1.0 The environment is made up of chemicals that can support or harm living things.

Medicine From The Environment

Willow bark contains ***salicylic acid***. **Hippocrates** - now known as the 'Father of Medicine' - as early as 400B.C. - recommended willow bark be used to treat pain and fever. First Nations people used willow bark tea as a medicinal drink. A synthetic version of salicylic acid - ***acetylsalicylic acid*** - was developed by the Bayer company in 1898 and **Aspirin** was born. Other medicines derived from plants found in the environment include:

- *Echinacea Purposa* - extract from the purple cornflower to help stimulate the immune system.
- Check out other medicines developed from plants in the environment at:

Grade 7 'Science Focus' Notes - (Unit 2 - Topic 1)

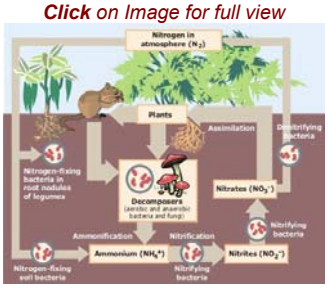
1.1 - Chemicals in The Environment

All living things are made of chemicals and depend on chemicals to survive. Without carbon dioxide and water, green plants could not produce sugar for food. Without oxygen, plants and animals could not carry out cellular respiration. Forest fires and volcanoes release large quantities of carbon dioxide (*volcanoes alone release 130 million tonnes of carbon dioxide each year*), sulfur dioxide and ash, which can be harmful to living things. Many chemicals that we use can cause harm.

The Nitrogen Cycle

Nitrogen occurs naturally in the atmosphere as Nitrogen gas **(N_2).** In order for living organisms to be able to use this nitrogen, the two atoms must be separated (fixed), so they can easily combine with other elements to form usable compounds.

Click *on Image for full view*



Nitrogen Fixation is the process by which atmospheric nitrogen gas is converted, (***fixed*** by *lightning*) so it can combine with other chemicals to form compounds that organisms can use. Certain types of bacteria (*found in root nodules of beans, clover and alfalfa*) can ***fix*** nitrogen in the soil, by separating the two nitrogen atoms, so they can combine with other elements to form compounds that can then be used by other living organisms.

After nitrogen fixation has occurred, plants can use the nitrogen-containing compounds, animals then eat the plants and make larger compounds called proteins, which decomposers can then break down into simpler compounds, to be used over again. Eventually nitrogen is released back into the atmosphere to begin the cycle all over.

The concentration of nitrogen is not the same everywhere, and if nitrogen is needed in the soil, nitrogen-fixing plants (like alfalfa) and fertilizer can help to replenish the supply.

Processes and Activities That Affect Environmental Chemicals

- The chemicals in the air and food, that are used by living organisms, are changed by the processes of **cellular respiration** and **metabolism**
- human activities can cause **pollution** (*any change in the environment that produces a condition that is harmful to living organisms*)

  - too much of a harmless substance
  - toxic materials not occurring naturally

Phosphates: nutrients that enhance growth of plants (excess phosphates stimulate the growth of algae and weeds).
Dioxins: chemicals found in certain pesticides and industrial wastes can cause severe illness and possibly birth defects.
Noise Pollution: can cause hearing loss and other damage to living organisms.
Thermal Pollution: can eliminate species unable to tolerate the increase in temperature

Human Activities

Many chemicals are released into the air, water and soil every day. Activities such as agriculture, sanitation, water and waste treatment, industrial processes, manufacturing, transportation can change the concentration of different chemicals and cause an imbalance. If this becomes a problem, an *issue* is born, which can have various points of view. The issue is stated in a statement that can be supported or opposed and is science-related when science can provide relevant information on the issue.

Ecological - concern for protection of ecosystems
Economic - concerned with money & jobs
Educational - acquiring & sharing knowledge
Egocentric - concern for self
Ethical/Moral - right or wrong
Health-related - physical and mental well-being
Recreational - useable for leisure activities
Political - affects a govt. party or politician
Scientific - knowledge gained by observation & experimentation
Technological - problem solving/application

An **issue** is a matter about which people have different opinions or viewpoints.
-cause of the problem
-seriousness of the problem
-how to solve it

Researching Environmental Issues Activity

(Decision Making - *Viewpoints on Electric Power* - sia p. 189 **)**

Issue Statement **- This statement presents the issue in such a way that people can support the statement or be opposed to it.**

Related Articles - **Present articles related to the Issue being studied.**

Summary of Articles **- Brief summary of each of the articles as they relate to the issue.**

Identify Viewpoints - **Identify the various viewpoints on the Issue. Underline these in each article and color code them for easy reference.**

Scientific and Non-Scientific Information - **Underline this information in each of the articles and make a chart which summarizes this information.**

References - **Identify your sources**

Agricultural Activities

Farmers must have an understanding of chemistry to produce crops that will give a good yield. (*Meeting the Need for Food and Fibre*) - **fertilizers** - **pesticides** - **herbicides**
All of these activities can produce issues, which can have far reaching effects, as outlined in the supplementary notes (*links provided*).

Solid Wastes

Solid waste includes the garbage collected from households, industries, commercial retailers, institutions and construction or demolition sites. Some of this waste can be recycled or reused, but most of it is placed in landfill sites. A small amount is incinerated (burned). Some of the hazards that can occur when solid waste, containing chemicals that are harmful to the environment, are not properly disposed of include:

- air pollution (controlled emissions - scrubbers)
- leaching (prevented by plastic liners and compacted clay foundation at the landfill site)

Wastewater

Sewage includes: dissolved and undissolved materials from your kitchen, bathroom and laundry.

Septic tank (rural areas) -
A septic tank is a large underground container that traps grease and large solids. The remaining liquid waste is distributed through pipes with holes; the pipes lead into a drainage area containing gravel. Bacteria and other micro-organisms in the grave! and soil break down the organic waste and use it as a source of food energy. This system mimics the way in which decomposers normally recycle biodegradable wastes.
(tank is periodically pumped out to prevent overflow)

Sewage Treatment Plant (urban areas) - A facility treating sewage in three levels or steps.
Primary - *physical*
- filtering. sieving and settling
- waste water can be further treated with chlorine and returned to the environment as **effluent**.
Waste material, called **sludge**, can be recycled as fertilizer or landfill.
Secondary - *biological*
- bacteria and micro-organisms decompose most of the remaining biodegradable waste.
Tertiary - *chemical*
- removes dissolved nitrates, phosphates and undissolved solids from the effluent

Fuel Combustion

The burning of **hydrocarbons** (fossil fuels - including coal, oil and natural gas - from dead plants and animals) produces large amounts of carbon dioxide and water vapour. Sulfur dioxides and nitrogen oxides, traces of mercury and lead are also produced.

