Understanding Water Quality

Students gain an understanding of key water quality parameters by reading texts and completing quizzes.

Curriculum Links:	Science	(Science in Daily Life, Life & Living, Natural & Processed Materials)
	English	(Reading)
	Math	(Measurement)
	S&E	(Natural & Social Systems)

Outcomes: In completing this activity, students will:

- understand the water quality parameters they will be testing
- understand that all living things in the environment are interdependent and changing one aspect of the environment will affect other organisms
- understand that consistent units of measurement are necessary for comparisons to be made
- be able to describe conditions of tested samples using correct, accurate terminology and units of measure.

Preparation:

Make sufficient copies of information sheets and relevant quiz sheets or have them available on the computer for individual completion.

Class Activity:

Students could work as a class, or in groups which rotate through the learning centres. If working as a group, the equipment to measure each parameter could be displayed with suitable captioning for name, use and units of measurement used.

1. Read and discuss the general information sheet, "About Water" with the students.
2. Students then read through information sheets, either individually or as a group.
3. Discuss / have students find out anything that is not clear.
4. Students then self-test their understanding by completing a quick quiz.
5. Students then self-mark from answer sheet if working in groups, or with the teacher if class is working as a whole before proceeding to next information sheet / quiz.

NB: Primary classrooms will generally only require the material on temperature, pH, turbidity, conductivity and macroinvertebrates.

Secondary classrooms should extend these parameters to include phosphorus, nitrogen, chlorophyll 'a' and dissolved oxygen.

About water

Water has some remarkable features:

- Water is known as the universal solvent because it can dissolve many substances, both solid and gaseous, that come into contact with it.
- Water is the only natural substance that exists as solid, liquid and gas within normal earth temperatures.
- The temperature of water affects how quickly substances dissolve in it and, in some cases, the quantity that can be dissolved: for example, warm water holds less dissolved oxygen than colder water, but it holds more of most solids.
- Temperature also has a major effect on living things within the water. Compared to air or soil, bodies of water change temperature slowly, so aquatic life is generally not exposed to sudden fluctuations of temperature.
- Water containing salts is a good conductor of electricity – the basis of the technique for measuring the level of salt in the water (salinity).
- Moving water and ice are powerful agents of erosion – removing particles from unprotected soil surfaces, stream banks and rock faces, resulting in cloudy or turbid water.
- Water has a surface tension, which causes it to form drops and to have a 'skin' strong enough to support the weight of some aquatic insects.
- Water also sticks to other surfaces, enabling the capillary action of water in fine tubes, such as soil pores.

The properties of water vary naturally depending on the surrounding environment, so data collected about water quality must be interpreted in the context of that particular environment and position in the catchment.

The following activities provide background information on the parameters that may be tested to determine water quality. Knowing about these parameters will help students understand water pollution and the affect on aquatic ecosystems.

Your Ribbons of Blue coordinator has equipment to test temperature, turbidity, pH, conductivity (salinity) and macroinvertebrates. Please contact your coordinator (listed at the front of this file) if you would like your students to learn to use the equipment and/or be involved in water quality monitoring.

This information has come from the following sources:

Crook, Thelma. *Understanding Water Quality, Peel Ribbons of Blue*

Waterwatch South Australia 1996, *Catchment care and water quality monitoring manual for South Australia*. Waterwatch South Australia.

Waterwatch Australia National Steering Committee 2002, *Module 4 - Physical and Chemical Parameters*. Environment Australia.

Water Temperature Information

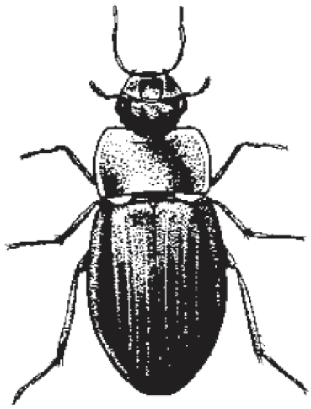
Many of the physical, biological and chemical characteristics of a waterway are directly affected by temperature.

