# WATERWATCH

Upper Murrumbidgee

# EDUCATION

# Assessing Water Quality

## Secondary Education: Years 9 - 12

Classroom resource adapted from '**Sustaining River Life**' Unit 3.1 *What water quality tells us about river health*.

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# Assessing Water Quality

Benthic metabolism chambers measuring dissolved oxygen, Image © Greg McDonald

## Background Information

Today, many waterbodies throughout Australia, have compromised water quality. This often occurs as a result of increased pollutants entering the system and reduced habitat and condition in the river to adequately process and absorb these pollutants. This reduces the environmental integrity of the water and consequently limits the potential uses for that water.

That said, it has not always been like this. It is likely the First Australians managed the land and waters in a way that minimised impacts upon the water quality of freshwater ecosystems. Living in Country for over 21,000 years enabled the First Australians, through careful observation, to intimately comprehend the environment and manage it sustainably. For the upper Murrumbidgee River catchment area, the First Australians were the Ngunnawal, Ngambri and Ngarigo peoples.

The changes that came with European settlement has meant that the environment, including our freshwater creeks and rivers, continue to be at risk of becoming more degraded. Land use and water management practices, as well as the pressures created by growing population, all contribute to compromised water quality in our water bodies.

This is why today, scientists and the community are also interested in careful observation and measurement, to better determine the water quality status of our freshwater resources. To do this, we must measure and quantify the various parameters associated with water quality. These parameters are primarily physical and chemical but other influencing factors can also be investigated during water quality monitoring.

Water quality monitoring of physical (such as temperature and turbidity) and chemical (such as dissolved oxygen and electrical conductivity) are key ways both scientists and the community can assess the health, not only of water ways, but also of the land associated with a particular body of water.

Interpreting water quality data, in the context of where and when it was collected, can help in understanding the environmental health of both the waterbody and the surrounding landscape of the catchment in which it is located. However, this can only be achieved if we are confident that the data is representative of the actual conditions. We achieve this confidence by following good scientific practice when monitoring water quality.

Water quality is a complex subject requiring an assortment of measuring techniques. The number and types of measurements or tests will vary and be dependant upon the scientific question being asked, the management goals for the waterbody and the resources available to monitor.

Upper Murrumbidgee Waterwatch measure the following parameters when assessing water quality. These parameters provide a useful suite that assist the assessment of environmental water quality:

<u>Temperature</u>: The temperature of water changes with the seasons and weather. It is affected by altitude, water volume, shading or exposure to sun and more generally, climatic conditions. Warming water loses capacity to hold dissolved oxygen. Water temperature also influences the rate of chemical reactions and metabolic processes. Water temperature has a strong effect on fish, very warm water can lead to fish kills due to oxygen reduction, while excessively cold water, especially when out of season, may interfere with fish breeding behaviour.

<u>Dissolved oxygen</u>: Low oxygen severely limits the survival of macroinvertebrates (waterbugs) and native fish in water bodies. If this persists, then only very tolerant animals such as mosquito larvae, leeches and some feral fish species such as carp, may survive. Dissolved oxygen may be reported as ppm, mg/L or % saturation. Water experiencing extended periods of oxygen super saturation can also be harmful but this is quite uncommon.

<u>Phosphorus</u>: Phosphorus is an important plant nutrient. In the natural Australian landscape and freshwater ecosystems, it is a 'limiting factor' to plant growth because it is not abundant or freely available in our continent's geology. Excess levels of phosphorus, which can come from either animal/human waste or fertilizer, causes rapid plant growth in waterways and often produces algal 'blooms' if conditions are conducive. Phosphorus occurs in the form of Phosphate. Depending on the test used, it may be reported as either Phosphorus or Phosphate. The values for each are not interchangeable but one can be derived from the other.