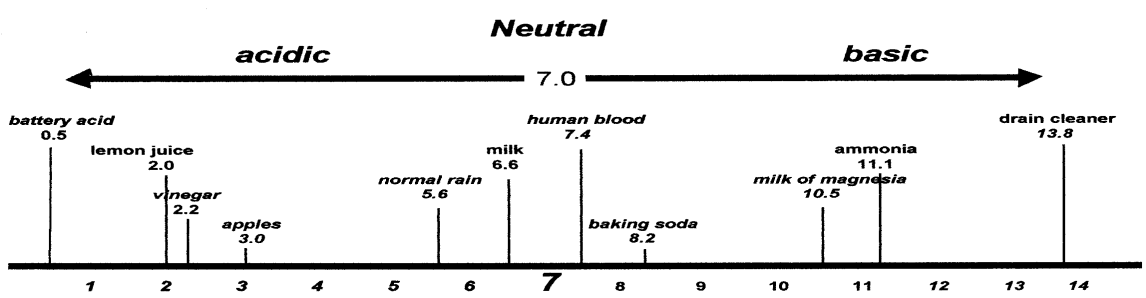
Industrial Processes

The generation of electrical energy , mineral processing and fertilizer production can release harmful chemicals (sulfur dioxides and nitrogen oxides) into the air. Natural gas contains compounds such as methane, ethane, propane, and butane. If natural gas contains hydrogen sulfide it is called '*sour gas*'. If it doesn't it is called '*sweet*'. When hydrogen sulfide is removed, sulfur dioxide is produced. Laws have been made to reduce these emissions, and the recovery of most of the pure sulfur has enabled the natural gas processing plants to manufacture sulfuric acid, which is used in making fertilizers, steel, synthetic fibers and paint.

1.2 Acids and Bases

Acids taste sour, are soluble in water and undergo similar chemical reactions. It has a pH of less than 7
Bases taste bitter, are soluble in water, feel slippery, and react with acids. It has a pH of more than 7
Substances that are neither acidic nor basic, such as water, are said to be **neutral**.

pH is a measure of the **concentration of hydrogen ions** in a solution**.**

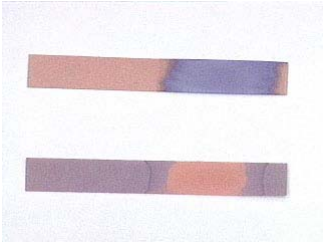


Acidity is measured on the pH scale, which is a scale of numbers from 0 to 14. 7.0 is neutral. All substances below 7.0 are acidic, while all substances above 7.0, are basic

Measuring pH

To identify a substance as an acid, a base, or neutral, an indicator is used. It changes color according to the type of substance it is put into. Indicators can be solids, such as litmus paper, or universal indicator (which change color over a wide pH range can identify many different substances and is more precise), or they can be liquids. such as phenol red. Common indicators include:
litmus paper / universal indicator paper / phenolphthalein / BTB (Bromothymol Blue) grape Juice / red cabbage Juice / tea

A **universal indicator** is used to measure pH.



Red litmus paper will turn **blue** in the presence of a **base**.

Blue litmus paper will **turn red** in the presence of an **acid**,

Neutralization

Acids and bases react together when they are mixed. This type of reaction is called **neutralization**. Both the acid and the base are used up in this type of reaction. A **salt** and **water** are produced.

Acid in your stomach has a normal pH of 2. This acid helps in the digestion of food and kills off bacteria. If you eat too quickly, or are under stress, your stomach produces an excess amount of gastric acid (giving you heartburn). To neutralize the excess acid, an antacid tablet is swallowed. This antacid is a mild base. (eg. Tums, Rolaids, Milk of Magnesia, Pepto Bismal)

Hydrochloric Acid + Sodium Hydroxide ------ » Sodium Chloride + Water
***HCl* + *NaOH* ------ » *NaCl* + H_2O**

Neutralizing The Effects Of Acid Rain

Rainwater is naturally slightly acidic. When this water combines with chemicals in the atmosphere such as sulfur dioxide or nitrogen dioxide, the effect results in **Acid Rain** (with a pH as low as 3 - in some parts of Canada). This can have devastating effects on living organisms. To neutralize this acid rain, lime (calcium hydroxide - which is a base) is added to lakes.

Calcium Hydroxide + Sulfuric Acid ------ » Calcium Sulfate + Water
$Ca(OH)_2$ + H_2SO_4 ------ » $CaSO_4$ + H_2O

This is not necessary in Alberta because the mountains contain rich deposits of limestone, making the water naturally basic.
When the acid rain falls, it is neutralized almost immediately.

1.3 Common Substances Essential to Living Things

Our body needs about 25 different chemicals for normal growth. The complex organization of these chemicals produces **organic compounds** which contain Carbon, as well as mostly Oxygen and Hydrogen. Substances that do not contain Carbon are called **inorganic compounds.**

Macronutrients

Nutrients, which are made up of elements and compounds, help living organisms survive. Plants obtain carbon, oxygen and hydrogen from the air, and nitrogen, phosphorus, potassium, magnesium, calcium and sulfur from the soil. These nine elements are called **macronutrients** (because they are in needed in large quantities) are essential for plants to grow. There are other elements that are also needed, but not in large quantities. These elements are called **micronutrients**.

The most important elements, which are *macronutrients* are:

Nutrient	Importance in Plants	Importance in Humans
Nitrogen (N)	- proteins & chlorophyll - leaf and stem growth	- composition of proteins & nucleic acids - growth and repair of tissue
Phosphorus (P)	- root and flower growth - cellular respiration & photosynthesis	- composition of bones, teeth & DNA - metabolic reactions
Potassium (K)	- stimulates early growth - starch and protein production - disease resistance - chlorophyll production & tuber formation	- muscle contraction & nerve impulses
Magnesium)Mg)	- chlorophyll structure - photosynthesis	- composition of bones & teeth - absorption of calcium & potassium
Calcium (Ca)	- cell wall structure - cell division	- composition of bones & teeth - blood clotting - muscle & nerve function
Sulfur (S)	- production of fruits and grains	- protein synthesis - enzyme activation - detoxification

Maintaining the Right Level of Nutrients

By knowing how plants use each element, agriculturalists can diagnose deficiencies and excesses, and act accordingly, to alleviate the problem.

