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WATER QUALITY

Water is a crucial resource for Earth. It is used for drinking, recreation, irrigation and as a habitat for living organisms. The Government of Alberta has set high standards for acceptable levels of chemical pollutants and micro-organisms in our water supplies. It is important that the quality of the water supply be monitored using both biological and chemical indicators.

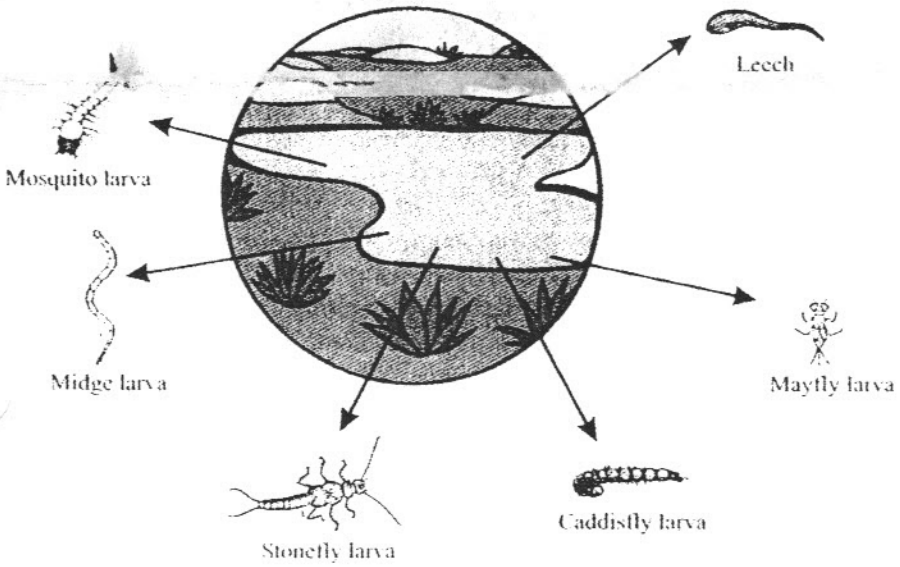
Biological indicator: aquatic invertebrates used to monitor water quality

Invertebrate: animal without a backbone

BIOLOGICAL INDICATORS

Invertebrate aquatic organisms are an excellent indicator of water quality.

Pond Organisms



Dissolved oxygen: oxygen mixed with air

ppm: parts per million

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 ones living in a stream or large lake.

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

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

Chemical indicator: a substance used to determine a specific characteristic of water, such as mercury in a thermometer or phenol phthaline to measure pH.

Concentration of chemicals is measured in:
- ppm (parts per million)
- mg/L (milligrams per litre)

Solute: chemical in a solution

Conversion:
0.2 mL of chemical in 1000 L of H2O

$$\frac{0.2}{1000} = \frac{\times}{1\,000\,000}$$

= 200 ppm

E. coli: a harmful bacteria

Government regulations enforce testing of water for organic and inorganic chemical compounds. Dissolved oxygen, acidity, heavy metals, plant nutrients, and pesticides all affect the quality of water and their concentration is frequently monitored.

The concentration of chemicals is measured in **part per million** (ppm) or **milligrams per litre** (mg/L).

A concentration of 4 ppm of chlorine in water means there is 4 parts chlorine in 1 million parts of chlorine/water solution.

A concentration of 8 mg/L of dissolved oxygen in the water is equal to 8 ppm. This is mathematically determined by using ratios.

8 mg / L = 0.008 g/1 000 g

Set up a ratio:

$$0.008 / 1\,000 = y / 1\,000\,000$$
$$1\,000 \times y = 0.008 \times 1\,000\,000$$
$$1\,000\,y = 8\,000$$
$$y = 8 \quad \text{or 8 ppm}$$

Extremely low concentrations are occasionally encountered and must be measured in part per billion (ppb) or in parts per trillion (ppt).