<u>Nitrate</u>: Nitrogen another plant nutrient, is commonly derived from decomposing plant, animal/human waste and/or fertilizer run-off. Like phosphorus, excess levels of nitrogen, in the various forms of nitrogen oxides, promote accelerated plant growth and algal blooms. Depending on the test used, it may be reported as either Nitrogen, Nitrate or NOx. The values for each are not interchangeable but can be derived from the others with the appropriate multiplier value.

<u>pH</u>: The pH of pure water is 7. A commonly acceptable range for fresh water is between 6 and 9. Below 6, water is considered to be too acidic, above 9 water is too alkaline (basic). There can be naturally occurring acidic or basic waters. In the Canberra region, with its limestone outcrops, some alkalinity and higher pH is natural. A pH of 8 is common in many of our streams. Seasonal leaf fall from deciduous trees can result in lowered pH levels.

<u>Electrical conductivity</u> (EC): This is a measure acting as a proxy for mineral ionic concentration. The ions tend to be derived from mineral salts. Fresh water above 212µS/cm (micro-Siemens/centimetre) in the upper Murrumbidgee region are indicative of lower water quality (see table on p. 7). Freshwater ecosystems, by definition, are not saline and exhibit low conductivity. Rising salinity from groundwater is often the product of irrigation or loss of tree cover. This abnormal salinity has signific impacts on both plants and animals.

<u>Turbidity</u>: This is a measure of the water's clarity. Good environmental water clarity should be below 10 NTU (Nephelometric Turbidity Units). Over 36NTUs is considered too murky. High turbidity affects aquatic animal's ability to navigate, can be damaging to gill structures and can limit the ability of aquatic plants to photosynthesise. This has ramifications for both plant health and the oxygen status of the water body.

The measurement of these variables forms the basis of the following lesson plan. There are water testing kits commercially available that will adequately test for these parameters. When available, however, a suitable water testing kit can be borrowed from a Waterwatch Coordinator. These kits have been determined to comply with ACT Department of Education as well as ACT and NSW Work Health and Safety standards.

## Vocabulary

Celsius Dissolved Oxygen (DO) Turbidity NTU pH Electrical conductivity EC Nitrogen Phosphorus Phosphate Nitrogen Nitrate Sample Temperature Ions

## Objectives

Students gain experience in testing water samples and understanding what good water quality means.

Students learn how to use water quality monitoring as a river health management tool.

## Duration of lesson

In class—1 hour

Field Trip—2 hours depending on travel time to and from site location

## Materials required

**Education Waterwatch test kit** specially prepared test kits with materials that may be borrowed from your **Waterwatch Coordinator** http://www.act.waterwatch.org.au

**Waterwatch manual** download from http://www.act.waterwatch.org.au/Waterwatch%20Manual.html

Large paper pad and markers

Field Data Sheets (see below)

**PPE**: Safety glasses and single use disposable gloves

## Lesson plan

Health warning: Contact with water from creeks, rivers and especially urban waterways (including ANY lakes, ponds or wetlands), can have associated health risks. Ensure students either maintain ‘observer’ status, or have disposable gloves or utilise hand washing facilities, immediately after the activity. No food should be handled or consumed during the activity. Urban storm water may often be contaminated with bacteria or blue/green algae. After contact with storm water, skin irritation or gastric illness may occur if proper hygiene is not observed.

1. Open the discussion by asking students how we might investigate the health of a river, stream, lake or pond. Discuss how water quality can be used as a measure of both stream and catchment health. Emphasise that field observations not only supplement the measured data, they also provide valuable context for the measurements. What do they see, hear and smell at the field site? When did it last rain?

2. Advise the students that they will be doing the same types of water quality testing as professionals and volunteer groups do at their waterways.

3. Explain briefly the significance of each test and pass out Field Data Sheets.

4. Discuss safety concerns and the need for careful and mature behaviour while handling water samples and test kit chemicals (especially these).

5. Break students up into groups of 4 to 6, giving each one a particular test. Offer assistance with instructions and methodology through-out. Alternatively, the tests may be set up as stations in the classroom-laboratory around which each group rotates.