Problem: yellow striping on lower leaves & soil test indicates high levels of potassium and low levels of magnesium
Analysis: potassium is interferring with the plants ability to absorb the magnesium
Solution: stop applying fertilizer containing potassium and apply more fertilizer with magnesium

Optimum Amounts

A micronutrient may be present in larger amounts than normal. If this occurs it can have harmful effects. Too little can also have harmful effects. The **optimum amount** of a substance, such as the micronutrient - *selenium*, is the amount that provides an organism with the best health.

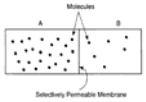
Types of Organic Molecules

Classes of Organic Compounds	Description	Examples
Carbohydrates	- are organic molecules made up of atoms of carbon, hydrogen, and oxygen	sugar, starch, cellulose, glucose
Lipids	- are compounds composed of many carbon, hydrogen, and oxygen atoms	fats, oils and waxes
Proteins and Amino Acids	- protiens are organic compounds made up of amino acids (each protein has its own unique number, combination and arrangement of amino acids) - functions include growth and repair, as well as a source of energy	enzymes
Nucleic Acids	- large complicated molecules that play a major role in heredity and in controlling the cell's activities	DNA (deoxyribonucleic acid) RNA (ribonucleic acid)

1.4 How Organisms Take In Substances

Plants take in **inorganic compounds** to make **organic compounds**. Consumers use the organic compounds made by plants for their energy, growth and repair. When organisms take in these compounds, other substances are also taken. These substances may be harmless or harmful.

Uptake Of Substances By Plants



Click *to see full Image*

Nutrients enter the roots by **diffusion** - the movement of molecules from an area of high concentration to an area of low concentration. This action continues until the areas are equal concentrations. (No energy is required for this to occur).

Osmosis

Click *to see full Image*

Water moves through plants by a special type of diffusion, called **osmosis**. In this process, water moves through the walls of the plant's roots from an area where there are more water molecules to an area where there are fewer water molecules. As the plant uses the water it draws more up from its roots.

Active Transport

Plants need high concentrations of some nutrients in their roots. These nutrients may have higher concentrations in the roots than in the surrounding soil. To maintain these high concentrations, plants move more nutrients into their roots from areas of lower concentration (in the soil) by a process called **active transfer**. This process requires energy.

Ingestion and Absorption of Materials by Animals

25 different elements are used by humans for growth and function. The process of taking in the nutrients (elements and compounds) we need is called ingestion. These compounds are broken down chemically in the digestive system by a process called hydrolysis. A substance that has been broken down by **hydrolysis** has been **hydrolyzed**.

(example) **Maltose + Water ------ » Glucose**

$$C_{12}H_{22}O_{11} + H_2O \text{ ------ » } 2C_6H_{12}O_6$$

Nutrients such as glucose and amino acids are then absorbed through cell membranes and into the bloodstream, which carries them to where they will be used or stored.

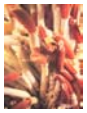
Taking In Nutrients In Different Environments

Where organisms live affects how and when they can obtain the nutrients they need. Some organisms get the nutrients they need often by restricting other organisms from getting the same nutrients (reducing the competition).

Substrates

A **substrate** is a material on which an organism moves or lives. Some organisms attach themselves to the substrate, others obtain their nutrients from their substrate.

Red single-celled algae survive on a substrate that is near freezing, low in nutrients and often acidic.



Tubeworms can survive on the floor of the ocean where lava is rising to the surface - "hot smokers' - and many harmful chemicals (like hydrogen sulfide) are being dissolved in the water nearby.

2.0 The quantity of chemicals in the environment can be monitored.

Monitoring keeps track of something for a specific purpose.

2.1 – Monitoring Water Quality

Clarity may be one indicator, but clear water does not indicate what chemicals are present. **Water Quality** is determined using ***chemical*** and ***biological indicators*** according to what the water is going to be used for.

There are five categories of **water use**:

- human drinking water
- recreation
- livestock drinking water
- irrigation
- protection of aquatic life

Biological Indicators

Microbiological Indicators

Microscopic organisms (bacteria) can cause serious health problems if they are present in sufficient numbers. Samples are taken to identify their presence to avoid contamination of the water supply.

Aquatic Invertebrate Identification: (**sia p.214**)

Click on Image to enlarge

Species of aquatic organisms (invertebrates – animals without a backbone) require certain amounts of oxygen in the water to survive
Identification Practice Test -
http://www.edquest.ca/Tests/invertebrates.htm

Aquatic Environments

The place where aquatic organisms live can vary, depending on the pH level and the amount of dissolved oxygen present.

… there will likely be no fish in water that has a pH below 5.0
... worms and midge larva thrive in polluted water, as they require only small amounts of dissolved oxygen for survival

Chemical Factors That Affect Organisms

Chemical indicators of water quality include: dissolved oxygen, acidity, heavy metals, nitrogen, phosphorus, pesticides, salts – such as sodium chloride and magnesium sulfate.

Measuring Chemicals in the Environment

The concentrations of chemical indicators is usually measured in

parts per million (ppm), $\text{ppm} = \frac{\text{grams of solute}}{\text{grams of solution}} \times 10^6$

or in **milligrams per Litre** (mg/L). $\text{ppm} = \frac{\text{mg of solute}}{\text{L solution}}$

One part per million means that one unit of an element or chemical can be found in one million units of solution. (**SKILL Practice** – Parts per Million – **SIA p. 217**)
Investigating Parts per million – Activity Lab

Dissolved Oxygen

- Abiotic factors - water temperature, rate of flow (turbulence), obstacles in the water, wind, amount of photosynthesis by water plants,

- Biotic factors - number of organisms using oxygen

Most organisms need 5 milligrams per Litre (5 ppm) of dissolved oxygen to survive. The diversity of species often gives us a relative idea of the amount of dissolved oxygen present. A large number of different species means a high level (likely 8 ppm or more) of dissolved oxygen, whereas a few species indicates a low level (below 5 ppm) of dissolved oxygen.

