Water Quality

Rating guidelines for tests **(State of the Environment report – Victoria's Inland Rivers)**

Parameter	Excellent	Good	Fair	Poor	Degraded
Salinity (EC)					
mountain	<30	<90	<150	<225	>225
valley	<80	<240	<500	<750	>750
plain	<100	<250	<500	<750	>750
Turbidity (NTU)					
mountain	<5.0	<7.5	<10.0	<12.5	>12.5
valley	<10.0	<12.5	<15.0	<22.5	>22.5
plain	<15.0	<17.5	<20.0	<30.0	>30.0
pH	6.0-7.0	5.5-6 or 7-8.0	8.0-8.5	5.0-5.5 or 8.5-9.0	<5.0 or >9.0
Reactive Phosphorus (mg/L)	<0.008	<0.025	<0.050	<0.10	>0.10
Total Phosphorus (mg/L)	<0.010	<0.025	<0.50	<0.10	>0.10
Nitrates (mg/L)	<0.05	<0.1	<0.2	<0.4	>0.4
E. coli (0/m per 100 mL)	0-50	51-200	201-600	601-2000	>2000

Salinity

The quantity of soluble salts in a water sample measured with a conductivity meter. Salty water conducts more electricity than fresher water. Units of measurement are normally in micro Siemens (uS), this has been abbreviated to EC or electrical conductivity.

- 0-800 EC Good drinking water for people and other animals.
- 800-2500 EC People can drink this water but it would taste salty. Some plants cannot be grown in water > 1500 EC (peas, grapes)
- 2 500 – 10 000 EC Not suitable for people, most crops or irrigation.

10 000 EC Not suitable for poultry, pigs, beef up to 17 000 EC, sheep up to 23 000 EC, sea water is 50 000 EC

Nutrients

Nutrients are chemicals that stimulate plant growth. The two nutrients of greatest environmental concern are phosphorus and nitrogen. These compounds occur naturally. In farm ponds, they are often artificially increased to improve plant growth and fish production. In large lakes and reservoirs, high levels of nutrients can result in too much algal growth, causing nuisance conditions (smelly green water and scum).

a. Phosphorus

Most high school phosphorus tests are for dissolved phosphorus. To get total phosphorus you need to convert any undissolved phosphorus into dissolved form e.g. phosphorus held in algae needs to be released by digesting the algae in acid first. Phosphorus is probably the most critical nutrient affecting lakes and rivers. It is the least available nutrient - the "limiting nutrient" = and often controls the amount of plant growth in lakes and rivers.

When phosphorus enters a lake in polluted runoff from urban or rural areas or from poorly working septic systems, the growth of algae and other aquatic plants in the lake will increase greatly. Treated sewerage is the most significant point source of phosphorus.

Aquatic plants provide a habitat for fish and wildlife and are vital in a biologically well-balanced and productive lake or river. But rapid, excessive growth of algae and aquatic plants can change the character of a lake and impair its recreational uses.

As phosphorus levels increase, aquatic plants and algae become more and more evident and begin to dominate the shoreline. Water clarity may be reduced. The lake can begin to shrink in size as shoreline areas accumulate decaying plant materials. Fish population can become dominated by species tolerant of these conditions.

High concentration of phosphorus in lakes and rivers can cause extensive blue-green algal blooms. This type of algae may produce surface mats that can turn the water green and stain boats, may cause skin rashes in swimmers, may make drinking water taken from the lake taste bad and may be toxic to animals drinking the water and fish swimming in it.

Two additional factors need to be remembered in connection with phosphorus. First, soil erosion contributes to the problem because phosphoric compounds adhere to soil particles. Wind and water erode soil, then deposit it and the attached pollutants some distance from their source. Because phosphorus attaches mainly to the smaller sediments particles, which travel farther in water than heavier particles, the sediments that eventually reach a water body may have higher phosphorus concentrations that the land where it originated. Controlling soil erosion is a way to reduce phosphorus loading to water resources.

The second factor is the misuse of fertilisers containing phosphorous. Many homeowners regularly purchase and apply lawn fertilisers without evaluating their lawn's nutrient needs. Generally, suburban lawns require very little additional phosphorus. The phosphorus in fertilisers that is not taken up by plant growth or attached to soil particles can wash off the lawn into the nearest lake or stream.

b. Nitrogen

Nitrogen is found in the environment in many different forms. Two of these, ammonia and nitrates, account for most of the non point source pollution caused by nitrogen.

