

Seqwater

The Catchment - Water Quality Testing

Senior School Field Guide Workbooklet



Introduction

Water quality guidelines

Water quality requirements depend on how we want to use the water and the needs of the environment. The different categories of water use are:

- human drinking water
- livestock drinking water
- irrigation water
- visual amenity (no human contact)
- secondary contact recreation, eg boating
- primary contact recreation, eg swimming

aquatic ecosystems (healthy water for animals and plants).

Water quality

In Australia, water quality standards are set according to national [water quality guidelines](#).



The following national water quality guidelines provide the authoritative guide to set water quality objectives and standards.



[Australian and New Zealand Guidelines for Fresh and Marine Water Quality](#) (Australian and New Zealand Environment and Conservation

Council (ANZECC) and Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000). These guidelines are for environmental waters and provide the methodology to assess and track changes to water quality over time. The ANZECC guidelines are used to assess water quality in South East Queensland's drinking water catchments.



[Australian Drinking Water Guidelines \(National Health and Medical Research Council \(NHMRC\) 2004\)](#). The Australian

Drinking Water Guidelines are predominantly used to assess the safety of treated drinking water. They protect public health.

Effects in the Catchment

Many complex factors affect water quality on its way from rain clouds to your tap.

Natural bushland yields relatively clean water with small amounts of nutrients that can affect water quality in reservoirs. However, heavy rainfall after a long dry period can bring sediment, leaves, branches and animal droppings into the rivers and lakes.

Natural wetlands hold water for some time. They can form habitats for many aquatic and semiaquatic animals - invertebrates, fish, frogs, reptiles, water birds and mammals. Wetlands affect, and often improve, water quality by filtering sediments and transforming nutrients as water passes through them.

Not all of the drinking water supply catchments are unspoilt bushland.

Runoff from **farmland** can carry sediment, animal droppings (which may include pathogens), and traces of chemicals, such as fertilisers, pesticides and herbicides.

Urban areas contribute many undesirable impurities in stormwater, including oil and grease washed off roads, household and garden chemicals, rubbish and animal droppings. Some urban areas also release treated or untreated sewage effluent into rivers and streams.

Once rainfall reaches **streams and rivers** instream processes begin to affect water quality. These include:

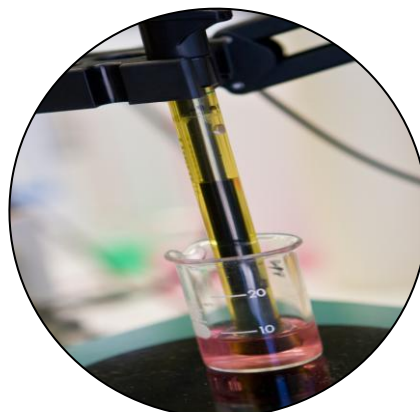
- nutrient assimilation by algae, sediments and biochemical transformations
- oxygenation by flowing water, algae and streamside vegetation
- dilution from mixing
- settlement of matter in slower flowing areas
- disinfection by ultraviolet rays in natural sunlight
- riverbank erosion and streambed scouring which contribute sediment to water during heavy flow periods.

Water quality in **reservoirs** is determined by the quality of water flowing into the reservoir and in-lake processes. Water flowing in can transport materials such as nutrients, sediments and other contaminants. These can then be affected by in-lake processes such as settling and biochemical action.



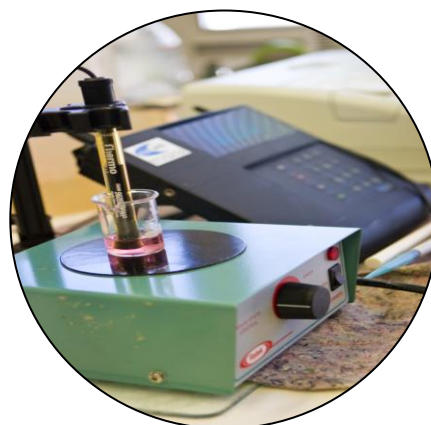
Your Tasks

This workbook gives you the chance to investigate the catchment and compare 4 samples of water . This field work will help you to learn about the work of chemists and other scientists who manage and monitor waterways and storages in the catchments to ensure safe drinking water and to protect habitats.