Phosphorus and Nitrogen Content

Phosphates and Nitrates often enter the water supply by sewage and runoff – They increase the growth of algae and weeds in the water. This then increases the food supply for bacteria, which decompose the plants, as they die. The presence of more and more bacteria uses up the available supply of dissolved oxygen and many of the aquatic organisms die as a result.

pH Testing (see notes from Section 1) Acid Rain & Acid Shock

Sulfur and nitrogen oxides emitted from industries (such as smelters) combine with water vapor in the air to produce sulfuric and nitric acid. These pollutants then fall to the ground as **acid rain** (with a pH lower than normal rain - which is about 5.6)

... causes chemical changes in the soil reduces soil fertility
... retards tree growth
... kills organisms in lakes & streams
... corrodes exposed metal surfaces
... breaks down stone and limestone
... leaches toxic chemicals from the soil

Acidity is measured on the pH scale with 7.0 being neutral and anything below 7 is acidic. A decrease of one unit indicates the acidity has been multiplied by a factor of 10. Periods of extreme acidity (like in the spring when the acid snow melts and the acidic water enters the waterways) are called **acid shock**.

Pesticides

Some insects have become pesticide-resistant and so, new pesticides have to be developed. When these chemicals remain in the environment, a toxin is created. Several pesticides mixed together can have a cumulative effect and become very toxic. A toxic substance is poisonous.

Measuring Toxicity

Toxins, or poisons are substances that produce serious health problems, or death when introduced into an organism.

Scientist measure toxins in **LD50** amounts.
Table - http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/L/LD50.html

LD stands for '**Lethal Dose**" and **50** represents **50%** of the the subject group that will die if they are given the specified dose, all at once.

Heavy Metals

Heavy metals have a density of 5g/cm^3 or more. Examples include: mercury, copper, lead, zinc, cadmium and nickel. These metals occur naturally and are also processed into a wide variety of products. Heavy metals can be toxic to a wide range of organisms, so concentrations are constantly monitored. Heavy metals can enter the water supply by the action of acid rain and improper solid waste disposal (which can leach heavy metals into the groundwater). Heavy metals are especially toxic to children cause abnormal development, brain damage or even death.

Suspended Solids

- Turbidity
- unpleasant appearance
- blocks sunlight
- decreases oxygen production

Testing: Use the filtration method to separate the sample into residue and filtrate
Phosphates: nutrients that enhance growth of plants (excess phosphates stimulate the growth of algae and weeds).
Dioxins: chemicals found in certain pesticides and industrial wastes can cause severe illness and possibly birth defects.
Noise Pollution: can cause hearing loss and other damage to living organisms.
Thermal Pollution: can eliminate species unable to tolerate the increase in temperature

2.1 – Monitoring Air Quality

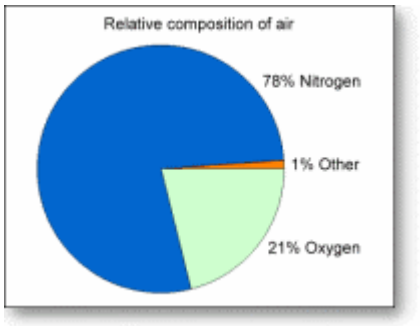
Composition of Air

Nitrogen (78%)

Oxygen (21%)

Carbon Dioxide (0.03%)

Hydrogen & Neon (tiny amounts only)
(Argon (<1%)



Air quality can be measured in two ways: by measuring the levels of pollutants in the air and by estimating the amount of emissions from pollution sources.
Air Monitoring http://www3.gov.ab.ca/env/air/airqual/monitor.html
Mobile Laboratory http://www3.gov.ab.ca/env/air/maml/mamlmap.html

Sulfur Dioxide

Sulfur Dioxide ($\mathbf{SO_{2(g)}}$) is a major air pollutant (forming smog and acid rain). It can affect your respiratory system and irritate your eyes. It is produced through industrial processes. **Scrubbers** are used to reduce sulfur dioxide emissions by up to 99%. They use limestone to convert it to a useful product – **gypsum**.

$$\underset{\text{sulfur dioxide}}{2\,SO_{2(g)}} + \underset{\text{Water}}{4\,H_2O_{(l)}} + \underset{\text{limestone}}{2\,CaCO_{3(g)}} + \underset{\text{oxygen}}{O_{2(g)}} \longrightarrow \underset{\text{gypsum}}{2\,CaSO_4\text{-}2H_2O_{(s)}} + \underset{\text{carbon dioxide}}{2\,CO_{2(g)}}$$

Nitrogen Oxides

Nitrogen Oxides ($\mathbf{NO_{x(g)}}$) are mixtures of **NO** and $\mathbf{NO_2}$ and are major contributors to smog and acid rain as well. Vehicle emissions and the burning of fossil fuels are the main contributors of Nitrogen Oxides. (See chart in SIA textbook p. 226)

Carbon Monoxide

Carbon monoxide is called the **silent killer** because it is a colorless, odorless gas. It is caused by the burning of fossil fuels and not enough oxygen to produce carbon dioxide. Motor vehicles are the main producers of carbon monoxide, but other sources include the burning of wood (forest fires produce large quantities) in fireplaces and stoves, natural gas, industrial processes, airplanes and cigarettes. If inhaled, carbon monoxide reduces the amount of oxygen in the blood and can cause headaches, sleepiness, chest pains, brain damage and death. **Catalytic converters** are used to convert carbon monoxide into carbon dioxide.

Ground-Level Ozone

Ozone ($\mathbf{O_{3(g}}$) is an odorless, colorless gas that has 3 oxygen atoms. It protects us from harmful ultraviolet rays from space, but at ground-level it can be harmful, because it can affect the respiratory system, deteriorate plastics and can have serious effects on crops. Ground-level ozone forms from reactions between oxygen, nitrogen oxides and compounds that are volatile organic compounds (**VOC**'s), in the presence of sunlight and heat. Fuel combustion is the major source.

