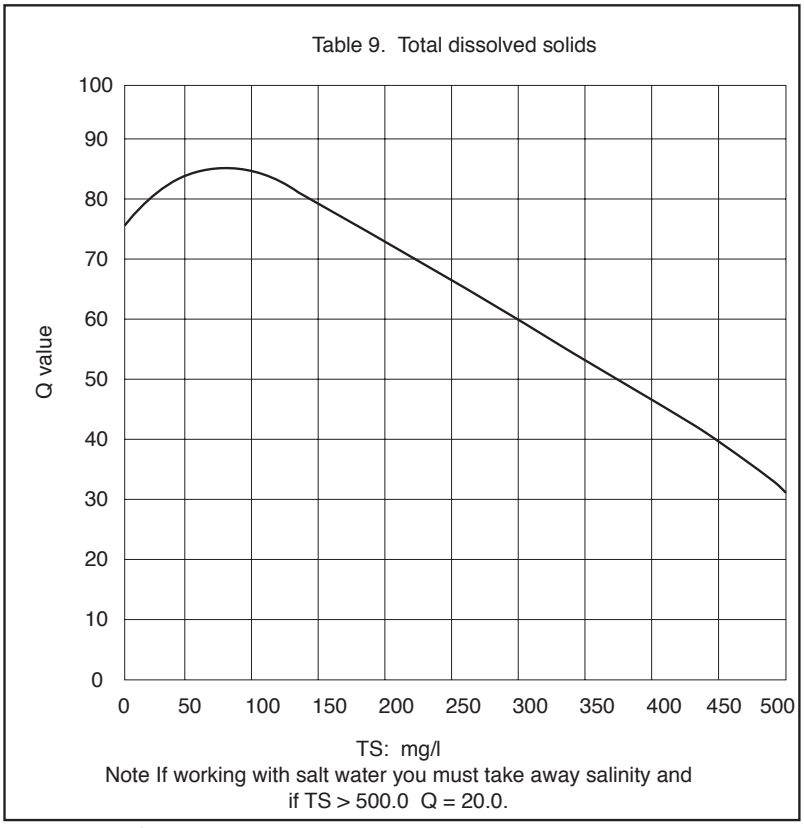


Fig 60 A milligram balance is used to measure TDS

- Subtract W2 - W1, multiply by 1,000,000 and divide by the number of mLs in the original sample to give the ppm. Now read the Q value off the table below and multiply by 0.07 to give the weighted Q value and record in Column D of your data table.



After Mitchell and Stapp (1988) Page 74. Reproduced with permission.

Fig 61 TDS Q conversion table (After Mitchell and Stapp 1990)

How polluted was your sample?

Now that you have the nine weighted Q values in column D add them up to give the overall Water quality index. A clean table for you to copy is given below. As mentioned earlier values 0-50 indicate a very serious condition, 50 - 70 indicate a problem and values over 70 should pose no health problems. However it must be stressed that the individual values must be considered separately. High concentrations of faecal coliform should be reported to school authorities who can make appropriate decisions.

A school environmental committee is one avenue to report findings and then the school should make the appropriate decision as to how the data should be treated. If individuals become involved then they are subject to individual criticism and this should be avoided where possible.

Fig 62 **Analysing the results**

Date _____ Time _____

Location _____

Weather conditions _____

Variable	Results (Column A)	Column B	Factor (Column C)	Column D
1. Dissolved oxygen	%		0.17	
2. Faecal coliform	colonies /100ml		0.16	
3. pH	units		0.11	
4. B.O.D.	p.p.m.		0.11	
5. Temperature	$\Delta^{o}C$		0.10	
6. Total Phosphorous	mg/l		0.10	
7. Nitrates	mg/l		0.10	
8. Turbidity	cm		0.08	
9. Total solids (-salinity)	mg/l		0.07	
Overall water quality index				

After Mitchell and Stapp 1988

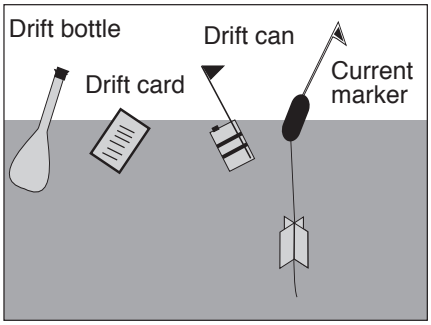
Additional data

Current measurement

Currents are certainly the most important physical processes at work in estuaries. They exist in three dimensions throughout the entire system and are produced by several factors. The flood and ebb of the tides usually produce the greatest currents, but there is often a residual gravity-driven flow or river or stream water, and wave or wind-driven currents may have considerable local influence. Currents often change both velocity and direction with depth, and it is by no means uncommon to find surface river water flowing out of the estuary while deep-sea water flows in underneath.