You are given four 3 samples and you are asked to test them and identify those samples which have come from

1. Intensive agriculture.
2. Urban.
3. Undisturbed bushland.



The results from your first hand investigations are vital to know the water quality of each of the 3 samples. You will need to make the connection between the land use types and your experimental results.

Specific parameters are used when monitoring a water supply system.

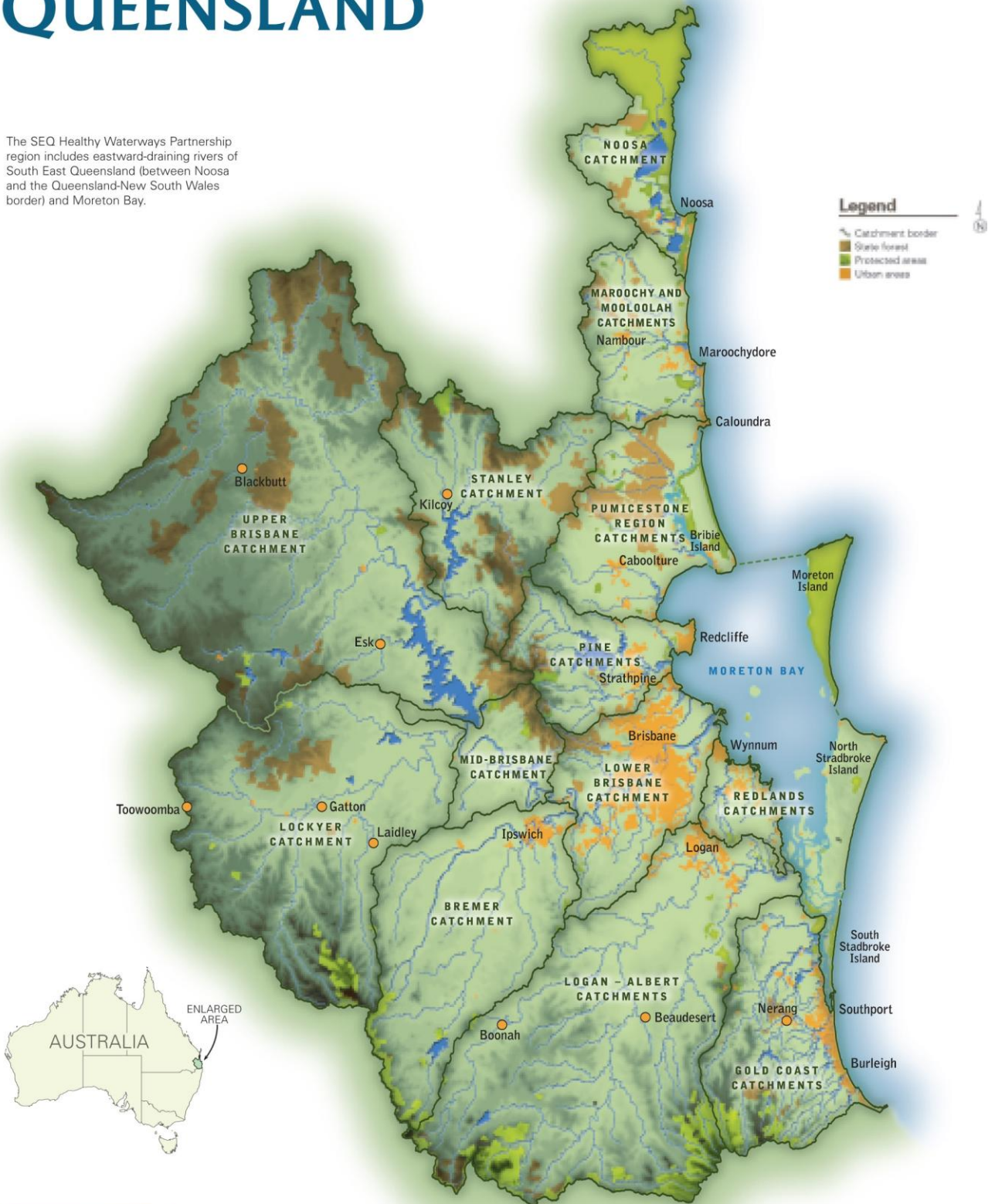
You will be involved with testing water samples for

- Ph
- Turbidity
- Dissolved Oxygen
- Available phosphates
- Electrical conductivity



CATCHMENTS OF SOUTH EAST QUEENSLAND

The SEQ Healthy Waterways Partnership region includes eastward-draining rivers of South East Queensland (between Noosa and the Queensland-New South Wales border) and Moreton Bay.