2.3 Monitoring The Atmosphere

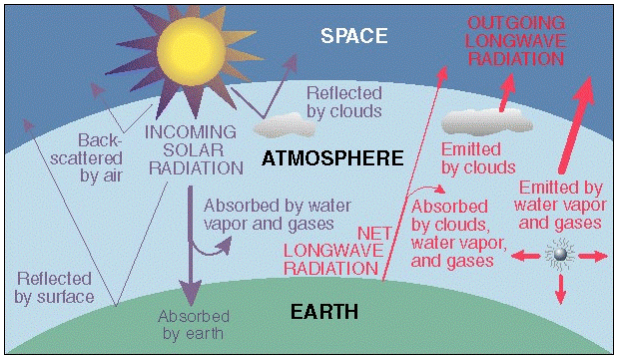
Chemicals in the air can cause mild to serious effects in local areas, but chemicals in the atmosphere can have serious global effects. Ozone depletion and climate change are the primary concerns internationally.

Carbon Dioxide As A Greenhouse Gas

Carbon dioxide occurs naturally in the environment, but increasing amounts that are being produced by various human activities is creating a concern globally. The increasing population and increasing use of fossil fuels is creating some issues.

The Greenhouse Effect

The **Greenhouse Effect** is a naturally occurring event, the result of **greenhouse gases** (water vapor, carbon dioxide, and other gases) trapping some of the outgoing energy - retaining heat in a way somewhat similar to the glass panels of a greenhouse – helping to maintain the Earth's average surface temperature of 15°C.

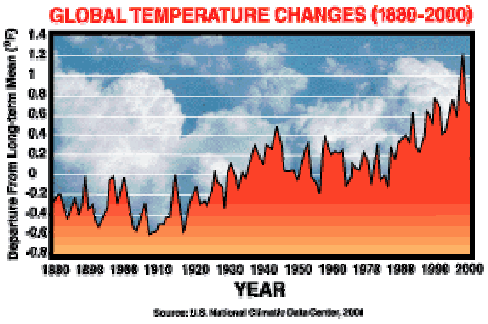


The Enhanced Greenhouse Effect

Many scientists support the theory that the enhanced greenhouse effect is causing temperatures to increase around the world. Human activities – essentially, the burning of fossils fuels is the primary reason. Monitoring stations are set up to record the higher levels and governments are trying to find ways to reduce the emissions of carbon dioxide which is fueling this enhanced greenhouse effect and depleting the ozone layer.

Global Warming

It is not just human activities that are contributing to global warming, but volcanoes and forest fires are also part of the cause. The questions remain – What should be done? – or, Can we do anything about it at all?



The Ozone Layer

Ground-level ozone can have dangerous effects. Atmospheric ozone is the chemical that occurs high in the atmosphere where it maintains a shield around the Earth protecting everyone from harmful **UV radiation** from the Sun. The ozone layer is a natural formation 15 to 50 kilometers above us. Since the late 1970's Scientists who have been monitoring this protective layer, have noticed that it is becoming thinner. They have also discovered 'holes' in the layer. This results in more UV radiation getting through to the surface of the Earth and increasing the likelihood of more organisms getting skin cancer and cataracts. It is also affecting the plankton population – which is an important food supply for many animals.

The Role of Chlorofluorocarbons

The thinning of the atmosphere is caused by our use of **chlorofluorocarbons** (**CFC**'s). These chemicals eventually get into the upper atmosphere where they are broken down into elements like chlorine – which destroys ozone. (1 chlorine atom can destroy 100, 000 ozone molecules. Many countries have signed agreements to reduce their use of these chemicals.

3.0 Potentially harmful substances are spread and concentrated in the environment in various ways.

The source of a pollutant may be in one place, but it can show up in many other places around the world.

3.1 – Transport of Materials Through Air, Soil and Water

There are three stages of transport of substances in the environment:.

- **Release** of chemicals at the source
- **Dispersion** of the chemical into the atmosphere
- **Deposition** of the chemical in soil or water

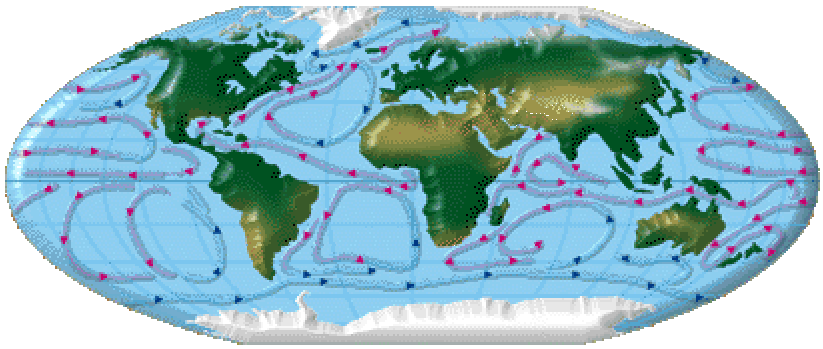
Transport In Air

The direction and distance that airborne chemicals travel are determined by various factors, including:

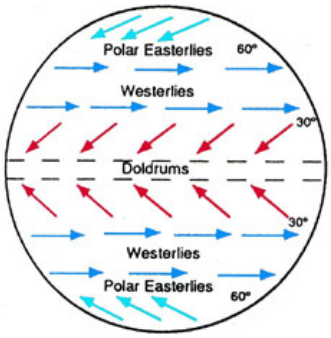
- The properties of the chemical pollutant
- The wind speed
- The direction of the prevailing winds

The distribution of particles may also be limited by lack of wind or precipitation.

Ocean Currents



Surface Winds



Transport In Groundwater http://www.groundwater.org/kc/kc.html

Water in Alberta - http://www3.gov.ab.ca/env/water/index.cfm

Water that soaks into the soil is collected in a zone called the groundwater zone. The top of the **groundwater** zone in the soil is called the **water table**. Groundwater moves sideways, up or down and can move very slowly (1 meter per year) or very quickly (1 meter per day).

Certain contaminants (http://www.cee.vt.edu/program_areas/environmental/teach/gwprimer/gw-types.html) can remain collected in the groundwater for long periods of time (because they are heavy metals), posing problems if the groundwater is used for drinking, agricultural purposes or industrial use.

Factors that affect the movement of contaminants in groundwater include the number and connection of **pores** (tiny spaces between soil grains) in the soil. When the pores are packed together very tightly and are not connected, the soil is considered **impermeable**. If the pores are connected the soil is **permeable** and water can move through easily.