MICRO-ORGANISMS

E. coli and other disease-producing organisms are found our water supply. Constant monitoring determines what needs to be done to control their numbers. Proper monitoring could have prevented the catastrophe that occurred in Walkerton, Ontario, in May-2000. Eleven people died from *E. coli* bacteria poisoning by drinking contaminated water.

DISSOLVED OXYGEN

An acceptable level of dissolved oxygen for aquatic life is between 5 and 8 ppm. The amount of dissolved oxygen in water is dependent on:

- temperature
- turbulence
- decay

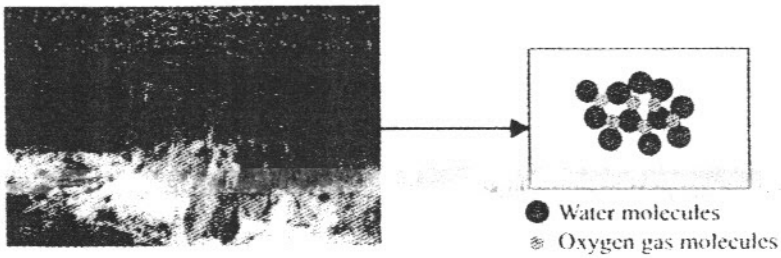
TEMPERATURE

Cold pop contains more carbon dioxide and fizzes more than warm pop. Similarly, cold water contains more dissolved oxygen than does warm water. Because living things depend on the amount of available oxygen, cold water streams have a greater diversity of living species.

TURBULENCE

Oxygen from the air has a better chance to mix and dissolve in turbulent water. Oxygen gas molecules squeeze in between the water molecules more readily in fast-moving streams.

Turbulence: state of being disturbed



DECAY

Fertilizers used by farmers and homeowners are beneficial in one sense but harmful in another. The phosphorous and nitrogen fertilizers often leach into the soil or are carried into nearby lakes. Once dissolved in lake water, the nutrients promote rapid plant growth. Plants grow out of control until the nutrients become depleted. When there is no longer a food supply available, the plants die and start to decay. Aerobic bacteria use oxygen during the decay process, leaving little for the aquatic organisms. This process of decay that causes oxygen depletion is called **eutrophication.**

Eutrophication: process of decay that depletes the oxygen supply

ACIDITY CONTENT

The pH of rain water is slightly acidic, about 5.6. Most organisms can survive at this level. If the pH drops below 4.5, fish and other aquatic organisms soon die. As mentioned previously, the burning of fossil fuels contributes to high sulfur dioxide and nitrogen oxide concentrations in the atmosphere. When sulfur dioxide and nitrogen oxide combine with water vapour, rain containing sulfuric acid and nitrous acid falls. This acidic rain —known as acid rain— enters the soil and water supply. Organisms exposed to acidic water go into **acid shock.** This affects their reproductive ability.

Rain water has a slightly acidic pH (5.6)

Acid shock: conditions that organisms undergo in acidic water

PESTICIDES

Some pesticides have long-term effects and remain in the environment for many years. DDT is a good example of such a pesticide. DDT was used as an insecticide to control mosquitoes and other insects in the mid-1900s. It's use is now banned in Canada. It was found that DDT was cumulative in the food chain. The peregrine falcon and other birds of prey were particularly affected by DDT. The high DDT concentration in the body of these birds affected their reproductive process, causing the female to lay very thin-shelled eggs. The eggs cracked before hatching.

It was also noticed that many insects developed a tolerance to the chemical pesticide and were no longer effectively control by it.

Toxicity: measure of how poisonous a substance is

TOXICITY

The use of pesticides and combinations of pesticides can produce a poisoning effect. This is referred to as the chemical's **toxicity**. Toxicity describes **how poisonous a substance is**.

LD50: measure of toxicity

Toxicity is measured by a scale called the Lethal Dose 50, or LD50. "LD" stands for lethal dose and "50" refers to 50%. LD50 is the amount of chemical that causes 50% of the population to die if given the specified dosage at once.