For further information about the SEQ Healthy Waterways Partnership telephone **(07) 3402 4206** or visit: www.healthywaterways.org

Electrical Conductivity

About Electrical Conductivity

Electrical conductivity is a measure of the physical ability of a sample to carry an electrical current.

Measuring electrical conductivity is an indirect way to measure salinity and includes the measurement of all salts and organic acids.

Most dissolved solids are ionic salts. The higher the concentration of the dissolved salts, the higher the electrical conductivity (EC).

You will test the electrical conductivity of your water samples using an ECScan Low conductivity meter

Measuring electrical conductivity of water samples is an indirect measure of the concentration of dissolved ionic salts.

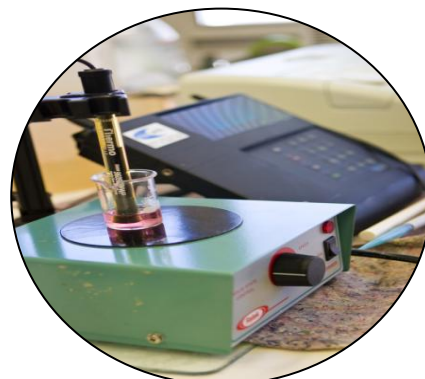
Salt occurs naturally in the Australian landscape from the weathering of rocks, salt spray from the ocean and ancient marine sediments.

Salts control osmotic pressure. This affects which species can survive in the water. If the salt concentration level is too high, water bugs and plankton that are adapted to fresh water will have difficulty keeping water inside them, and they will shrivel and die.

Salinity can occur naturally, but where human activity has disturbed natural ecosystems, the movement of salts into rivers and onto the land can be accelerated. Salinity can be caused by removing deep-rooted vegetation and flood irrigation of agricultural land.

Effluent discharged into waterways and sewage effluent can influence salinity. Another cause of salinity in waterways is tidal influx where sea water intrudes beyond the normal area.

You need to calibrate the conductivity meter before each use to ensure the accuracy of the data collected.



Experiment

Follow these instructions to measure the electrical conductivity of your sample.

- Shake the conductivity standard solution.
- Rinse the beaker with a small amount of conductivity standard solution over the liquid waste container.
- Now fill the beaker halfway with conductivity standard solution.
- Remove the cap from the conductivity meter and turn it on.
- Rinse the electrodes with distilled water over the liquid waste container.
- Insert the electrodes into the beaker containing conductivity standard solution, making sure you don't touch the bottom. Swirl once. Wait until the reading stabilises
- The meter is not reading 500 microseimens. To calibrate, unscrew the top of the meter.
- The calibration buttons are located in the battery compartment. There is an increase and a decrease button.
- Immerse the meter in the conductivity standard solution and gently swirl once.
- Press the INCrease or DECrease button to adjust the reading to match the conductivity standard value shown on the conductivity standard solution bottle.
- Once the meter matches this value, wait three seconds until the display flashes three times, then shows "ENT". The meter is now calibrated. Replace the top cap.
- Rinse the electrodes with distilled water over the liquid waste container.
- Shake the water sample bottle and rinse the beaker with a small quantity of this sample water over the liquid waste container.
- Now fill the beaker halfway with sample water and insert the meter. Swirl it once. Make sure the electrodes are not touching the bottom of the beaker.
- When the reading stabilises, press the "hold" button to freeze the display and record your result
- The result will appear in microsiemens per centimetre for the ECScan Low meter used here. Turn the meter off
- The last step is to rinse the electrodes and beaker with distilled water, over the liquid waste container

Answer the following questions to enrich your understanding of electrical conductivity testing.

Question 1:

Three causes of high electrical conductivity readings in water samples are:

1. removing deep-rooted vegetation
2. increased water temperature
3. the action of microorganisms
4. flood irrigation of agricultural land
5. discharge of sewage effluent into waterways.