Ammonia is a waste product of humans and other animals. Animal feedlots and fertilisers are typical non point sources of ammonia. Ammonia can be toxic to fish, and fish kills have been attributed to ammonia. Treated sewerage contains high concentrations of nitrogen compounds.

Ammonia readily converts to other compounds in a process called nitrification. Under warmer summer conditions, ammonia in water can convert to nitrite and then to nitrate in one or two days. The conversion process consumes great quantities of oxygen. When nitrification in a lake or stream is high, so much oxygen can be consumed that not enough is left to support aquatic life. Under these conditions, fish and other aquatic organisms may die from lack of oxygen.

The nitrification process occurs in lakes and streams. It also takes place in field drains and feedlots. Nitrate, a product of nitrification, is a very serious pollutant in groundwater with harmful effects not related to fish or aquatic life, but to drinking water.

Nitrate concentrations above 10 parts per million in drinking water are a health threat to humans, particularly infants. Drinking water contaminated by nitrates can cause methaemoglobinaemia, or "blue baby syndrome" in infants. This condition can be fatal and is a serious threat during hot weather when water consumption is greatest. It is most serious in rural areas where shallow wells are the primary source of drinking water.

Nitrates are also applied as a fertiliser to fields and pastures. Improper fertiliser storage and handling near wells, and drainage from feedlots and manure piles can allow nitrates to seep into groundwater. High groundwater concentrations of nitrates are most common is areas with frequent connections between surface and groundwater, such as in sandy soils, shallow soils, and fractured bedrock.

Faecal Bacteria

Faecal bacteria are prolific in the intestines of warm-blooded animals - including humans - where faecal wastes originate. In themselves, may are not harmful. However, pathogens (disease-causing organisms) associated with faecal wastes can cause diarrhoeal diseases, infectious hepatitis, parasitic diseases, cholera, dysentery salmonella and typhoid fever in humans and domestic animals. Since testing for the presence of such a wide variety of pathogens if difficult, faecal coliform bacteria are measured as an indicator of faecal waste pollution. During periods of heavy runoff, health officials may close beaches because of high faecal coliform bacteria counts.

Faecal bacteria can enter water in runoff or seepage from urban area, feedlots and grazing paddocks, failing septic systems, and sites with naturally high populations of wild animals. The principal point source of faecal bacteria is poorly disinfected municipal sewerage.

Urban runoff is a source of faecal contaminations often overlooked. Stormwater carries faecal wastes from pests, wild birds, rodents, and faulty sewer connections into storm sewers and then to local lakes and streams. Rain washes this material out of city parks, yards, and streets into area lakes, streams and ponds. Our urban areas are not as clean as we would like to believe. In rural areas, feedlots, dairy farms domestic animal manure and failing septic systems are typical sources of faecal contamination. Runoff from these areas can carry high levels of faecal bacteria to streams and lakes. Rural residents with domestic animals need to be aware when lakes or ponds used as watering sources show high levels of faecal bacteria. Such watering sources may spread disease amongst animals.

In order to be considered safe for drinking water samples should meet the following standards: Coliform organisms should not be detectable in 100 millilitres of any two consecutive samples. No sample should contain any faecal coliform in 100 millilitres.

Faecal wastes are and associated bacteria can seep through the ground and contaminate the groundwater. This can result in high bacterial levels in wells used for drinking water.

Dissolved Oxygen (DO)

The dissolved oxygen (DO) concentration of a waterbody is a very important indicator of the "health" of a lake or stream. For aerobic organisms, such as fish, zooplankton, and invertebrates, the concentration of DO in the water will determine the type of organisms that can live in a lake or stream.

The production of oxygen by green plants (either algae or aquatic macrophytes,) during the day, and respiration by aquatic animals and plants at night greatly affect DO concentrations.

DO is supplied to water body through:
(1) the diffusion of atmospheric oxygen into the water and
(2) the production of oxygen through photosynthesis by algae and aquatic macrophytes.