Temperature affects:

- The solubility of oxygen in water (that is how much oxygen will dissolve in water). There is less oxygen in warmer water than in cooler water. A small rise in water temperature can mean a significant drop in the amount of dissolved oxygen available for plants and animals.
- The rate of plant growth. Plants such as algae and other water plants can grow faster in warmer water. When the water is both warm and nutrient enriched algal blooms can occur.
- The rate of photosynthesis (when plants convert carbon dioxide and water into food and oxygen). Warmer water increases photosynthesis resulting in an increase in dissolved oxygen during the middle of the day.
- The metabolic rate of plants and animals. With an increase or decrease in temperature, organisms don't function as effectively and are more sensitive to toxic waste, parasites and disease. With extreme temperature change, many organisms will die. Long-term changes in temperature may alter the species present in a particular ecosystem.

Water temperature is affected by:

- Clearing of native fringing vegetation. Creeks and rivers in the south-west are naturally well shaded with dense fringing vegetation. Clearing of the vegetation results in direct sunlight warming the creek water.
- Turbidity of the water, which is often a result of erosion in the catchment. The particles in turbid water absorb heat and so lead to higher temperatures.
- Runoff from roads and car parks that have been warmed by the sun, discharge of warm water from industry and power plants, or cold water from dams.



Water Temperature Quiz

1) Warmer water holds:

a) less oxygen than cooler water
b) the same amount of oxygen as cooler water
c) more oxygen than cooler water
d) no oxygen at all

2) Water temperature can be affected by:

a) turbidity
b) runoff from roads and car parks
c) industrial waste
d) all of the above

3) Warmer water:

a) decreases the growth of algae
b) does not affect the growth of algae
c) increases the growth of algae
d) stops the growth of algae

4) Increased water temperature can:

a) affect the lifecycle of insects
b) increase plants and animals risk of disease
c) affect the food chain
d) all of the above

5) Water temperature can be affected by:

a) time
b) macroinvertebrates
c) amount of native vegetation on the stream
d) all of the above

6) Water runoff from roads and car parks may affect temperature:

a) yes
b) no

Turbidity Information

Turbidity measures the cloudiness of water. It is measured in Nepholmetric Turbidity Units (NTU's). This comes from the Greek word nephos, which means cloud. The more material that is suspended in water, the greater its turbidity. If the water is cloudy, it will affect sunlight penetration. The depth to which sunlight penetrates the water depends on its "cloudiness" or turbidity. Any change in light can affect the ecosystem.

Suspended material can be particles of clay, silt, sand, algae, plankton, micro-organisms and other substances. When these particles are washed into the water body, they are held in the water column and are called "suspended solids".

Water in metropolitan and south-western streams is often naturally stained by tannin from plants and is dark in colour. This is not caused by suspended solids and is not related to turbidity.

Turbidity affects:

- Water temperature - suspended particles absorb heat causing an increase in water temperature.
- The amount of dissolved oxygen in the water – dissolved oxygen levels are lower in warm water so an increase in temperature through turbidity can also lead to a decrease in dissolved oxygen.
- Light penetration – turbidity leads to less light penetrating the water, causing a decrease in photosynthesis and ecosystem disturbance. All plants need light to photosynthesize, and animals need varying degrees of light depending on the species. Plants that can either photosynthesize in low light or move within the water column, such as blue-green algae, have an advantage in turbid water.
- Suspended particles may clog aquatic invertebrate and fish gills, reduce growth rates, and prevent egg and larval development. Habitat is also lost when suspended sediment settles into crevices and holes.
- Particles in suspension can carry heavy metals, pesticides, nutrients (phosphorus and nitrogen) and bacteria attached to them. Turbid water can result in an increase of these potential pollutants.