Question 2:

Electrical conductivity can be tested using a conductivity meter. This is a:

1. physical test
2. chemical test?

Question 3:

What is the difference between a test for total dissolved solids (TDS) and electrical conductivity?

1. TDS is a measure of all solids dissolved in water. Electrical conductivity is a measure of the current that flows through water due to dissolved ionic solids.
2. TDS and electrical conductivity measure the same thing: dissolved solids concentration.

Question 4:

Choose three pieces of safety equipment that may be required when conducting an electrical conductivity test.

1. goggles
2. ear muffs
3. mask
4. gloves
5. a liquid waste container.

Question 5:

What are two ways that the reliability of the test results from electrical conductivity testing be improved?

1. conducting a fair test
2. doing the experiment correctly in the first place
3. repeat the test
4. test more samples.

Question 6:

What three factors can affect accuracy of your results?

1. using calibrated equipment
2. engaging trained people to conduct tests
3. following standard procedures
- 4.

Turbidity

About turbidity

Turbidity is a measure of the cloudiness or muddiness of water. Turbidity results will be higher with more suspended and colloidal solids in the water.

Turbidity affects aquatic ecosystems

High turbidity can reduce the amount of light penetrating through water and smother organisms living in or on the bottom sediments of aquatic habitats.

If light penetration is significantly reduced, plant growth may decrease impacting on the organisms that are dependent on plants for food and shelter. This can result in a reduced rate of photosynthesis by plants and therefore less oxygen being released into the water

Long-term turbidity can reduce biodiversity

Very high levels of turbidity for a short period of time may not be significant, however, long-term high turbidity can reduce biodiversity.

Suspended solids can suffocate aquatic organisms (by clogging or damaging gills), prevent proper egg or larval development and potentially interfere with particle feeding activities.

Clay sediments can increase turbidity

Types of suspended and colloidal solids can cause an increase in turbidity include: sediments, e.g. clay, silt; phytoplankton (very small floating plants); finely divided organic and inorganic matter; and other microscopic organisms.

Suspended and colloidal solids vary in colour. They are usually white, red, brown, grey or green

Erosion can cause turbidity

Causes of turbidity include: soil washed off the surrounding land during heavy rainfall or floods; river/stream bank erosion; and stormwater.

Turbidity can be measured using a turbidity tube.



Experiment

- Shake the water sample bottle several times to mix.
- Uncap the sample bottle and pour the water sample into the tube in small volumes.
- After each volume of water has been added, wait for the water surface to become still and then look down the tube through the water.

- The turbidity tube has three wavy lines on the bottom.
- When the three wavy line can no longer be distinguished as separate lines, do not add any more water.
- Read the value off the scale on the side of the turbidity tube below the water level.

Answer the following questions to enrich your understanding of turbidity testing.

Question 1:

What are three of the factors (suspended and colloidal solids) that cause an increase in turbidity?

1. sediments
2. phytoplankton
3. finely divided organic and inorganic matter
4. fertilisers.

Question 2:

What are three ways the suspended and colloidal solids that cause turbidity get into waterways?

1. soil erosion
2. deep-rooted vegetation
3. erosion of banks of streams and rivers
4. stormwater entering waterways.

Question 3:

The turbidity tube is rinsed with distilled water to:

1. to make the tube wet
2. to remove impurities.

Dissolved Oxygen

About Dissolved Oxygen

One measure of water quality is concentration of dissolved oxygen. Low oxygen levels affect fish and other aquatic animals.

Dissolved oxygen (DO) is the volume of oxygen that is contained in water.

Oxygen has a very low solubility in water, however dissolved oxygen is vital for aquatic animals such as fish, amphibians and aquatic macroinvertebrates.

Oxygen is dissolved into water by transfer from the air/water surface, plants carrying out photosynthesis and through wave action and waterfalls.

Why test dissolved oxygen?

Dissolved oxygen (DO) is vital for fish, aquatic invertebrates and amphibians to survive.

Dissolved oxygen levels in waterways depend on the physical, chemical and biochemical activities in the water.

Running water increases oxygen

Oxygen enters the water: as a waste product from the photosynthesis of aquatic plants and algae; as the transfer of oxygen across the water surface; through wave action, waterfalls and riffles.