Naturally the diffusion of oxygen usually occurs from the atmosphere into water. The agitation of water by wind, waves or as occurs in the ripples or falls of a stream quickens the diffusion process. Internal mixing in a lake or stream helps distribute the oxygen throughout the water body.

The solubility of oxygen in water is related to temperature. Oxygen is more soluble in cold water than in warm water. Thus during winter, the surface waters of a lake or river usually will have a higher concentration of DO then they will in the summer.

DO can be depleted by respiration or decomposition. At night, when photosynthesis ceases, the plants take up oxygen. Coupled with bacterial respiration associated with the decomposition of material, and the respiration of fish and invertebrates, this can lead to a serious depletion or even exhaustion of the DO content. This places a great stress on the organisms living in the water and leads to a condition where the water body becomes dominated by highly tolerant organisms.

Low DO can be caused by:
(1) increasing nutrients such as nitrogen and phosphorus that accelerate plant growth,
(2) runoff of manure and other organic wastes directly into water bodies, and

(3) discharge of poorly treated waste waters with high concentrations of organic compounds.

Temperature

The temperature of a water body affects the solubility of oxygen. In addition, nearly all organisms have some temperature range they prefer or even require. For example, some fish live only in cool mountain rivers.

Water temperatures often increase when tree cover is removed - on stream banks or when sediment clouds the water. Sediments absorb heat. Also, some factories and power plants discharge heated water.

pH

By definition, pH is a measure of the concentration of free hydrogen ion (H+) or acidity. In pure water, the pH is 7.0. Salts, acids and bases are normal components of natural waters and will result in some deviation in pH. Those materials which increase the concentration of H+ will decrease the pH (more acidic).

Changes in the pH of a waterbody are influenced by the addition of salts, acids, and bases and by photosynthesis. Changing the pH of a waterbody can influence the numbers and types of aquatic plants and animals which can live there.

The pH of water or any substance is how acid or alkaline it is. Natural waters generally are around 5.5 to 8 and pH levels above and below these would be reason for some concern. Sea water and tap water have a tendency to be slightly alkaline pH>7.

A good way to make up some “polluted” water for comparison with students creek water results is to add a small amount of vinegar (acetic acid) to one sample of water and some cloudy ammonia (alkaline) to another. This is a good way to show students what could happen if the water was polluted and also proves that the indicator can change to the other colours.

Alkalinity

Analyses which measure the alkalinity of a waterbody are, in essence, measuring buffering capacity. Buffering capacity refers to the ability to resist pH change upon addition of an acid or base. In fresh waters, buffering is accomplished through the chemical interrelationship between carbon dioxide, bicarbonate, and carbonate. In essence, the alkalinity helps the waterbody resist changes in pH due to the addition of acids or bases. Alkalinity measures the total amount of carbonate, bicarbonate, and strong bases (like hydroxide) present in the water.

In soft water bodies that drain land overlying igneous rock, the alkalinity (measured as calcium carbonate, $CaCO_3$). For typical temperate lakes and large streams, alkalinity ranges from 30 to 150 mg/L $CaCO_3$. Highly productive lakes will tend to be more alkaline than lakes of low buffering capacity. This is the result of photosynthetic activity that fixes Carbon dioxide (CO_2). As the CO_2 content of the water decreases, the pH of the waterbody will shift towards the basic side of neutral. The buffering capacity of the lake will determine the extent to which the pH will deviate from neutral. Low alkalinity lakes will feel the effects of acid rain, whereas high alkalinity lakes will buffer pH changes due to rain.

Hardness

Hardness is a measure of the amount of calcium and magnesium ions there are in water. Hardness is generally of concern where the water is being used as water supply. Freshwater mussels also require relatively hardwater in order to grow and maintain their shells. It is typically expressed as calcium carbonate ($CaCO_3$). Hardness is a function of the watershed being drained.

Among other observable effects, hard water will:
(1) have a slimy fell to it, prevent soaps from properly lathering, and
(2) may result in the precipitation of "lime" in pipes and water heaters.
Hardness values of approximately 60 to 70 mg/L $CaCO_3$ are considered average for temperate lakes, 10 to 20 mg/L $CaCO_3$ are considered low, and, above 150 mg/L, is considered high.