Example

The LD50 dosage for DDT on rats is 87 mg/kg. Half of the rats in a population would die if given a dosage of 87 mg/kg of DDT.

HEAVY METALS

Heavy metals have a density greater than $5 g/cm^3$.

Many of the fish caught in Alberta lakes are unfit for human consumption because of high mercury content. Mercury, along with copper, lead, zinc, cadmium, and nickel are classified as **heavy metals**. **Their density is greater than 5 g/cm^3**. This means that, for an equal volume, the metal contaminant is more than five times heavier than water. Some of the heavy metals are found naturally in rock formations and are mined for use in the manufacture of batteries, gasoline, paint, and thermometers. Improper disposal of heavy metals can lead to soil and water contamination.

PRACTICE EXERCISES

1. An invertebrate is defined as

a) an animal that lives in a water habitat
b) a plant that survives harsh desert conditions
c) an animal without a backbone
d) a plant that reproduces from runners

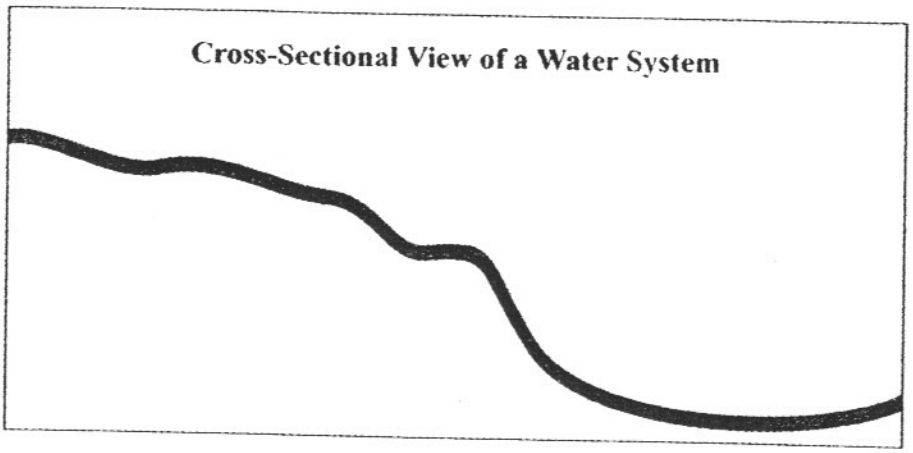
2. A salt solution is made by adding 5 parts salt to 995 parts water. The concentration of this solution is

a) 5 ppm
b) 50 ppm
c) 500 ppm
d) 5 000 ppm

3. *A dos of 0.86 ppm of nicotine, a common chemical in cigarettes, has an LD 50.* What is meant by this statement?

4. A field biologist collected 14 midge larvae, 5 leeches and 8 mosquito larvae from a pond sample. What do these organisms indicate about the water quality of the pond?

5. A streams flows from a small lake through rocky terrain, down a waterfall, and into a large lake, as illustrated below

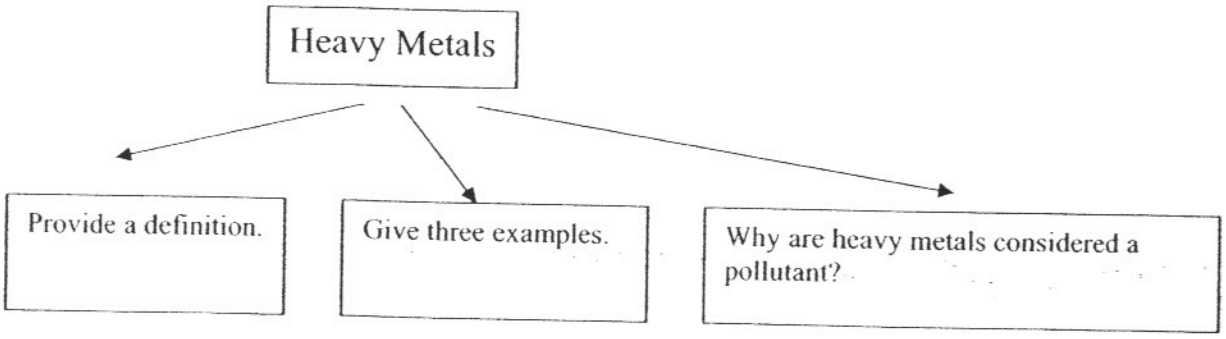


a) Shade in the section of the water system that has the greatest quantity of dissolved oxygen.

b) Explain why you chose this area.

