C2 Identify processes for measuring the quantity of different substances in the environment and for monitoring air and water quality

C2.1 identify substrates and nutrient sources for living things within a variety of environments

Substrate and Nutrient Sources

A **substrate** is any surface on which a plant or animal lives or moves. It may be abiotic or biotic. In biological terms, nutrient stores contained in the substrate are essential to the survival of organisms.

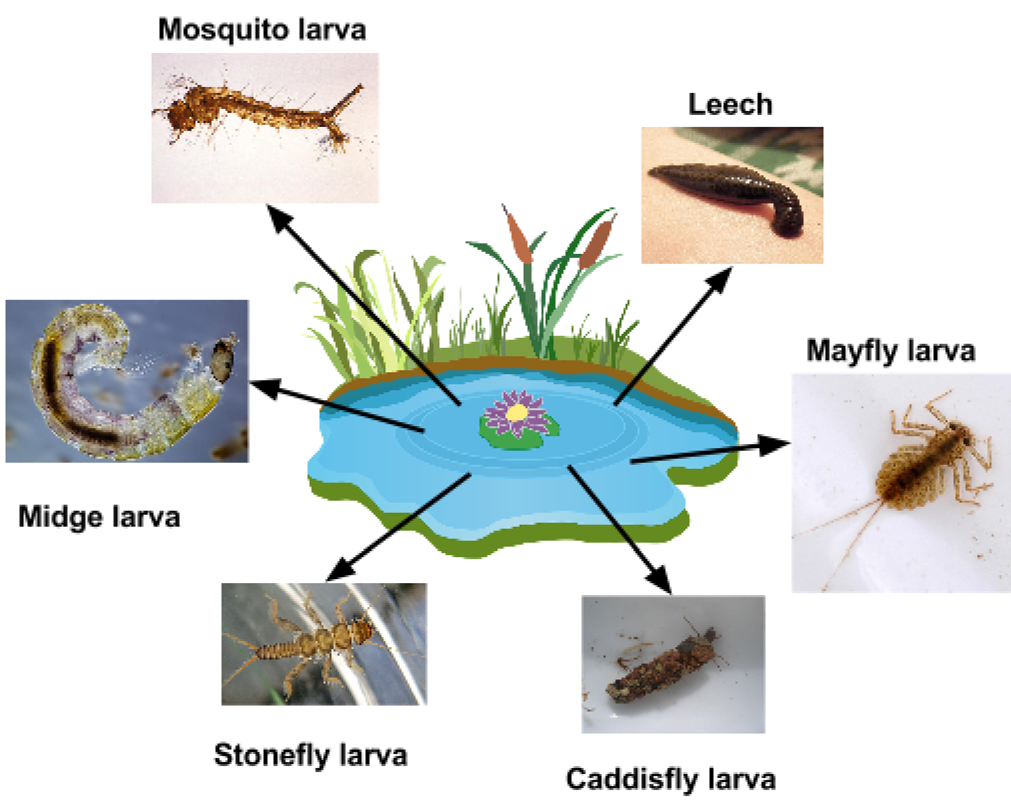
Coral reefs are made up of millions of animals called polyps that secrete calcium carbonate shells. These hard shells are the substrate, or living area, for molluscs, worms, crustaceans, echinoderms (such as sea cucumbers and sea urchins), and sponges. Food particles that settle on the surface of the coral provide nutrients to feed the organisms that are living there. Algae use the reef as a substrate, while organisms such as the sea urchin use the algae as food.

The forest floor is one of the richest sources of nutrients in a forest ecosystem. It is mainly made up of decaying vegetation such as branches and leaves. As the decay, minerals and organic compounds are released and added to the nutrient-rich soil. The soil provides the substrate for a large number of decomposers such as bacteria, fungi, algae, and worms, as well as for the trees and other vegetation.

C2.2 describe and illustrate the use of biological monitoring as one method for determining environmental quality (e.g., assess water quality, by observing the relative abundance of various vertebrate and invertebrate species)

Biological Monitoring

The invertebrate aquatic organisms found in a water habitat are an excellent indicator of water quality.