Two methods can be used:-

- The bottle method with a card, and recover the bottle at a later date. Inside the bottle, place a return questionnaire postcard and enough sand or other weight so that the bottle floats with only its top above water. Cork or seal the bottle securely.
- The drogue method as shown below:- The angle gives the current speed. The compass direction gives the current direction.



Wet Paper

Fig 62 Types of free trajectory current measuring devices

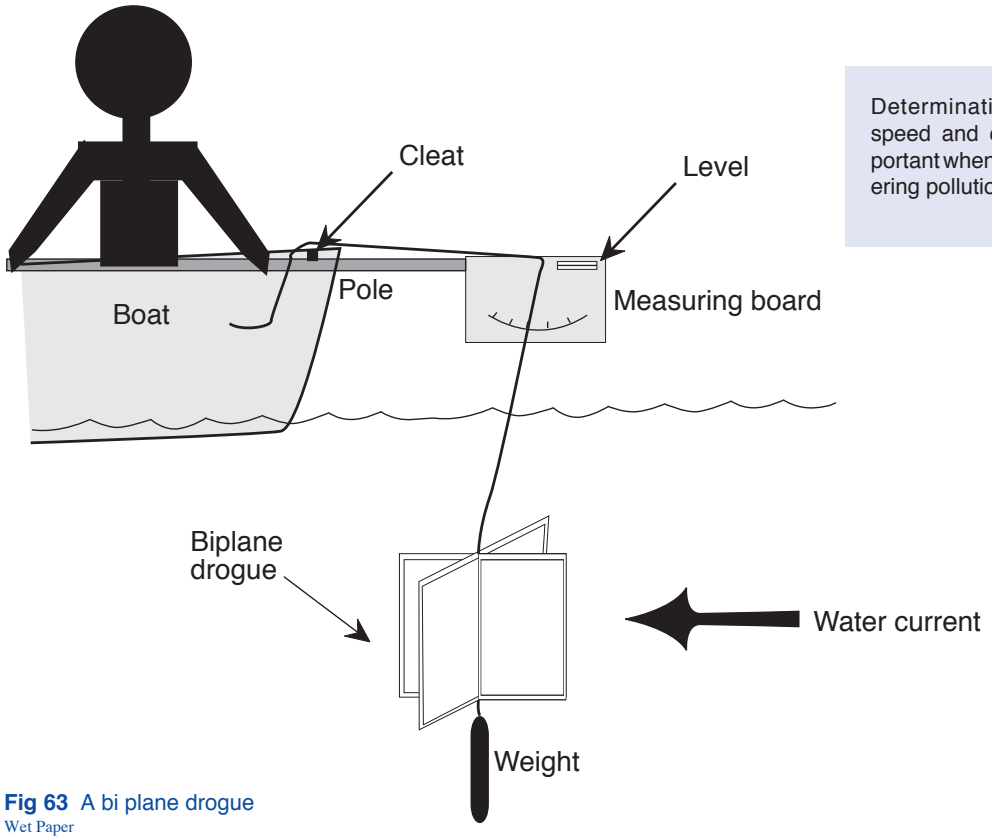


Fig 63 A bi plane drogue
Wet Paper

Determination of current speed and direction is important when we are considering pollution

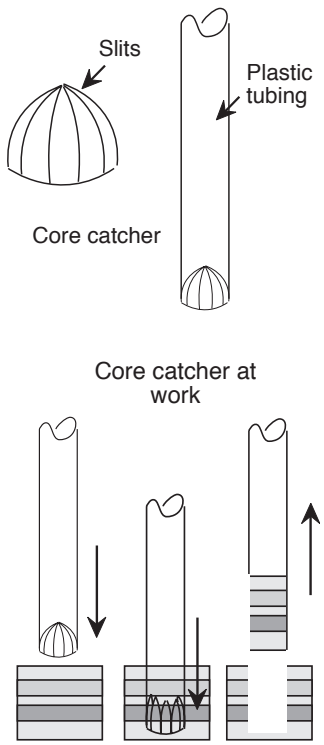


Fig 64 A core catcher
Wet Paper

Sediment composition

Sediments reveal many aspects of environmental composition and pollution. A hand corer can be used to collect the sediment. It consists of a clear plastic tube, 40 mm in diameter and about 6 metres long, with a core catcher inserted into the end that will penetrate the sediment.

You can build a core catcher as follows.

- A core catcher can be made from a tennis ball which is cut in half, and slits cut from the apex to about two centimetres from the equator. It should fit snugly into the end of the core tube, and should be attached by bolts through holes cut in the end of the core and in the equator of the core catcher.
- After a core is taken, cut the core tube with a saw just above the sample, remove the catcher, seal the sediment core in the sawed off part of the tube on top and bottom with plastic electrical tape and bottle caps and store vertically (in a cold place if possible). The core catcher is then inserted into the remaining part of the empty tube (now about four feet shorter) for reuse.