6. What is the long-term effect of phosphorous/nitrogen leachate draining into a lake?

7. Complete the chart below.

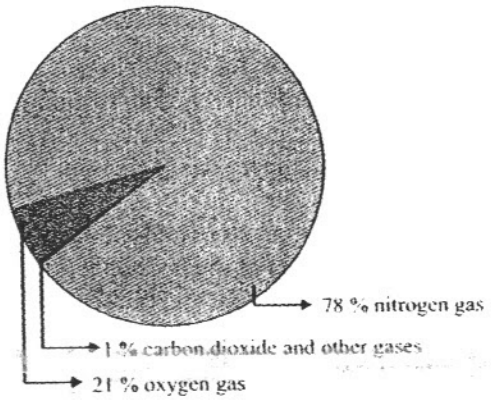


8. Define the term "pesticide" and give three examples of pesticides.

AIR QUALITY

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

Composition of Air



Fossil fuel pollutants:
– carbon dioxide (CO_2)
– sulfur dioxide (SO_2)
– nitrogen dioxide (NO_2)

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. There is presently concern about emissions of sulfur dioxide, nitrogen oxide, carbon dioxide, and chlorofluorocarbons into the atmosphere and the effect of these emissions on the environment.

SO_2, NO_2, CO_2 + rainwater → acid rain

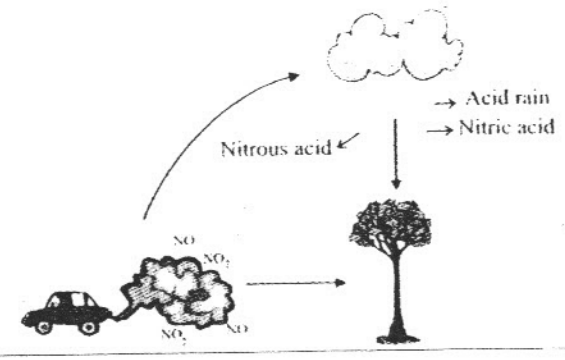
SULFUR DIOXIDE

Industrial burning of fossil fuels has contributed to an increase in sulfur dioxide emissions. The burning of coal in the production of electrical power is one of the leading causes of sulfur dioxide pollution.

Sulfur dioxide combines with moisture in the air to produce acid rain. Sulfur dioxide in precipitation lowers the pH of soil and lakes, making them more acidic in nature. Most living organisms cannot survive in conditions with a pH less than 4.5

NITROGEN OXIDES

Nitrogen and oxygen combine to form compounds of nitrogen oxide (NO) and nitrogen dioxide (NO_2). Both of these are a common byproduct of vehicle exhaust. Nitrogen oxide and nitrogen dioxide combine with the water in the air to produce a nitrous and nitric acid, another form of acid rain.



The Great Lakes of eastern Canada have become acidic in nature. This is mainly a result of the emissions from the vast numbers of industry and vehicles in the area. The changing acidic nature of the soil and water has caused large areas of trees and many aquatic organisms to die. This indirectly affects food chains and the balance within the ecosystem.