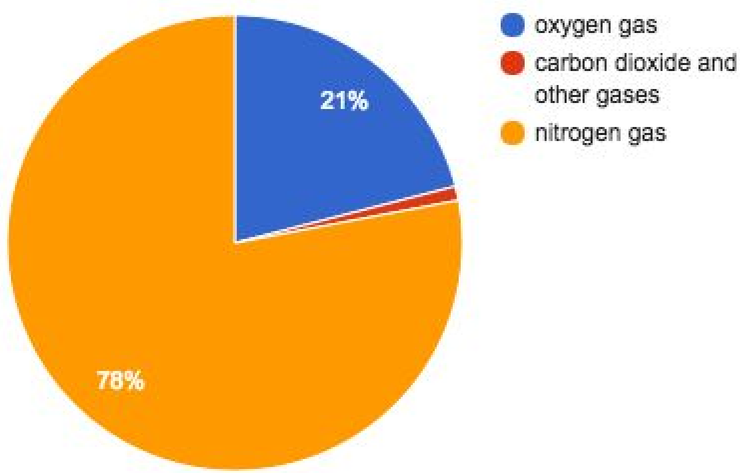
Factors such as temperature, pH, and dissolved oxygen affect the kind of organisms found in water habitats. Organisms living in a stagnant pond are different from the organism living in a stream or large lake.

Biological Indicators of Dissolved Oxygen in Water		
Poor Quality (0 to 4 parts per million of oxygen)	Moderate Quality (5 to 8 parts per million of oxygen)	Good Quality (9 to 10 parts per million of oxygen)
• Midge larvae • Leech • Mosquito • Wriggler	• Freshwater clam • Dragonfly nymph • Fairy shrimp	• Caddisfly larvae • Stonefly larvae • Mayfly larvae

If a water supply has lots of midge larvae, some leeches, and no caddisfly larvae, it has little dissolved oxygen and is poor quality. If the water has caddisfly and mayfly larvae, it is rich in dissolved oxygen and is good quality.

The Importance of Monitoring Air Quality

Air is a blend of several gases. It is just as important as water for sustaining life.



The quality of air should be carefully monitored and good air quality maintained. Collecting data about chemicals in the air provides information about immediate and long-term trends. Presently there is concern about emissions of sulfur dioxide, nitrogen oxide, carbon dioxide, and chlorofluorocarbons in the atmosphere and the effect of these emissions on the environment.

C2.3 identify chemical factors in an environment that might affect the health and distribution of living things in that environment (e.g., available oxygen, pH, dissolved nutrients in soil)

Chemical Factors Affecting the Distribution of Living Things

Chemical concentrations indicate the quality of water and may affect the distribution of living organisms within an ecosystem.

Water has oxygen dissolved within it, which is essential for the survival of aquatic life. The amount of oxygen dissolved in water depends on factors such as the temperature, the rate of photosynthesis, and the number of organisms present in that water. The number and diversity of living things is greater in water that has a good supply of dissolved oxygen.

Phosphates and nitrates enter the water supply through sewage and runoff containing fertilizers. Phosphorus and nitrogen are elements essential for living organisms, but high concentrations of these elements can cause adverse effects in an ecosystem. These chemicals cause an overgrowth of algae in the aquatic system.

Bacteria break down dead plant matter and use oxygen in the process. This depletes the supply of oxygen for plants and animals living in the water.

Natural rainwater has an average pH of 5 and a typical range from pH 4.5 to 5.6. However, any precipitation with a pH lower than 5.6 is called **acid rain**. When acid rain reaches the ground, it mixes with other water sources, increasing the acidity of these water sources. Fewer organisms are able to survive in an acidic environment.

Pesticides are chemicals that farmers use to control unwanted insects and rodents. Pesticides usually have long term effects because they remain in the environment long after their intended use. It is possible that insects can develop a tolerance to a certain pesticide, creating the need for a stronger pesticide. Chemical pesticides can make the water and soil toxic. As well, some pesticides are not broken down within organisms and can bioaccumulate.