6. Have students record their results on the Water Quality Data Sheet provided.

7. When all students have recorded their results, invite the entire group to draw conclusions about the water quality. Use the 'Information starter pack' sheet (below) to assist with this task.

## Back in the classroom

1. Using the **Catchment Health Indicator Program (CHIP) Score Card** (below), have students assess what each parameter suggests about the water quality. The instructions and table for calculating % saturation of dissolved oxygen is on the following page.
2. Using the **Information starter pack on factors that affect Water Quality** (below) as a prompt, ask the students to hypothesise on the causes of any water quality concerns they've identified. This may be expanded into further class or homework research. Is a single field visit adequate enough to determine environmental health? Why? Additional information is provided in our **Volunteer Resource Manual** (pages 22-29, http://www.act.waterwatch.org.au/Waterwatch%20Manual.html).
3. Get the students to explain what of their own or community behaviour may be having a deleterious impact on the waterway.
4. Ask students to hypothesise about what they, or other members of the community, could possibly do to improve water quality. Look for answers such as:

- Tree planting
- Livestock exclusion from the waterway or river bank
- Controlling non-point (generalised) such as deciduous leaf litter and point source (specific location) pollution, such as leaking sewer pipe
- Controlling erosion
- Education of the community to reduce stormwater pollution such as 'drain is for rain' promotions and rain garden establishment
- Protect areas that have good vegetation and instream habitat

Additional resources and ideas can be found at H2OK's web site:

*https://www.environment.act.gov.au/water/ACT-Healthy-Waterways/h2ok/what-can-i-do/urban-residents*

## In-class room adaptation

Provide the class with 3 to 4 one litre samples of water from various sources. (Give them mystery labels such as Sample A, Sample B etc.) Depending on your location, try to get samples from sources such as the school bubbler (or similar), from a nearby river, stream, wetland or a dam, or from a parkland or stormwater drain. For the final sample contaminate drinking water with either a 1/4 cup lemon juice or a teaspoon of table salt. Clay may also be added to another to mimic soil erosion.

After testing and recording their results on the water Quality Data Sheet provided, ask students to form an opinion on which samples came from which sources. Return to the lesson plan at step 7. For each sample get the students to suggest what the contaminant or contaminants may be. Continue with Lesson Plan at 'Back in the classroom'.

## Extension

Have students make a bumper sticker or leaflet or create a stall at the local market to encourage members of the community to take better care of water quality. Alternatively, have the students create a short video.

Youtube examples include:

'Waterwatch on the Darebin' https://www.youtube.com/watch?v=py3noB5gFbc

'Maria Regina Catholic Primary School - Mini Eco Film' https://www.youtube.com/watch?v=uZnqWKc-ntk

## Projects Using the Waterwatch kit

Schools are welcome to borrow our Education Waterwatch Kits to conduct investigation projects. Some ideas:

- Testing a stormwater way and comparing the results to a nearby natural river or creek.
- Testing the inflows and outflow points in a local wetland to test the effect on water quality.
- Comparing farm dams to urban wetlands.
- Creating polluted samples by adding typical pollutants that may find their way into our stormwater system.

Safe, in classroom examples include:

- Car washing and other household detergents/cleaning products.
- Lawn fertilizers and compost.
- Leaf litter and lawn clippings.

These can be left in water samples for nominated periods and tested to see what changes are detected.

- Testing locations along a small local catchment and noting changes along its length.
- Testing between two different local sub-catchments and comparing the possible influences that natural factors (eg. geology) and land use (urban/cropping/nature reserve) may be having on water quality.

## Glossary of Terms

Dissolved oxygen - Gaseous oxygen (O2) will dissolve in water. When the oxygen concentration of a water body is in equilibrium with the overlying air, at a given temperature 100% saturation will occur. Photosynthetically-active species (plants, algae etc.) generate oxygen as a by-product of photosynthesis.