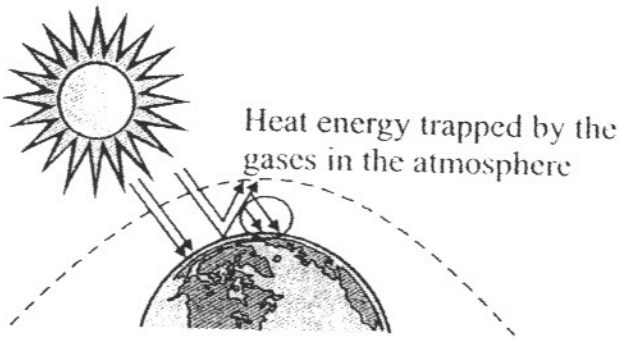
CARBON DIOXIDE

Carbon dioxide gas is part of the natural carbon cycle. It is required for photosynthesis by plants and is produced during respiration by animals. With emissions of carbon dioxide gas by industry and vehicles, the amount of CO_2 accumulating in the atmosphere has increased.

Greenhouse effect: trapped atmospheric gases prevent reflected sunlight from losing heat in space

Carbon dioxide, along with nitrogen oxide and methane gas, contributes to the **greenhouse effect**. These gases in the atmosphere act like glass in a greenhouse. They trap heat from the sun and prevent it from being reflected back into space.

Global Warming



Global warming: increase in average mean global temperature

As a result of trapped gases, the average global mean temperature has gone up by 0.5°C over the past 150 years, producing a phenomenon called **global warming**. Scientists believe that global warming has an affect on climate and may be one of the causes that produce the severe weather patterns we are experiencing throughout the world.

Scientists believe that human activities such as clearing and burning large areas of rainforest are contributing factors in increased atmospheric carbon dioxide levels. Combustion (burning) produces carbon dioxide that accumulates in the atmosphere. Cleared land reduces the number of trees available to use up carbon dioxide during photosynthesis. The result is more CO_2 in the atmosphere. This situation is referred to as **enhanced greenhouse effect**.

THINK ABOUT THIS!

What is going to happen in the future if the rate of global warming continues?
Perhaps:

— ecological boundaries will shift farther northward
— permafrost in Canada's north will continue to melt
— water levels in the lakes will drop
— polar ice caps will continue to melt
— weather patterns will change

CHLOROFLUOROCARBONS (CFCS)

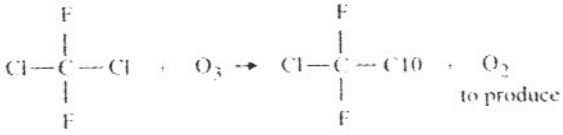
At one time, chlorofluorocarbons (CCl_2F_2) were commonly used in aerosol spray cans, air conditioners, and refrigerators. Then, it was discovered that CFCs released into the atmosphere combine with the ozone molecule (O_3) in the air to produce oxygen gas (O_2) molecules. Each chlorine atom removes up to 100 000 ozone molecules. This reaction reduces the thickness of the ozone layer and the protection it provides from harmful ultraviolet rays.

CFC: chlorofluorocarbon

Ozone: O_3
Oxygen gas: O_2

Structure of the CFC Molecule

Ozone Depletion



CFC formula: Cl_2F_2C
changes ozone to oxygen gas; this depletes Earth's protective ozone layer

By changing the ozone molecule to oxygen, CFCs deplete the ozone supply and cause a thinning of the ozone layer. Satellite images have shown that holes in the ozone layer exists, particularly at the poles.

The sun's ultraviolet light is partially absorbed by the ozone gas. When the layer becomes thin, more UV rays pass through and strike Earth. An increase in skin cancer is directly related to an increase in ultraviolet light.

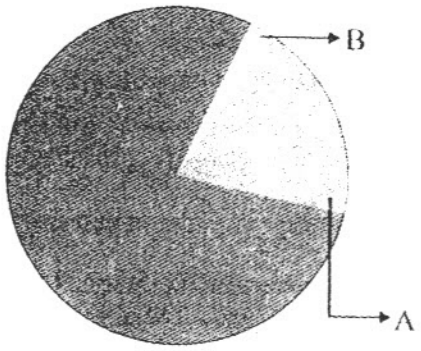
OZONE

Atmospheric ozone is beneficial. It prevents excess ultraviolet rays from reaching Earth. **Ground-level ozone** is harmful. Ground-level ozone forms when oxygen reacts with volatile organic compounds (VOCs) found in gasoline and solvents. Large quantities of ground-level ozone are harmful to people with lung disease and often cause respiratory problems.