Turbidity is affected by:

- Erosion in the catchment – soil and organic matter washed into streams. Turbidity is usually higher in winter when water is flowing faster, picking up and carrying the suspended solids.
- Streambank erosion caused by clearing of fringing vegetation and stock access (trampling). Turbidity levels are often low at the top of the catchment where the land is well vegetated. Turbidity tends to increase as you move down the catchment where particles can be washed off degraded or cleared land.
- Excessive algal growth.
- Waste discharge, sewerage and stormwater.

Turbidity Quiz

1) Turbidity measures:

a) the acidity and alkalinity of the water
b) the clarity of water
c) how salty the water is
d) how hot or cold the water is

2) Turbidity can be caused by:

a) soil erosion
b) dense vegetation
c) no rain
d) direct sunlight

3) Increased turbidity can:

a) increase water temperature
b) decrease oxygen
c) decrease sunlight penetration through the water column
d) all of the above

4) Increased turbidity relates to increases in:

a) the amount of silt and sediment in a stream
b) the amount of phosphorus in the water
c) the amount of tannins in the water
d) all of the above

5) NTU stands for:

a) Not Tested Underwater
b) Nephelometric Turbidity Units
c) Nephelometric Testing Units
d) Not Too Unclean

6) Turbidity is caused by particles of:

a) clay, sand and silt
b) plankton
c) algae
d) all of the above

pH Information

pH is the measure of how acid or alkaline the water is on a scale of 1-14. The neutral reading for pH is 7. pH is measured on a logarithmic scale so when a value changes from say 8 to 9 then the change is equal to a ten fold increase in pH, an additional rise in pH to 10 is 100 fold increase. This would mean a pH reading of 10 is one hundred times more alkaline than 8.

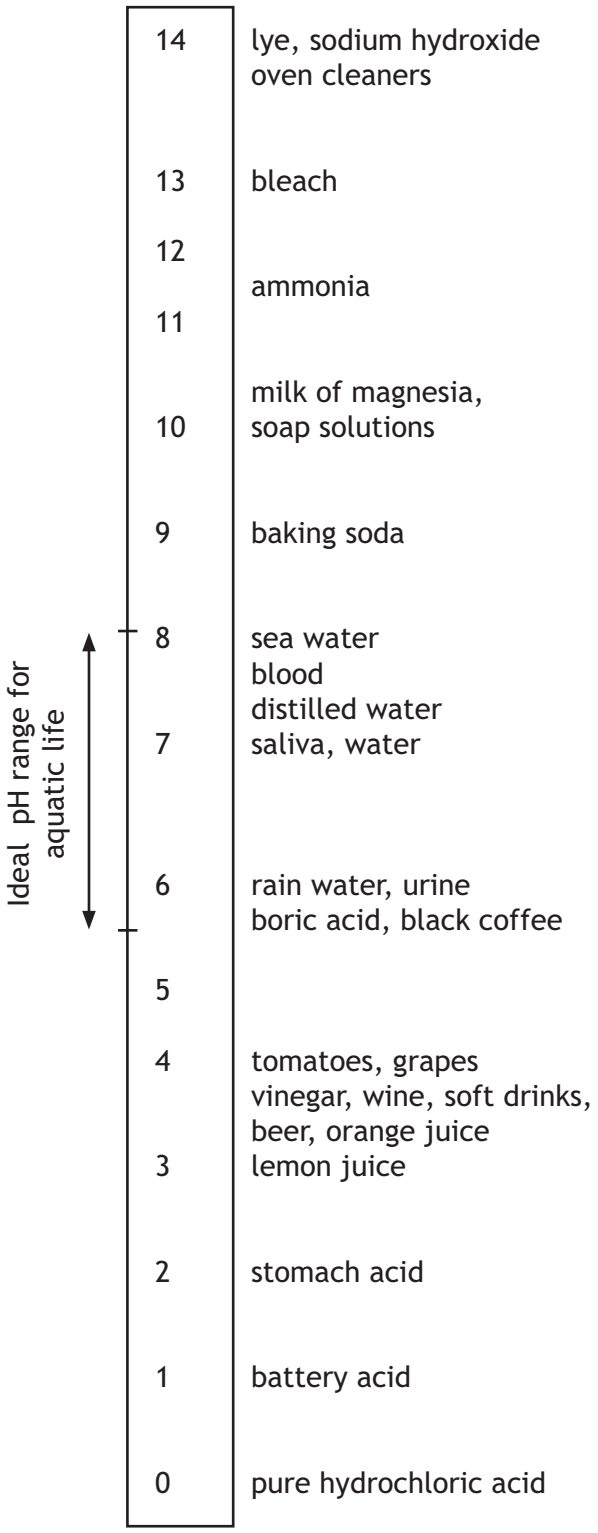
pH affects:

- The 'suitablility' of environment for an organism. All animals and plants are adapted to specific pH ranges, generally between 6.5 and 8.0. If the pH of a waterway is outside the normal range for an organism it can cause stress or even death to that organism.
- The solubility of compounds and how easily they can be taken up by plants. Many compounds are more soluble in acidic waters. The pH around roots affects nutrient uptake by plants; pH also affects the solubility of heavy metals in water and the concentrations of total dissolved solids in water.

pH can be affected by:

- The geology and soils in the area. Water running through limestone will have a higher pH than water running through peaty soils.
- Salt content. Increased salinity causes an increase in pH.
- Discharges of industrial waste.
- Disturbance of acid sulfate soils.
- Photosynthetic activity - when dissolved carbon dioxide is removed from the water by plants during photosynthesis, the pH of the water is increased. When an algal bloom occurs, pH and dissolved oxygen values are highest mid afternoon because plants are removing carbon dioxide and releasing oxygen.

pH Scale



pH Quiz

1) pH is a measurement of:

a) phosphorus
b) acidity and alkalinity
c) nutrients
d) salinity

2) The neutral reading for pH is:

a) 10
b) 8
c) 5
d) 7

3) During an algal bloom, pH is highest:

a) at night
b) mid afternoon
c) doesn't change
d) at dawn

4) If pH in the waterbody changes, it can:

a) affect the plant life in the water
b) affect the animal life in the water
c) indicate there is pollution or an algal bloom in the water
d) all of the above

5) Which is correct? The pH of…

a) battery acid is approximately pH 14
b) blood is around about pH 2
c) distilled water is pH 7
d) concentrated Sodium Hydroxide is acidic

6) A lake situated over limestone would have a pH that is:

a) acidic
b) alkaline
c) neutral
d) all of the above

Electrical Conductivity/Salinity

Salty water conducts electricity more readily than pure water. Therefore electrical conductivity is routinely used to measure salinity. The types of salts (ions) causing the salinity are usually chlorides, sulfates, carbonates, sodium, magnesium, calcium and potassium.

Conductivity is often measured in microSiemens/cm with the symbol µS/cm. Saltwater conducts electricity at a faster rate than freshwater, so the higher the reading on your meter the saltier the water.

	µS/cm	**Parts per thousand-**(ppt)
FRESH	0 – 800	≈ 0 - 0.5 ppt
MARGINAL	800 – 1800	≈ 0.5 – 1 ppt
BRACKISH	1800 – 5000	≈ 1 – 3 ppt
SALTY	> 5000	> 3 ppt

Salinity affects:

- All life forms: while an appropriate concentration of salts is vital for aquatic plants and animals, salinity that is beyond the normal range will cause stress or even death.
- The availability of nutrients to plant roots.