Oxygen can be lost from water

Oxygen can be lost from water when: water temperature rises; salinity increases; water plants and animals increase respiration; and micro-organisms feed on decaying organic matter, e.g. sewage, leaf litter.

Effects of low DO levels

Prolonged exposure to low oxygen levels (less than 5-6 mg/L) may not directly kill an organism but will increase its susceptibility to other environmental stresses.

Exposure to very low dissolved oxygen levels (less than 2 mg/L) will kill many of the biota in the system and only the air-breathing organisms will remain.

If still water undergoes less internal mixing, the upper layer of oxygen-rich water tends to stay at the surface, resulting in lower dissolved oxygen levels throughout the rest of the water levels.

DO and the time of day

DO levels are highest in the afternoon as plants photosynthesise during the day.

DO levels are lowest just before dawn as oxygen is used for respiration by aquatic plants and animals through the night.

BOD

Biological oxygen demand (BOD) is determined by testing the dissolved oxygen (DO) of water samples.

Two samples are taken at the same place, at the same time. One water sample is tested for DO levels. The other sample is stored for five days in a dark cupboard and then tested again for DO.

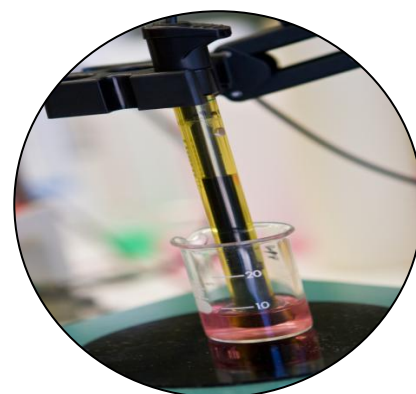
The difference between the two results indicates the quantity of oxygen that has been used by micro-organisms such as bacteria.

Ranges for typical BOD levels in water bodies are:

- < 5 mg/L in natural, unpolluted waterways
- 20–30 mg/L for well-treated sewage
- 150–300 mg/L for raw sewage
- 100–500 mg/L for urban stormwater run off.

In this investigation you will be following a planned procedure to test the concentration of dissolved oxygen using the modified Winkler titration method.

© *The Streamwatch Manual 3rd edition 2003.*



Equipment

- gloves
- safety goggles
- DO sample bottle
- liquid waste container
- DO reagent No. 1 (manganous sulfate solution, MnO_4)
- DO reagent No. 2 (alkaline potassium iodide azide: contains potassium hydroxide, KOH; potassium iodide, KI; and sodium azide, NaN_3)
- paper towel
- DO reagent No. 3 (sulfuric acid)
- 20 mL vial with hole in lid and titrator syringe
- sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) and syringe
- starch indicator
- distilled water

Experiment

The Winkler method involves Mn^{2+} ions reacting with the dissolved oxygen in the water to form MnO_2 as a brown precipitate.

This brown precipitate is dissolved by acid and then reacts with I^- to form iodine.

Iodine is titrated with thiosulfate ions ($\text{S}_2\text{O}_3^{2-}$) because the concentration of iodine is directly proportional to the DO concentration.

Starch reacts with iodine to produce a blue colour. Once the end point is reached, all of the iodine is reduced by the thiosulfate ions to iodide and the blue colour disappears.

This shows that, for each mole of thiosulfate ($S_2O_3^{2-}$) used in the titration, there was 0.25 moles of dissolved oxygen in the original sample.

1 Hold the DO sample bottle above the liquid waste container and carefully remove the lid.

2 Add eight drops of DO reagent No. 1 (manganous sulfate solution) to the sample water.

Reagent bottles must be held vertically upside down for standard drops.

3 Add eight drops of DO reagent No. 2 (alkaline potassium iodide azide) to the sample water.

4 Replace the lid on the DO sample bottle and wipe the bottle dry with paper towel.

5 Invert the DO sample bottle several times to mix the solution – brown precipitate will appear. Stand the DO sample bottle and wait until the precipitate has settled to at least halfway down the bottle.

This will take five or more minutes if the water is saline.