VOC: volatile organic compounds
– found in paints, varnishes, and waxes
– react with O_2 to increase ground-level ozone

PRACTICE EXERCISES

1. The circle graph below shows the approximate percentage of different gases in our atmosphere.



Section A of the graph represents the portion of the air made up of

a) nitrogen gas
b) hydrogen gas
c) oxygen gas
d) carbon dioxide gas

2. Fish are sensitive to changes in water pH and can not tolerate a pH lower than

a) 8.2
b) 7.1
c) 5.5
d) 4.5

3. Much of the power generated in Alberta comes from coal-fired plants. The burning of coal is the leading cause of

a) carbon dioxide pollution
b) nitrogen dioxide pollution
c) sulfur dioxide pollution
d) methane pollution

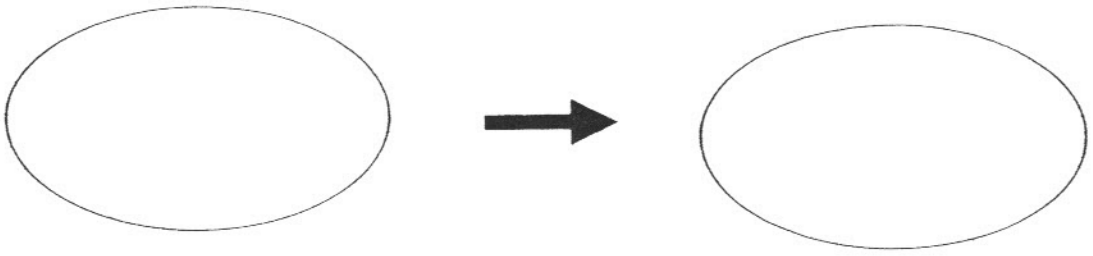
4. On the chart below, indicate the two nitrogen compounds produced when vehicle engines are running. Write the chemical formula for each form.

Nitrogen Compounds Formed	Chemical formula

5. Answer the questions below in the space provided.

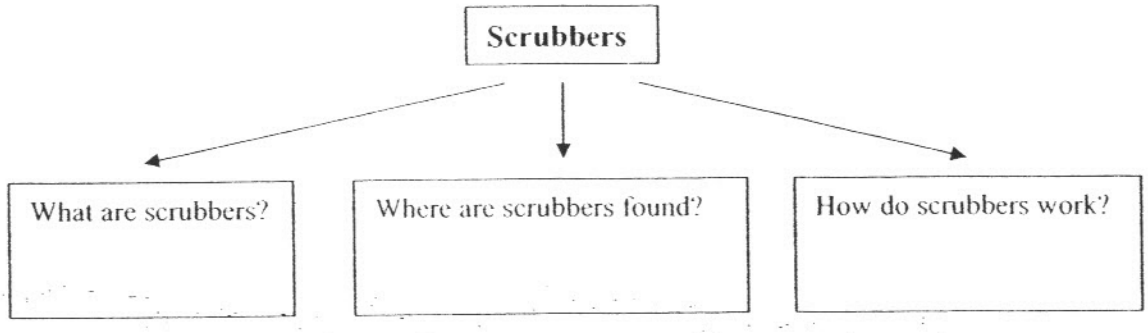
What is the greenhouse effect?

How does the greenhouse effect relate To global warming?



6. List three greenhouse gases.

7. Research the topic of "scrubbers." Indicate what they are, where they are found, and how they work.



8. List four possible long-term effects of continued global warming.

9. Why do CFCs cause ozone depletion?

10. Write the chemical formula for an

— oxygen atom

— oxygen gas molecule

— ozone molecule