Oxygen-Demanding Pollutants

While land animals extract oxygen from the air, aquatic life depends on oxygen dissolved in water. The oxygen consumed by aquatic life is naturally replenished through photosynthesis by living aquatic plants, and through re-aeration, which occurs when the layer of oxygen-depleted water contacts surface air. Re-aeration takes place more quickly in fast-moving, shallow streams where the rate of air/water interchange is greater than in quiet lakes.

Pollutants, such as inadequately treated sewerage, manure, crop residues, and natural loadings of leaves and algae require oxygen for decomposition, creating an oxygen demand on a waterbody. A discharge of nitrogen of ammonia can also create an oxygen demand through the process of nitrification.

When oxygen-demanding pollutants enter a waterbody as a result of poor land use practices and waste disposal activities, they upset the delicate balance between oxygen-consuming aquatic life and the oxygen-replenishing process.

The pollutants can increase the rate oxygen consumption to a level higher than the waterbody is adequately replenished. As a result, the oxygen content of the water will fall below what is needed to support aquatic life.

Toxic Chemicals

Modern Society uses a host of chemical compounds in industry, agriculture, and the home. These chemicals provide many benefits and new compounds and uses fare being developed regularly. But problems, as well as benefits, have been generated with these new substances.

Many chemical compounds are considered toxic. Animals or people who ingest, inhale, or come in contact with them may suffer diseases, genetic mutations, or death. Improper disposal of toxic chemicals can cause serious environmental damages and can present human and animals health risks from exposure to the substances.

Because toxic chemicals are in such widespread use, their threat to health and the environment comes from many areas. Toxic chemicals can enter surface waters in urban and rural runoff, industrial discharges, and in long-range atmospheric transport.

Urban areas typically have a large proportion of land covered by hard-surfaced roads and parking lots. Toxic chemicals such as lead (from petrol and car exhaust) and cadmium (from tyres) collect in small cracks and crevices where they can be picked up by rain. These metals are toxic to aquatic organisms and can accumulate to very high levels in stream and lake sediments.

In agricultural areas, toxic compounds are frequently applied to crops and fields as insecticides, herbicides, or other pesticides. The use of these chemicals helps farmers produce high yields. However, improper applications of these substances can provide significant pathways for toxic pollutants to enter out waters. The pesticides can wash off crops and fields into lakes and streams where they may be toxic to fish and other aquatic organisms. There is also a growing concern that pesticides are entering groundwater.

The potential for pesticides to become serious pollutants does not suggest they shouldn't be used. It does indicate that their use should be carefully controlled.

Those who use pesticides need to understand their properties so they can avoid excessive application rates, improper use, and application to sensitive care, such as near surface area and drainage ditches. These actions can minimise the potential for pesticides to affect organisms other than the target pest.

Sediment

Sediment consists of material washed or blown from land into lakes, rivers, or streams. It is considered one of the most damaging non-point-source pollutants for two reasons. First, it affects many kilometres of rivers and streams and hectares of lakes and reservoirs. Second, many other pollutants are transported with sediment.

The impacts of sediment washing into a water body can be profound. Lakes and reservoirs can receive so much sediment that they begin to fill in. Deep lakes and reservoirs can be turned into shallow wetlands in a matter of a few decades.

Finer sediment particles settle in thin layers on the bottoms of streams, lakes and reservoirs after erosive runoff periods. These thin sediment layers create blankets that smother the aquatic habitat, and depending on the time of year, can smother fish eggs or larvae and aquatic insects, - the food source for many kinds of fish.

This smothering effect may be visible. Sediment can creep in a thin layer along a stream or reservoir bottom - slowly moving downstream to engulf less mobile aquatic organisms and destroy additional habitat.

Before sediment settles to the bottom, it makes the water very cloudy or turbid. High turbidity can be unsightly and affect water usage in a variety of ways.

(I) Some species of fish do not thrive in a highly turbid environment

(ii) Excessive turbidity

(a) decreases light penetration needed for aquatic plant growth
(b) increases water temperature by absorbing more solar radiation
© may significantly increase the cost of treating drinking water, and
(d)recent studies indicate that it also decreases fishing success.

Pollutants carried along with sediments create different, but equally serious, problems. The term polluted runoff is used in this context. Rain washes sediment containing nutrients, pesticides, and other harmful chemicals into water bodies. Polluted runoff flows from both urban and rural areas.