7 Hold the DO sample bottle over the liquid waste container and carefully remove the lid.

8 Add eight drops of DO reagent No. 3 (sulfuric acid) to the sample water.

9 Recap the DO sample bottle and wipe the bottle dry with paper towel.

10 Invert the DO sample bottle for several minutes until the precipitate has completely dissolved.

Important: All brown flakes must be dissolved. If the water has a high DO level this may take several minutes. If brown flakes remain after five minutes, add four more drops of sulfuric acid and continue mixing. If brown flakes still remain, let the bottle stand to settle the precipitate, then pour off the clear coloured solution.

17 When the solution changes to a light straw yellow colour, remove the plastic lid with the titrator syringe attached and add eight drops of starch indicator. The solution will turn deep blue.

The starch indicator is added to make the titration end point easier to see.

18 Replace the lid and titrator syringe to the 20 mL vial. Swirl to mix the solution.

19 Continue adding single drops of sodium thiosulfate, swirling a few times in between each drop, until one drop changes the solution from blue to clear.

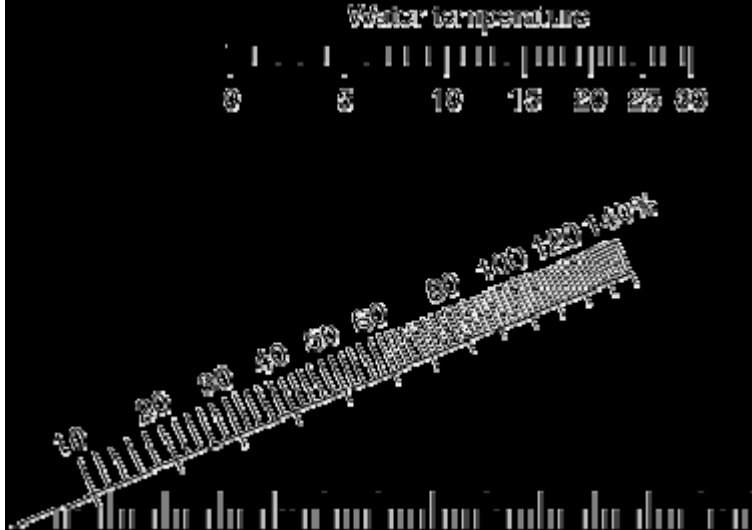
20 Record the number of units of sodium thiosulfate used. This is equivalent to the mg/L of dissolved oxygen in the sample water.

21 Calculate the percentage saturation of DO using the scale on the next page and record this result.

Important: Occasionally, the sample may require more than 10 units of sodium thiosulfate to reach the endpoint. Before refilling the titrator syringe, rinse the tip with distilled water and dry it with paper towel. Five units of sodium thiosulfate will be more you need to finish the titration.

Calculation of percentage saturation of DO

- Plot temperature on the upper scale (water temperature °C).
- Plot oxygen concentration on the lower scale (oxygen mg per litre).
- Hold the ruler between the two points.
- The point where the ruler crosses the middle scale (%) is the percentage saturation of DO.



Answer the following questions about dissolved oxygen.

Question 1:

The modified Winkler titration to test for dissolved oxygen is a quantitative test.

- true
- false.

Question 2:

Which three factors reduce dissolved oxygen levels in water?

- high temperatures
- decay of organic matter by bacteria
- respiration by aquatic organisms
- low temperatures
- photosynthesis by green plants.

Question 3:

Dissolved oxygen levels are important because:

- light penetration can be affected
- salinity can increase at low oxygen levels
- it is essential for aquatic animals to survive

Question 4:

What are two ways oxygen can enter water?

- respiration of aquatic organisms
- photosynthesis by green aquatic plants
- water mixing with air in waterfalls, rapids and rain.

Question 5:

What is meant by the end point of a titration?

1. when the reaction is complete
2. when the maximum change of the indicator has occurred
3. when equivalence point has been reached.

Question 6:

Biological oxygen demand (BOD) indicates:

1. dissolved oxygen levels
2. cloudiness or turbidity
3. salt levels or salinity
4. organic matter levels in water

Question 7:

What is the relationship between dissolved oxygen (DO) and biological oxygen demand (BOD)?

1. high BOD reduces DO as the organic matter decays
2. high BOD means high DO levels
3. BOD has no impact on DO.