Electrical conductivity - Measure of a material's ability to conduct an electric current. This is generally used as an indicator of mineral salts in an aquatic ecosystem as salty water is more conductive than fresh water.

pH – pH is the hydrogen ion (H+) concentration and is expressed on a log scale of 0 (acid) to 14 (base), with the neutral point at 7. Alkalinity, although often referred to as higher pH, is not the same as pH as water does not need to be strongly basic (high pH) to have high alkalinity. Alkalinity can be considered as the capacity of water to neutralize an acid. In other words, it is a measure of how much acid can be added to a water sample without causing a significant change in pH.

Sample - A small amount or part of something, used as an example of the character, features, or quality of the whole.

Nitrogen – (N) A non-metallic element that occurs as a colourless, odourless, almost inert gas and makes up four-fifths of the Earth's atmosphere by volume. Used in the manufacture of ammonia, explosives, fertilisers and by plants and animals to make proteins and as part of DNA and RNA. Both ammonia and oxides of nitrogen are absorbed by plants. Nitrate is the most common and bio-available form.

Phosphorus – (P) A non-metallic element essential to plant and animal growth. Total phosphates is a measurement of all forms of phosphate compounds in a sample - orthophosphate, condensed phosphates and organically bound phosphates. Available phosphate is a measurement of the phosphate compounds that are soluble in water and therefore available to be absorbed by plants.

Turbidity - Turbidity is a measure of the cloudiness or muddiness of water. Turbidity can be caused by silt, mud, clay, algae or fine particles of organic matter. The greater the load of suspended and colloidal particulates in the water, the higher the turbidity. Colour is not turbidity. Tannin stained waters can be very dark but low in turbidity. Turbidity tends to increase after rain mainly due to soil washing from the surrounding landscape. Industrial activity, urban development, agricultural and mining activity can elevate turbidity levels.

# Water Quality Data Sheet

Name: ______________________________________________________________

School/Class: ____________________________________ Date __________________

Site___________________________________________________________________

| Parameter | Result | Units | Comments |
|---|---|---|---|
| Water Temperature | | °C | |
| pH | | - | |
| Electrical Conductivity | | µS/cm | |
| Turbidity | | NTU | |
| Dissolved Oxygen | | mg/L | |
| Phosphorus | | mg/L | |
| Nitrate | | mg/L | |

Site Observations (including frogs, platypus, water rats, algaem pollution, feral fish):

_______________________________________________________________________

_______________________________________________________________________

| | | | | | | |
|---|---|---|---|---|---|---|
| Water Level/ Flow: | Dry with isolated pool | Low | Med | High | Flood | No Flow |
| Rain in the last 24 hours: | Nil | Light | Moderate | Heavy | | |