Pollutants, which occur naturally or through human activities, can move more quickly through permeable soil.

Some Substances That Contaminate Groundwater

Substance	Source	Examples	Occurrence
Minerals	Rocks and Soil	Iron, Calcium, Selenium	Natural
Organic Substances	Soil	Pesticides, solvents	Natural & Human Activities
Leached Substances	Landfill sites, mines	Heavy metals, organics	Human Activities
Leaked substances	Underground storage tanks, pipelines	Gasoline, Natural gas, oil	Human Activities
Inorganic substances	Run-off	De-icing roadways, sewage, industrial processes	Human Activities
Micro-organisms	Septic tanks, sewage treatment ponds, runoff	Bacteria, viruses, Protozoans	Human Activities
Chemicals	Household	Nitrates, phosphates, detergents, cleaners	Human Activities

Transport In Surface Water

http://www3.gov.ab.ca/env/water/SWQ/index.cfm

Hazardous chemicals can enter surface water from the air, the groundwater, runoff from agricultural fields and industrial sites and outflow from storm sewers and sewage treatment plants. A substance that dissolves in water easily may be carried by water a fair distance and dispersed over a wide area. Substances that do not dissolve easily may sink to the bottom and be concentrated close to the source, affecting organisms in the immediate area. Because humans use water for drinking and agricultural use, it's quality is monitored regularly.

Transport In Soil

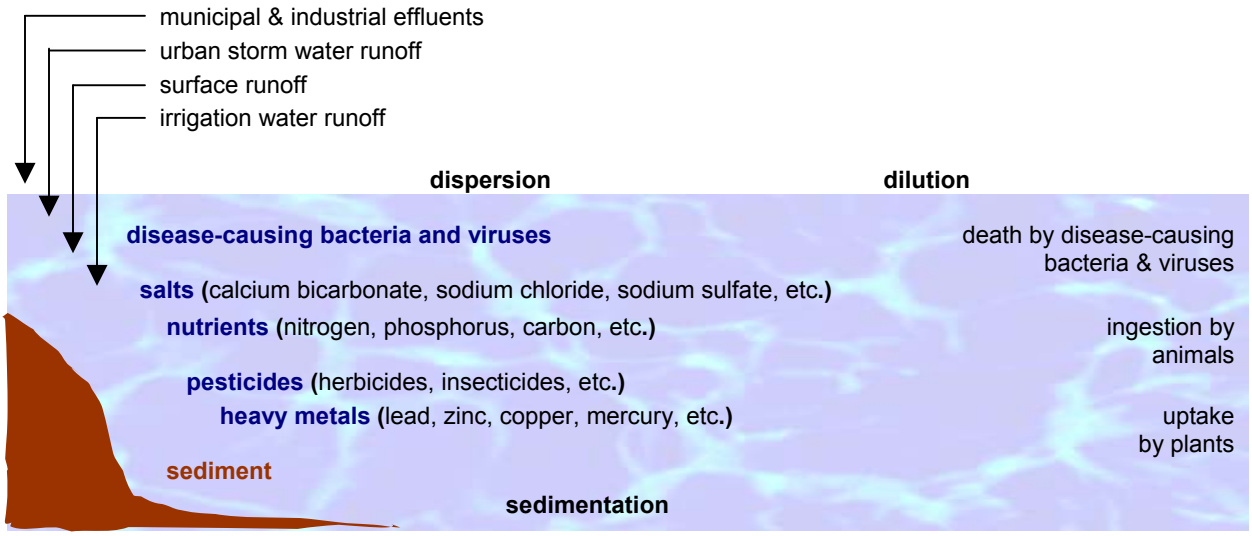
Water is moved in one of four ways: evaporation, absorption by plants, runoff (into surface water) and soaking into soil dissolving substances (**leachate**). The type of soil plays an important role in how quickly water passes through it. Packed clay is impermeable (so fluids won't pass through it). That is why sanitary landfill sites use a layer of packed clay to prevent leaching. Organic material can absorb fluids and slow their movement through the soil. Hazardous chemicals can be changed by what other chemicals are present in the soil. (acids can be neutralized by naturally occurring bases – like limestone)

Transport of Hydrocarbons In Soil

The daily use of hydrocarbons in vehicles and industry contaminates the soil. Some of these hydrocarbon emissions are carried by the air into the soil, or are carried by water where they can clog up soil pores – usually close to the source of the contamination. Hydrocarbons are toxic to plants and animals.

3.2 – Changing the Concentration of Harmful Chemicals In the Environment

The concentration of chemicals in the environment can be changed using different techniques. **Dispersion** is the scattering of a substance away from its source. **Dilution** reduces the concentration of a pollutant by mixing it with large quantities of air or water. A fast flowing river or air mass can disperse and dilute a chemical very quickly. Regulations set by governments require that acceptable levels of pollutants be achieved. To do this **biodegradation** may be an effective alternative.



Biodegradation

Biodegradation occurs in the environment because living things (earthworms, bacteria and fungi) are actively breaking down organic substances, including many pollutants. Micro-organisms are especially important in the biodegradation of pollutants. The existing organic molecules provide carbon atoms, which are used to build biological compounds, such as carbohydrates and proteins. This is a multi-step process in which the large organic molecules are broken down (hydrolyzed) either inside or outside bacteria.

Bacteria

Some bacteria grow and reproduce only when oxygen is present. They use the oxygen for the process of **aerobic biodegradation**. When oxygen is not present – in an **anaerobic** environment (like deep in landfill sites) - some bacteria remove chlorine from harmful chlorine-containing compounds, such as **PCB's** (polychlorinated biphenyls - human made oils used in electrical equipment), by replacing them with hydrogen atoms – which can then be used as food for the bacteria.