Phosphates

About available phosphates

Phosphorus (P) is an essential nutrient for the growth of plants and animals. Phosphate levels can be measured as total phosphates and available phosphates. Phosphorus is an important nutrient for plants. However, high phosphate levels can encourage excessive plant growth.

Why test available phosphates?

Phosphates are naturally low in soil and water in Australia. The activities of humans can increase the levels of phosphates in our waterways with undesirable consequences.

Experiment.

Test the *available* phosphate levels using a Smart 2 colorimeter following the method

Measuring the concentration of common ions such as phosphates is an important measure of water quality.

Pay close attention to the safe work practices as testing for phosphates involves the use of hazardous chemicals.

Follow these instructions to measure available phosphates in your sample. Shake the sample bottle well to mix its contents.

To avoid confusion the phosphate colorimeter tube has a blue label. Rinse this twice with sample water over the liquid waste container.

Now rinse the 60 millilitre syringe twice with sample water over the liquid waste container.

Using the 60 millilitre syringe, draw up approximately 40 millilitres of sample water.

Attach and hold a new 0.45 micron filter to the syringe.

Gently expel a small portion of this sample water through the filter into the liquid waste container.

Then expel a 10 millilitre portion of sample water into the phosphate colorimeter tube.

Narrator: Rinse the blank colorimeter tube with filtered sample water over the liquid waste container.

Narrator: Then fill this colorimeter tube to the 10 millilitre mark with filtered sample water.

Now, select the phosphate acid reagent and the one millilitre syringe.

Draw the plunger back halfway and insert the tip of the syringe into the small hole in the top of the bottle. Push the plunger in to expel the air into the bottle.

Turn the bottle and syringe upside down and while supporting both, slowly pull back on the plunger until the black stopper is aligned with the one millilitre line.

Turn the bottle upright and carefully remove the syringe by pulling from its base. Add one millilitre of phosphate acid reagent to the phosphate colorimeter tube.

Replace the lid on the tube and invert several times to mix.

Using the phosphate reducing reagent and the 0.1 gram spoon, add one level spoonful of phosphate reducing reagent to the phosphate colorimeter tube.

Replace the lid and invert several times until the crystals are dissolved.

Time this five-minute reaction with the stopwatch. While you wait for the reaction, prepare the Smart-2 colorimeter.

clean the blank colorimeter tube with paper towel to remove all smudge marks and fingerprints.

Press and hold ON button until the colorimeter turns on.

Press ENTER to start. Press ENTER again to select TESTING MENU.

Press ENTER to select ALL TESTS.

Scroll and press ENTER to select 78 PHOSPHATE-L from menu.

Narrator: Insert the blank tube into the colorimeter, close the lid and press enter to select SCAN BLANK.

Remove the blank tube from the colorimeter.

Clean the phosphate colorimeter tube with paper towel to remove all smudge marks and fingerprints.

Insert the phosphate colorimeter tube into the chamber, and close the lid.

At the end of the 5 minute reaction time, press ENTER to select SCAN SAMPLE.

Narrator: Record the result and turn your colorimeter off.

Empty the contents of the colorimeter tube into the liquid waste container.

Rinse the colorimeter tubes twice with distilled water.

Clean the 60 millilitre syringe with distilled water over the liquid waste container.

Steps in the process of eutrophication

1. excess nutrients enter waterways
2. nutrients promote plant growth, especially algae
3. algal bloom occurs
4. algae die and are decomposed by bacteria
5. decomposition of algae increase biological oxygen demand
6. there is a drop in oxygen levels
7. fish, macroinvertebrates and other aquatic life forms die

Check your understanding of testing for phosphates with this quiz.

Question 1:

Phosphates occur naturally in low concentrations in Australian soils and water. Identify three sources of excess phosphate compounds in waterways.

1. algal bloom
2. detergents containing phosphates
3. superphosphate
4. animal manure.

Question 2:

Testing for phosphates using a colorimeter is a quantitative test.

1. true
2. false.

Question 3:

Total phosphates and available phosphates are equivalent.

1. true
2. false.

Question 4:

Which of the following would NOT need to be considered for working safely in this investigation.

1. wear gloves to protect your skin

2. wear goggles to protect your eyes
3. hold all tubes and bottles over the liquid waste container to prevent spills
4. recap all reagents after the experiment
5. wash any spills immediately
6. time the experiment accurately.