For ready reuse of the core catcher, you can drill holes at about 350 mm intervals along the tubing before you go into the field, or you can take a hand drill with you into the field. In this way, you will be able to take three cores or more with each core tube. If you do not have a long plastic tube, you can make the corer from a metal pipe. Upon retrieval, slide the core out into a tray, or push it out into a tray gently with piston plunger, as shown in Figure 64 .

Wave Determination and Analysis

Wave effects within sheltered estuaries are usually of minor importance. To develop waves of any real size, the wind must have the opportunity to work on the water surface for a considerable time and over a considerable distance.

The only estuarine areas, then, where waves are likely to be significant are places exposed to waves coming in from the open sea. In these areas, there is likely to be considerable mixing of surface waters and long shore currents developing in the shallow water. Also, the energy of breaking waves is such that finer sediments are carried away and sand or gravel is left behind to form a beach.

Your research report may be deferred until you have completed Chapters 14, 15 and 16.

It is important that you know the methods and are skilful with them so that you reduce the experimental error.

The research report here is based on the work of Bishop (1991), but acknowledgement is given to the teachers at Malaney High School and Acacia Ridge SHS as well as the others involved with Project GREEN whom the author has been unable to contact at time of publication.

Fig 65 Wave determination

Your research project

Details of a case study and associated report can be found in Chapter 5 of the Book, A Field Manual for Water Quality Monitoring, by Mitchell and Stapp which is available from your local Environmental Education Centre. Bishop (1991) has modified this program as follows for his group of Year 11 Environmental Studies classes over a period of two - three weeks.

A. An identification and mapping of a watershed and places on the coastal plain that are study sites that lead into the estuary of ocean basin. This could be done using aerial photographs and topographical maps. 2 lessons.

B. Beginning the project where community members are involved in planning committees and workshops are conducted. Letters and telephone calls. 2 lessons.

C. A bus trip where the entire study site is traversed and photographed collecting initial samples. Discussion of water use in the catchment area. It is advisable to contact local authorities during the trip. Half - one day.

D. Discussion and practice in using test equipment. Discussion of the factors that affect the parameters to be tested. Allocation of groups to each test. Students work in the laboratory using either collected samples or tap water, in order to understand each test procedure. Seawater samples are analysed to determine dissolved salts. 2 Lessons

E. Allocation of groups. Collection of water samples from sites to be tested and analysis of water. Determination of water quality index as each group reports their findings. Completion of data table from Page 392.

F. Communication with other schools. Letter, visit or fascimile of results to other schools. Computer input to computer network.

G. Building skills to identify and define problems and their sources.

H. Action planning - community involved to increase awareness of water quality in local area. Working with local water quality control officers and councillors. Planning action through school P and C if necessary.

I. Communicating with other students overseas and interstate.

STREAMWATCH
An opportunity to investigate your environment

WATERWATCH
A Federal - State Partnership

Resources

Emphasis has been placed on the need to provide low cost easy to assemble resources that can be duplicated in multiples and easily built by students. However some chemicals are needed and the lists below show the recipes for the solutions mentioned in the chapters.

Silver nitrate solution for the eye drop titration

Weigh out 4.97 g of silver nitrate and dissolve in 100 mLs of distilled water. Store in a painted bottle to reduce deterioration of the solution. You must use eye droppers that will deliver the same size drop or use the same eye dropper for each experiment.

Artificial Sea water

To 10 litres of distilled water add 310 grams of analytic reagent quality sodium chloride, 100 grams of magnesium sulphate and 5 grams of sodium bicarbonate

Bottles, eye droppers and storage containers.

Ice cream container with eye dropper bottles and a conical flask that most Science labs have. Try to use cheap and inexpensive materials such as orange drink containers, lots of electrical tape or masking tape and plastics which will not break in the sea.

Student worksheets

Packaging companies (look in the yellow pages) have zip top plastic bags that can store student field worksheets. A stiff piece of cardboard used as a backing inserted into the bag provides a low cost field clipboard that contains worksheets, pencils etc.

For the more scientifically minded Selbys Australia have a range of scientific supplies and purchases can be made from these.

Selbys Address are:-

Queensland PO Box 1263 Milton Centre 4064. Telephone: 07 3711 566

Sydney Locked Bag 65, Lidcombe, 2141. Telephone 02 643 2666

Melbourne Private Bag 24, Mulgrave North, 3170 Telephone 03 263 4444

Adelaide GPO Box 550 Adelaide 5001 Telephone 08 297 0177

Perth PO Box 300 Cloverdale 6105 Telephone 09 353 3577

Hobart GPO Box 914J Hobart 7001 Telephone 002 732 455

Darwin Unit 4 4 Durand Court Coconut Grove 0810 Telephone 089 480 622

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