Elements such as mercury, copper, lead, zinc, cadmium, and nickel are **heavy metals**. These elements are used in many commercial products such as batteries, thermometers, and electronic equipment. Heavy metals can enter the water system and accumulate in the bodies of animals. This causes illness, deformities, and death.

C2.4 apply and interpret measures of chemical concentration in parts per million, billion or trillion

Measuring in Parts per Million

Concentrations of chemicals in the environment are commonly measured in parts per millions (ppm) or milligrams per litre (mg/L).

$$ppm = \frac{grams\ of\ solute}{grams\ of\ solution} \times 10^6$$

$$\frac{mg}{litre} = \frac{milligram\ of\ solute}{litre\ of\ solution}$$

Example

One part per million means one unit of chemical is found in one million units of solution. If 1 mL of food colouring is dissolved in 999 mL of water, what is the concentration of the food colouring in the water in ppm?

Solution

Let x be ppm.

999 mL water + 1 mL food colouring = 1000 mL

$$\frac{1\ mL}{1000\ mL} = \frac{x}{1\ 000\ 000}$$

$$x = 1000\ ppm$$

The concentration of food colouring is 1000 ppm.

C2.5 identify acids, bases and neutral substances, based on measures of their pH (e.g., use indicator solutions or pH meters to measure the pH of water samples)

Acids, Bases and Neutral Substances

An **acid** is a compound that, when dissolved in water, has a pH less than 7. An acidic solution that has a pH of 1 would be a much stronger acid than a solution with a pH of 4. Stomach acid (pH 1) is more acidic than tomato juice (pH 4). Lemon juice is another example of an acid.

A **base** is a compound that forms a solution with a pH higher than 7. A solution with a pH of 14 is a strong base. Bases taste bitter and feel slippery. Baking soda is an example of a base. **Neutral substances** are neither acidic nor basic and have a pH of 7. Distilled water and blood are neutral substances.

The acidity of a solution is described by **pH**. The pH is a measure of the concentration of the hydrogen ions present in that solution. Substances have pH levels between 0 and 14 on the pH scale.

The difference between one whole number and the next on the pH scale represents a ten-fold difference in the concentration of hydrogen. For example, a substance with a pH of 2 is 10 times more acidic than a substance with a pH 3 and 100 times more acidic than substance with a pH of 4 ($10 \times 10 = 100$).

To identify a substance as an acid, a base, or neutral, use a chemical indicator such as pH paper. For example, red litmus paper turns blue in a base and remains unaffected in an acid. Blue litmus paper turns red in an acid and remains unaffected in a base. Other chemical indicators are phenolphthalein and bromothymol blue.

C2.6 investigate, safely, and describe the effects of acids and bases on each other and on other substances (e.g., investigate and describe the reaction that results when baking powder is dissolved; describe the role of acids and bases in neutralizing each other)

Neutralization

A **neutralization** reaction is a reaction between an acid and a base. When an acid reacts with a base, salt and water are produced.

Example

$HCl_{(aq)}$	+	$NaOH_{(aq)}$	→	$NaCl_{(s)}$	+	$H_2O_{(l)}$
Hydrochloric acid (an acid)		Sodium hydroxide (a base)		Sodium chloride (salt)		Water

C2.7 describe effects of acids and bases on living things (e.g., acid rain in lakes, antacids for upset stomachs, pH in shampoos and conditioners)

Effects of Acids and Bases on Organisms

Most industrial processes emit waste gases such as carbon dioxide, and nitrogen oxide. These gases dissolve in water droplets in the air to form acids. Carbon dioxide forms carbonic acid, sulfur dioxide forms sulfuric acid, and nitrogen oxide forms nitric acid. Acid rain pollution occurs when the water droplets containing these dissolved gases fall to the ground and run into lakes and ponds. Acid rain also causes chemical changes in the soil, reducing its fertility. Acid rain hinders the growth of some plants, corrodes metal surfaces, and deteriorates limestone and marble.

The effects of acid rain can be reduced by treating lakes with lime (calcium oxide). Lime is dissolved into the water and neutralizes the acid present in the lake water.