Salinity is affected by:

- The geology and soils of the catchment. For example the drinking water in the Peel-Harvey catchment is approximately 400µS/cm and in Geraldton it is closer to 1400 µS/cm. Some bore waters contain salt levels that are too high for drinking.
- The rate of flow in a waterway. Salinity is usually lowest during high flows and increases during low flows.
- Over-clearing of native vegetation in the catchment. Clearing deep rooted perennial vegetation leads to the water table rising and bringing with it salt that has accumulated in the soil.

Conductivity Quiz

1) Conductivity is the measure of:

a) acidity and alkalinity
b) cloudiness of the water
c) phosphates and nitrates
d) dissolved salts

2) Conductivity/salinity in a catchment is partly determined by:

a) the amount of rainfall
b) how deep the water is
c) by the geology and soil
d) how clear the water is

3) Conductivity/salinity can result from:

a) soil erosion
b) stormwater
c) algae
d) over-clearing of native vegetation in the catchment

4) Conductivity/salinity can affect:

a) plant life in and around the water
b) animal life in and around the water
c) quality of drinking water
d) all of the above

5) Saltwater conducts:

a) no electricity
b) electricity slower than freshwater
c) electricity faster than freshwater
d) none of the above

6) Conductivity is usually measured in:

a) microSiemens/cm
b) macroNutrients/cm
c) micronutrients/cm
d) macroSiemens/cm

Nutrients

Phosphorus

The phosphorus (P) found in both surface water and groundwater is in a form called phosphate (chemical formula, PO_4). It is naturally derived from the weathering of rocks and the decomposition of organic material and naturally occurs in low concentrations in water.

Phosphorus affects:

- The growth of plants: high phosphorus levels stimulate the growth of algae and aquatic weeds.
- Water quality: excess algae or plant growth is damaging as it:
    - depletes the water of oxygen as it dies and decays – the microorganisms associated with decomposition use oxygen.
    - causes unpleasant odours as it decays.
    - produces chemicals poisonous to humans and stock.
    - competes for light, space and nutrients.

Phosphate concentrations in water are affected by:

- Geology and soil type – some soil types hold on to nutrients more tightly than others.
- Animal and human waste (sewage) – intensive agricultural industries such as dairies and piggeries can contribute heavy nutrient loads to waterways if not properly managed.
- Phosphate-containing fertilisers – some of the fertiliser applied makes its way into waterways.
- Soil erosion – phosphates can be attached to soil that is carried into a waterbody.
- Urban runoff – fertilisers, detergents and manure in stormwater that is carried to waterbodies.
- Phosphates in domestic waste entering waterways from leaking septic systems and sewage treatment facilities. Many sewage treatment plants are allowed only a limited amount of phosphate in their discharges.
- Vegetation e.g. deciduous trees lose all their leaves every autumn and the leaves decompose very quickly contributing a lot of nutrients to the ecosystem. Native trees on the other hand, have waxy leaves that decompose very slowly and lose leaves slowly throughout the year.

Nutrients

Nitrogen

Nitrogen (N) is another element that is essential for all forms of life. The most common nitrogen compounds in water are ammonia (NH_4), nitrate (NH_3) and organic nitrogen. Organic nitrogen can be converted to either nitrates or ammonia by the decay of plant and animal material. Nitrogen is usually measured by the concentration of nitrate.

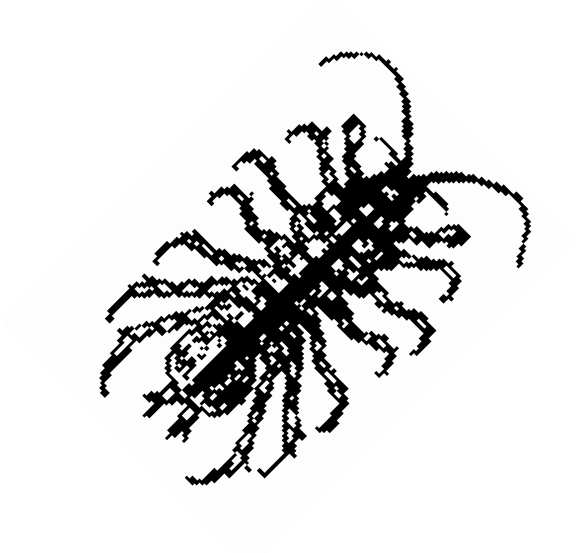
Nitrogen is recycled continually by plants and animals, and is present in freshwater at higher concentrations than phosphate. Although both nutrients are required for plant growth, phosphate is considered to be the limiting factor in fresh water. In saltwater ecosystems however, nitrogen is much less abundant, and it becomes the nutrient that limits algal growth.