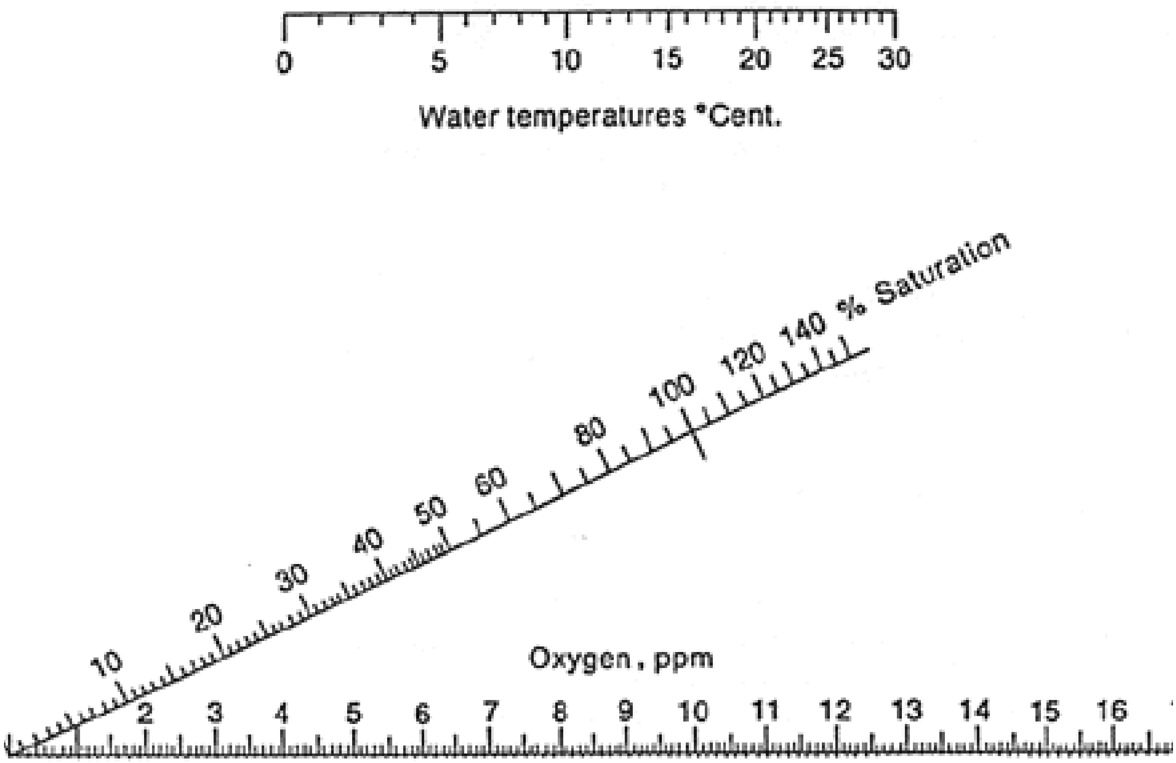
## Catchment Health Indicator Program (CHIP) Score Card

Table 1. Catchment Health Indicator Program (CHIP) Score Card with values of water quality taylored for the Upper Murrumbidgee/Greater Canberra Region, as used by Upper Murrumbidgee Waterwatch.

| Parameter | Excellent | Good | Fair | Poor | Degraded |
|---|---|---|---|---|---|
| pH | 6.6 – 7.8 | 6.1 – 6.5, 7.9 – 8.0 | 5.7 – 6.0, 8.1 – 8.2 | 5.4 – 5.6, 8.3 – 8.6 | < 5.4, > 8.6 |
| EC (uS) | ≤ 98 | 99 – 156 | 157 – 212 | 213 – 404 | > 404 |
| Turbidity (NTU) | ≤ 10 | 11 – 16 | 17 – 36 | 37 – 90 | > 90 |
| DO (mg/L) | *(Not included in CHIP)* | | | | |
| DO Sat. (%) | 88 – 99 | 84 – 87, 100 | 81 – 83, 101 – 106 | 78 – 80, 107 – 115 | < 78, > 115 |
| Phosphorus (mg/L) | < 0.02 | 0.02 – 0.03 | 0.04 – 0.05 | 0.06 – 0.08 | > 0.08 |
| Nitrate (mg/L) | < 1.0 | 1.0 – 1.3 | 1.4 – 1.7 | 1.8 – 2.6 | > 2.6 |

## How to calculate the Percent of Saturation of Dissolved Oxygen

Measure water temperature in degrees Celsius and find the value on the temperature scale.
Determine dissolved oxygen in mg/L or ppm and find the value on the lower scale.
Using a straight edge (ruler, piece of paper etc.), draw a line from the temperature value to the dissolved oxygen value. The point at which the line crosses the % Saturation scale is the percent saturation of sample.
An alternative approach is to utilise an algorithm that calculates the 100% saturation value under given conditions and subsequently provides the percentage saturation of the sample value. One such approach is on the USGS DO Tables web page; https://water.usgs.gov/software/DOTABLES/



# Information starter pack on factors that affect water quality

**Water temperature** - This is essential for assessing the percent of dissolved oxygen saturation. The warmer water becomes, the less oxygen gas it can hold. This is critical for aquatic animals. Water temperature is also a cue for breeding activity of many native fish species and unseasonably cold water can interrupt this cycle. It has been observed that 20°C is the temperature at which the feral European carp are triggered to breed.
**What can cause water temperature problems?** Shallow or stagnant water, lack of shade, open concrete drains, hot weather, deep water releases from dams and temperature stratification in standing water bodies.