Factors Affecting Biodegradation

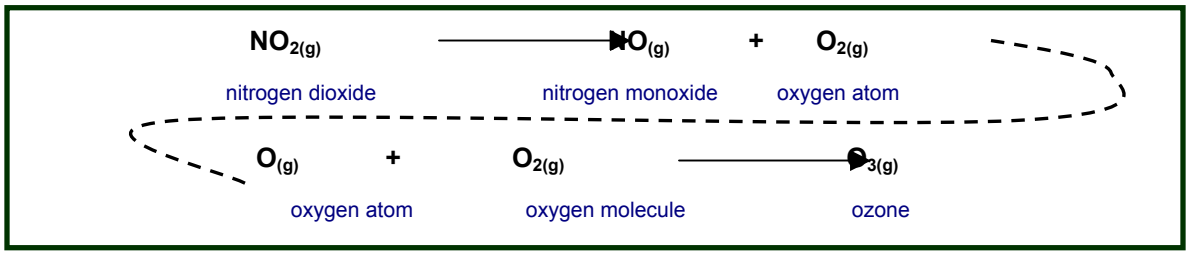
During the winter, biodegradation is slow, because *temperature* is one factor that affects the rate of biodegradation. Other factors include *soil moisture, pH, oxygen supply and nutrient availability*. Bioreactors are a new technology that speeds up the rate of biodegradation by adding water to organic waste in a sanitary landfill site. *Planting vegetation* also encourages faster biodegradation because the populations of bacteria and fungi are larger around plant roots and this higher level means more microbial activity.

Phytoremediation

Phytoremediation is a technique that can be used to reduce the concentration of harmful chemicals in the soil or groundwater. Plants have been used to clean up metals, hydrocarbons, solvents, pesticides, radioactive materials, explosives, and landfill leachates. The plants are able to absorb and accumulate large amounts of these chemicals. When the plants have matured, they are harvested, burned or composted. In some cases, the metal can be recycled. When most of the harmful chemicals are removed by phytoremediation from the soil, then other plants can be planted there.

Photolysis

Photolysis is the breakdown of compounds by sunlight. The formation of ozone is an example of this process (outlined below)



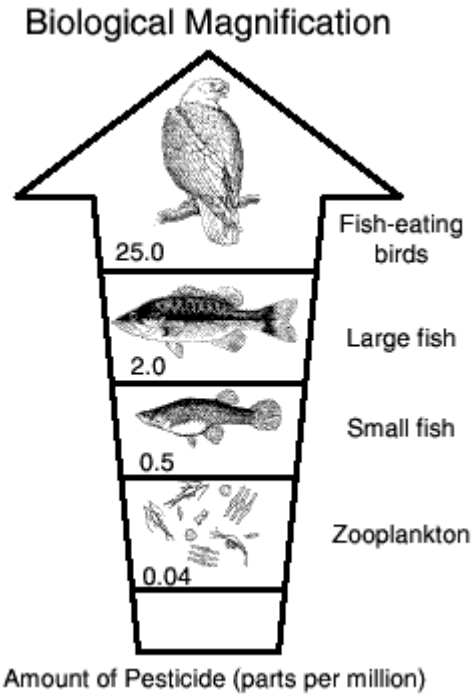
Another example of photolysis is photodegradable plastic. Photodegradable plastic is made of chemicals that react when exposed to sunlight. In three months, the plastic becomes a fine powder that is easier to dispose of. (This type of plastic will only degrade if it is exposed to sunlight – if it is buried, it will last in its original shape for hundreds of years.)

3.3 Hazardous Chemicals Affect Living Things

Chemicals can accumulate in living organisms. The increased concentrations mean that chemicals can remain in the environment for long periods of time.

Biomagnification

Biomagnification (or bioaccumulation) is the increase in the concentration of a chemical or element as it moves up the food chain.



A Case Study: Lynnview Ridge (Calgary) Lead Contamination

Environmental Report on Lynnview Ridge
http://www.calgary.ca/DocGallery/BU/environmental_management/land.pdf

Environmental Bureau of Investigation
http://www.e-b-i.net/ebi/index.cfm?DSP=content&ContentID=5605

Environmental Protection Orders
http://www.gov.ab.ca/acn/200106/10894.html & http://www.gov.ab.ca/acn/200308/15045.html

Land Center Library – CBC News
http://www.landcentre.ca/lcframedoc.cfm?ID=5190

A Case Study: The Exxon Valdez Oil Spill

Exxon Valdez

•1989 the Exxon Valdez tanker ran aground on Bligh Reef in Prince William Sound Alaska

•Spilled 11 million gallons of crude oil – largest spill in U.S. history and caused more environmental damage then any other spill in history

Aerial view of Exxon Valdez with containment boom

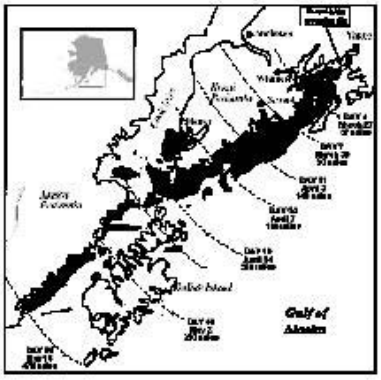
•Spill plume traveled

•450 miles –

•contaminating

•1,100 miles of

•shoreline



Oil spill plume

Crude Oil - A mineral oil consisting of a mixture of hydrocarbons of natural origin, yellow to black in color, of variable specific gravity and viscosity; often referred to simply as crude. Crude oil needs to be processed at an oil refinery, before the products it is made of, can be separated and used.

Besides the reading the information in the **Science In Action 9 Textbook** (pgs. 250-252) the following **Internet Links** will also help you understand how chemical spills in the environment can be extremely long lasting and harmful.

Exxon Valdez Oil Spill Facts (This is an especially comprehensive facts site)
http://www.oilspill.state.ak.us/facts/
Prince William Sound
http://library.thinkquest.org/10867/home.shtml
Environmental Update
http://www.valdezscience.com/
Explore North
http://www.explorenorth.com/library/weekly/aa032499.htm
How do they clean up an oil spill?
http://www.epa.gov/oilspill/oiltech.htm#Chemical