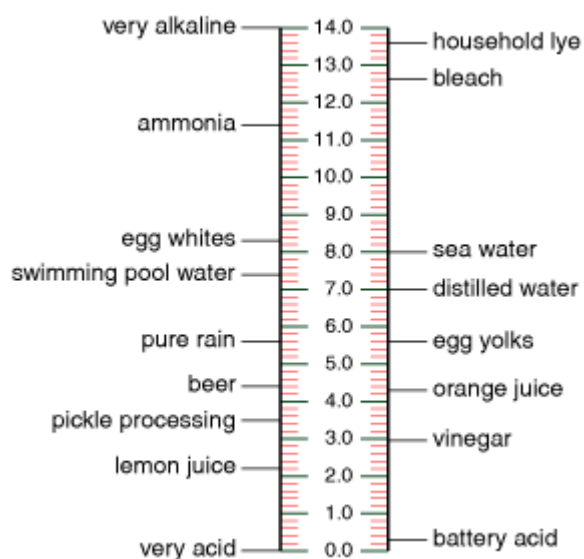


pH

About pH

pH is a measure of the relative acidity or alkalinity of a substance. pH is the hydrogen ion (H^+) concentration.

The pH of waterways is important because most organisms can only live in a fairly narrow pH range.



Why test pH?

pH is a measure of acidity or alkalinity of a waterway. The pH levels in waterways influence the diversity of species in ecosystem.

Fish species have an optimal pH

The optimal pH for most organisms in Australian freshwaters is 6.5-8.2. Changes in pH outside this range will cause a reduction in species diversity, as the more sensitive species disappear. Acidic water can cause fish and other aquatic organisms to suffer from skin irritations, tumours, ulcers and impaired gill function. Extremely high or low pH will lead to the death of aquatic life.

Changes in pH

Small changes in pH can greatly influence the solubility and biological availability (amount that can be used by aquatic life) of nutrients, e.g. phosphorus, nitrogen and carbon, and heavy metals, e.g. lead, copper and cadmium. pH levels below 5.5 can cause heavy metals trapped in sediments to be released in forms that can be toxic to aquatic organisms.

Factors influencing pH

The pH of water can be influenced by: geology, e.g. limestone catchments typically contain alkaline waters whereas basalt and sandstone catchments typically contain slightly acidic waters; characteristics of the catchment, e.g. in forested catchments waterways may be slightly acidic as the water drains through leaf litter; urban run off can contain pollutants such as detergents, pesticides, fertilisers which can increase or lower the pH of water; acid sulfate soils, when exposed to air, can leach sulfuric acid in the waterway resulting in decreased pH levels; and photosynthesis where levels of carbon dioxide increase during peak periods, resulting in an increase in pH.

Testing pH

The pH of water can be measured using indicator paper, pH strips or a pH meter.

- 1 Rinse a small beaker with sample water over the liquid waste container.
- 2 Fill the beaker with sample water.
- 3 Take one pH strip out of the container.
Do not touch the coloured squares on the end of the strip.
- 4 Immerse the coloured squares on the pH strip into the sample water for 5 minutes.
Time this using a stopwatch.
- 5 Match the colours on the pH strip to the colours on the chart provided on the container by holding the pH strip horizontally against the chart.

Important: If the colours on the squares do not exactly match the colours on the chart, the result can be recorded as halfway between these two values, e.g. between 7 and 8 would be 7.5.

Check your understanding of pH testing with this quiz.

Question 1:

What effect does a pH of less than 6.5 or higher than 8.2 have on a waterway?

1. there is no effect
2. light penetration is reduced
3. organic matter decomposes more quickly
4. species diversity is reduced.

Question 2:

The geology of a catchment can affect the pH of a waterway.

1. true
2. false.

Question 3:

Urban run off containing detergents, fertilisers and pesticides can influence the pH of a waterway.

1. true
2. false.

Question 4:

Small changes in pH make no difference to waterways.

1. true
2. false.



Grateful Acknowledgement is made to the SYDNEY CATCHMENT AUTHORITY for their permission to use materials published in their Water Chemistry HSC Chemistry Investigations booklet and corresponding web materials for the development of this Learning Resource for Seqwater.