Nitrogen affects:

- Plant growth: high levels of nitrate and/or ammonia can lead to excess algal growth. Algal blooms can only occur if all other factors for growth are also available in high levels, including phosphate. The damaging affects of algal blooms are listed in the previous section on phosphorus.

Nitrogen is affected by:

- Geology and soil type – some soil types hold on to nutrients more tightly than others.
- Animal and human waste (sewage) – intensive agricultural industries such as dairies and piggeries can contribute heavy nutrient loads to waterways if not properly managed.
- Nitrogen-containing fertilisers - some of the fertiliser applied makes its way into waterways.
- Industrial discharge and urban runoff.
- Decomposing plants and animals.
- Vegetation e.g. deciduous trees lose all their leaves every autumn and the leaves decompose very quickly contributing a lot of nutrients to the ecosystem. Native trees on the other hand, have waxy leaves that decompose very slowly and lose leaves slowly throughout the year.



Nutrient Quiz

Can you think of ways that you can reduce the amount of phosphorous and nitrogen entering the water?

1. Make sure the septic tank does not leak or overflow.
2. Plant native gardens because they need less water and fertiliser.
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Aquatic Macroinvertebrates

Macroinvertebrates or 'macros' are very small animals which do not have a backbone that are large enough to see with the naked eye. If they do have a skeleton, it is external, so their body and legs are jointed.

These animals live in the water for all or part of their lives, so their survival is closely linked to water quality.

Examples of freshwater 'macros' are:

- Insects and their larvae – bugs and beetles, dragonfly and caddisfly larvae.
- Molluscs – snails and mussels.
- Crustaceans – gilgies, marron and shrimp.
- Others – spiders, mites, leeches and worms.

The most common group of macroinvertebrate is the Arthropods (they have legs).

Small fish and turtles found in the same habitat should not be confused with macroinvertebrates. These animals have a backbone and are therefore vertebrates.

Macroinvertebrates are found in all parts of the waterbody from the margins and surface to the air: Including:

- on the surface
- beneath the surface
- amongst the reeds and vegetation along the banks
- among the rocks and sediments, gravel, pebbly or sandy areas at the bottom
- on submerged rocks, boulders, branches, logs and twigs
- in the riffles of a flowing stream.

Aquatic macroinvertebrates are a good indicator of a waterbody's health. Some are more sensitive to pollution than others. The presence or absence of particular 'macros' in a waterway tells us a lot about the health of the ecosystem: when water becomes polluted or disturbed, sensitive macroinvertebrates like stoneflies and mayflies could die.

Fly, midge and mosquito larvae are more tolerant to a polluted home and changes in habitat.

Variety is important. The more different types of organisms, the more likely it is that the ecosystem is healthy. So, finding 20 'macros' of 15 species is better news than finding 50 of only 5 species.