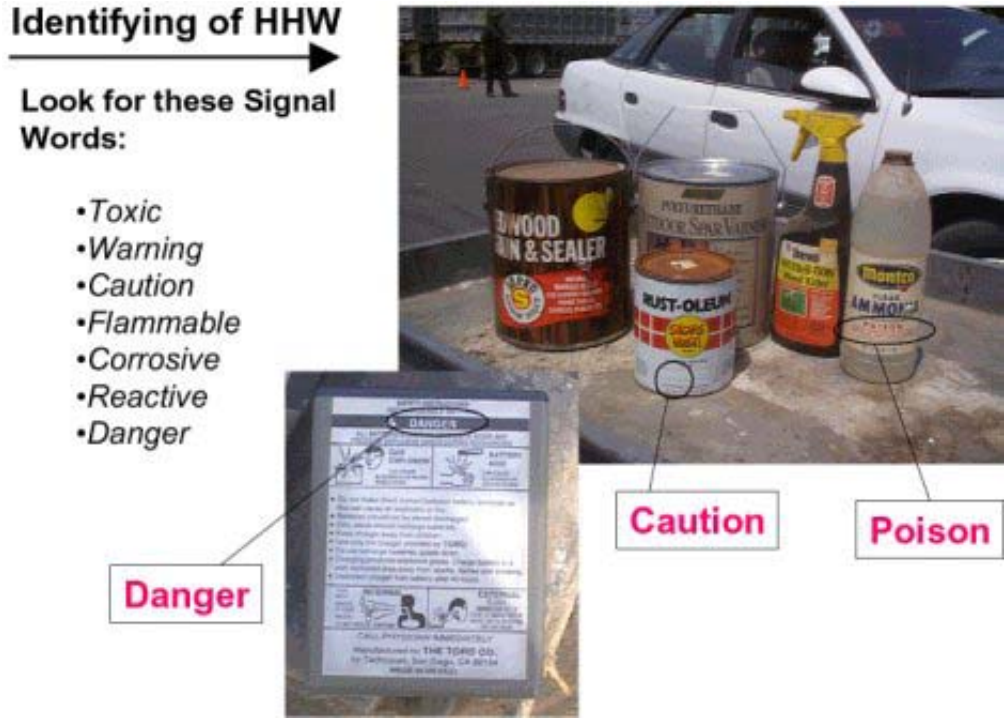
3.4 Hazardous Household Chemicals

Chemicals used in the home and garden can be hazardous to your health.
Some of these include:

Household cleaners	Personal hygiene products	Pet-care products	Paint and paint products	Pesticides and fertilizers	Automotive fluids

HOUSEHOLD PRODUCTS DATABASE - http://householdproducts.nlm.nih.gov/products.htm

A Sample List of Products Used in the Home
http://www.checnet.org/healthehouse/education/articles-detail.asp?Main_ID=650
Common Household Hazardous Waste
http://www3.gov.ab.ca/env/waste/aow/hhw/common.html



Improper storage, transport and disposal of these products can contribute to burns, heart problems, kidney failure, lung (respiratory) ailments, cancer and even death.

Government Regulations

Regulations are designed to protect consumers and reduce the risk of hazardous chemicals. The regulations reflect current scientific research done on the products and how they might interact with other products.

Labels (see **Toolbox 1** – Science In Action p. 477

Learn about Chemicals in your home
http://www.epa.gov/kidshometour/index.htm

Workplace **H**azardous **M**aterials **I**nformation **S**ystem

MSDS

Material **S**afety **D**ata **S**heets

An MSDS information sheet for the product gives a detailed description of the product – its composition, physical appearance, and chemical characteristics. It also describes the precautions that should be taken when handling, transporting and disposing of the product, as well as health effects, first aid treatment and what to do in case of a spill.

Different labels are used for different purposes:

Transporting	Supplying	Used in the Workplace	Disposal
 Figure 2 POISON Placard Transporting Hazardous Materials Test	**Toilet Bowl Cleaner** DANGER: Corrosive – produces chemical burns. Contains Hydrochloric Acid. Do not get in eyes, or on skin or clothing. May be harmful or fatal if swallowed. Do not breathe vapor or fumes. Keep out of reach of children. Fumes are corrosive to metal. STORAGE AND DISPOSAL: Store in original container out of reach of small children. Keep securely closed in a cool, well-ventilated area. Do not reuse empty container. When empty, discard in trash or recycle.	If a controlled product is transferred at the workplace to other containers, the employer may need to apply a **workplace label** to the new container. Workplace labels provide the following information: product identification; information for safe handling and a statement indicating that the MSDS is available.	

Eco-Label - Established in 1988, Canada's "Environmental Choice" Eco-Logo program helps consumers identify products and services that are less harmful to the environment.

http://www.environmentalchoice.com/index_main.cfm

New Product Regulations

When new products are produced, the supplier must apply for approval to make it available to the consumer. The information about the product must include:

- Intended use, physical and chemical properties, active ingredient(s)
- Instructions for use, safety precautions
- Health effects, environmental effects, toxicity to humans, and first aid instructions in case of poisoning

Storage of Hazardous Chemicals in the Home

- Leave original label on the product
- Keep out of reach of children (locked up)
- Containers should be in good condition and secure
- Store in a cool, dry, well-ventilated place
- Never store flammables or gas in glass containers
- Store different classifications of chemicals on separate shelves in separate locations
- Keep oxidizers away from flammables
- Keep upright
- Store chemical in proper place when not in use
- Discard old products
- Place rusted or leaking containers inside a second container – dispose of both

Transportation Of Consumer Goods

When it is purchased and when it is disposed of present transportation issues for consumers. Care should be taken to ensure that passengers are not at risk – from spills, leaks, fumes or accidental handling (by children or pets). Place the product upright and secure in the trunk (car) or box (truck). When disposing of many products, never mix them into one container – try to keep them in their original containers with their original labels.

Disposal Of Hazardous Chemicals

Never pour hazardous chemicals down the drain, or into the soil. Don't throw them into the garbage. The hazardous products may not be treated by the sewage treatment system or septic system and as a result could be released into the soil or enter the surface water system and harm living organisms downstream.

Hazardous Waste Collection Sites

http://www.landcentre.ca/foundation/hazardous/legab.cfm
Materials that cannot be recycled are packaged into larger containers and are then transported to **incinerators** like the one in Swan Hills.
Swan Hills Special Hazardous Waste Treatment Facility
http://www.townofswanhills.com/aswt.html

Solid Waste Garbage

Follow the GARBAGE guidelines that have been created to avoid toxic or hazardous products being placed in a sanitary landfill, where they might burn, explode or escape as a leachate into the groundwater and eventually come back to haunt us.

Summarize the ***Solid Waste Garbage Guidelines*** on p. 258 in your Science In Action 9 Textbook.