**Dissolved Oxygen (DO)** - Fish, aquatic animals, bacteria and plants depend on dissolved oxygen in the water to breath. The higher the dissolved oxygen content, the easier for these animals to breathe. Both low DO saturation (below 78% for our region) and supersaturation of DO can cause fish and invertebrates to die.
**What causes DO to decrease:** Sewage disposal in waterways, animal wastes, decomposing plant material, stagnant water, lack of shade, extremely hot weather, deep water releases from dams.
**What causes DO to increase:** Agitated water such as waterfalls, cascades, riffles. Supersaturation can occur in highly aerated waters (eg. near hydropower dams and waterfalls), or due to high photosynthesis activity by algae during warm temperatures. Under warmer temperatures, the water is less able to hold DO. This means that it saturates at lower concentrations and excess oxygen bubbles to the surface and is lost from the water.

**pH** - pH is a measure on a scale of 1-14. It is the measure of the hydrogen ion(H+) concentration. Because pH is a logarithmic scale, every unit change (e.g. from 5 to 4) represents a ten-fold change in concentration. Like many parameters for good water quality, a balance must be achieved between too much and too little. Acidic waters can be like swimming in lemon juice, too basic waters and it's like swimming in bleach!
**What causes changes in pH:** Urban pollution; ash from bushfires; mine leakage; decomposing organic material; chemical-laden run off; moderate levels of nutrient pollution can lead to too much photosynthesis and an increase in the pH of the water as CO2 is consumed.

**Phosphorus** - Phosphorus is primarily used for growth and repair of body cells and tissues, as part of the DNA and RNA and on the membrane of cells. It is available in limited quantities in natural freshwater systems and as such it becomes a pollutant at relatively low concentrations. Resulting algal blooms can suffocate fish by using up all the available oxygen when they decompose. Some blue green algae produce toxins to protect themselves. These toxins can make people and animals sick.
**Where does phosphorus come from:** Australian geology is low in phosphorus. Sewage; domestic run-off containing soaps; animal wastes; decomposing plant material; runoff from fertilizers can be high.

**Nitrate** - All plants and animals need nitrogen to make proteins and DNA. In most water habitats, low nitrogen concentrations limit the growth rate of plants. Too much nitrogen can lead to excessive plant growth and algal blooms.
**What causes high nitrate:** Urban stormwater; sewage; greenwaste; animal wastes; runoff from fertilizers.

**Electrical Conductivity (EC)** - Electrical Conductivity in water depends upon the concentration of dissolved salts (free ions). The higher salt concentration, the more conductive the water. Fish and most aquatic animals have evolved to live in a specific salinity range. Changes in salinity can stress or kill exposed organisms.
**What causes high EC:** Urban pollution; rising groundwater; saline-rich run-off from some farmlands.

**Turbidity** - Turbidity is a measure of water clarity, lower values representing greater clarity. Particles such as clay, silt, sand, algae, plankton, microorganisms, suspended in the water, increase turbidity. Fine particles in the water can clog gills and stress fish and aquatic insects. High turbidity can prevent light penetration into water and reduce the growth of submerged aquatic plants or of algae.
**What causes high turbidity:** Construction and the resultant soil erosion and mobilisation; soil erosion from deforestation; animals stirring up sediments (cows, sheep, pigs wading in water, even duck can cause turbidity problems); Carp searching for food; heavy rainfall.

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