Macroinvertebrate Quiz

1) Aquatic macroinvertebrates are animals that:

a) live part or all of their life cycle in the water
b) are large enough to see with the naked eye
c) have no backbone
d) all of the above

2) Macroinvertebrates:

a) all tolerate the same water conditions
b) can all live in polluted conditions
c) have different tolerances to different conditions
d) play no role in the food chain

3) Changes in the physical and chemical parameters of the water (e.g. temperature):

a) have no impact on the food chain in a waterway
b) affect the macroinvertebrates living in the waterway
c) have no impact on the macroinvertebrates in the waterway
d) none of the above

4) When a waterway is affected by an algae bloom, it can change:

a) turbidity
b) oxygen levels
c) macroinvertebrate numbers and diversity
d) all of the above

5) A marron is a macroinvertebrate and is a:

a) mollusc
b) crustacean
c) insect
d) none of the above

Dissolved Oxygen

Oxygen is essential for almost all forms of life. Aquatic animals, plants and most bacteria need it for respiration (getting energy from food), as well as for some chemical reactions.

The concentration of dissolved oxygen is an important indicator of the health of the aquatic ecosystem.

Dissolved oxygen affects:

- All aquatic life. Persistently low dissolved oxygen will harm most aquatic life because there will not be enough oxygen for them to use.

Dissolved oxygen is affected by:

- The atmosphere and other living things. The air is one source of dissolved oxygen, and aquatic plants, including algae, are another. The speed at which oxygen from the air enters and mixes through the water depends on the amount of agitation at the water surface, the depth of the waterbody and the rate at which it mixes itself. Generally, shallow, fast flowing streams have more oxygen than stagnant, deeper pools.
- Plant photosynthesis. During daylight hours plants release oxygen into the water.
- The clarity of the water. Turbidity can affect the amount of light available for photosynthesis and therefore affect the amount of oxygen being released into the water.
- Temperature: as water temperature rises, oxygen diffuses out of the water into the atmosphere.
- Salinity: saline water holds less dissolved oxygen than freshwater.
- Organic matter: organic matter in the water usually affects the amount of dissolved oxygen. Bacteria break down the organic matter and while doing so use dissolved oxygen in respiration. Organic matter is washed into streams during rain and will result in a decrease in dissolved oxygen in the water while it is being decomposed.

Dissolved Oxygen Quiz

1) The amount of oxygen in the water is directly related to:

a) water temperature
b) flow of the water
c) plant life in the water
d) all of the above

2) Shallow fast flowing streams usually have:

a) less oxygen than deep, slow flowing streams
b) the same amount of oxygen as deep, slow flowing streams
c) more oxygen than deep, slow flowing streams
d) none of the above

3) The concentration of dissolved oxygen is an indicator of:

a) the size of a river
b) the health of an ecosystem
c) how the salty the water is
d) acidity of the water

4) The amount of dissolved oxygen in the water is important because:

a) it provides food
b) animals in the water depend on it for respiration
c) it makes the water warmer
d) all of the above

5) Dissolved oxygen is a measure of:

a) the speed that oxygen dissolves in water
b) the number oxygen bubbles in water sample
c) the amount of oxygen dissolved in water
d) carbon dioxide levels

6) When an algal bloom dies and decomposes, dissolved oxygen levels:

a) remain stable
b) decrease
c) vary throughout the day and night
d) all of the above

Quick Quiz Answers

Temperature:

1) a)
2) d)
3) c)
4) d)
5) c)
6) a)

Turbidity:

1) b)
2) a)
3) d)
4) a)
5) b)
6) d)

pH:

1) b)
2) d)
3) b)
4) d)
5) c)
6) b)

Conductivity:

1) d)
2) c)
3) d)
4) d)
5) c)
6) a)

Nutrients

Test soil so that you use the right kind and amount of fertilisers.

Wash your car on the lawn so that detergents soak into the ground instead of washing into stormwater drains.

Pick up and dispose of dog poo in the compost or the bin.

Fence creeks to keep cows, sheep and horses out, so that manure doesn't go straight into the water.

Don't plant deciduous trees near drains, streams and rivers.

Dairies and piggeries should have effluent systems that stop manure being washed into streams.

Macroinvertebrates:

1) d)
2) c)
3) b)
4) d)
5) b)

Dissolved Oxygen:

1) d)
2) c)
3) b)
4) b)
5) c)
6) b)