SCIENCE

Unit 6

Natural Resources

Acknowledgements:

Editors: Marissa Rolnick, Tony Lelliott
Writers: Allistair Clacherty
Erna McCarthy
Helen de Wet
Jenny Woolway
Sharika Banwa
Artwork: Nelrie Pieterse
Layout: Lidia Kruger

Contents

Specific aims	Lesson 3 Agroforestry	
Knowing science: Content	Looking at the role of agroforestry; the use of forests and the social and environmental effects of using forests	Planting water-hungry exotic tree species.
Investigating science		
Science in society		
Science process skills		Looking at a case study (Activity 3)
Language skills	Interpreting information (Activities 1, 2)	

Specific aims	Lesson 4 Mining							
Knowing science: Content	Learning about the location of SA minerals; the extraction of minerals, ores, iron, copper, gold and aluminium; the effect of mining on the economy							
Investigating science		Learning about modelling (Activity 2)	Separating mixtures (Activity 4)					
Science in society			Extracting ores (Activity 3)					Debating information in a case study (Activities 9, 11)
Science process skills	Considering data response (Activity 1)				Using a flow chart and solving chemical equations (Activity 6)		Solving chemical equations (Activity 8)	
Language skills				Interpreting information (Activity 5)		Following explanations (Activity 7)		Interpreting information (Activity 10)

Specific aims	**Lesson 5 Processing natural resources**						
Knowing science: Content	Learning about the chemical industry; the principles in deciding on a process; the production of liquid from solid fuel; the production of acid, ammonia, soaps and detergents, plastics and polymers.						
Investigating science						Following instructions, and observing what happens (Activity 7)	
Science in society							
Science process skills	Classifying information (Activity 1)	Observing a chemical process (Activity 2)	Solving chemical equations (Activities 3, 4, 6)				
Language skills				Following and explanation (Activities 5, 8)			Comparing and com-prehending information (Activity 9)

Specific aims	**Lesson 6 Pollution and hazards associated with natural resource use**						
Knowing science: Content	Learning about the pollution of air and water; deforestation; soil depletion; chemical fertilizers; food as a commodity; alternative fuel sources and diseases associated with the workplace.						
Investigating science	Classifying & interpreting information; drawing conclusions (Activity 2)						
Science in society	Interpreting diagrams (Activity 2)				Following an argument (Activity 8)		
Science process skills	Translating information (Activities 1, 3, 7)			Following a diagram and explanation (Activity 6)			
Language skills		Interpreting information and giving reasons (Activity 3)	Explaining and listing information (Activity 4)	Giving and explanation (Activity 5)		Giving an opinion (Activity 8)	Translating information and following a case study (Activity 9)

Specific aims	Lesson 7 Sustainability of natural resource use					
Knowing science: Content	Learning about reforestation; crop rotation and companion planting; the removal of alien vegetation; reducing erosion; reusing water; recycling water; making biodiesel from algae					
Investigating science						
Science in society	Engaging in a discussion (Activity 1)			Tabulating and classifying information (Activity 5)	Translating and classifying information (Activity 6)	
Science process skills						
Language skills		Providing definitions, lists and advantages (Activity 2)	Giving an explanation (Activity 3); Following a case study (Activity 4)			Looking at definitions, lists and explanations (Activity 7)

Specific aims	Lesson 8 Land use			
Knowing science: Content	Learning about debates around land use	Using arable and marginal land	Paving urban areas and the consequences thereof	Looking at alternative designs for communal living
Investigating science				
Science in society			Providing an explanation (Activity 3)	Responding to data and following and argument (Activity 4)
Science process skills	Translating a case study (Activity 1)			Interpreting a diagram (Activity 5)
Language skills		Providing an explanation (Activity 2)		

LESSON 1

Natural resources and their uses

About this lesson

Resources are features which are needed and used by people. Natural resources include coal, oil, water, plants and animals. Some of the natural resources we use, such as coal and oil, have taken millions of years to form. These natural resources are referred to as fossil fuels. Much of our modern technology – for example, cars – uses these fossil fuels to work.
Unfortunately people are using fossil fuels faster than the Earth can replace them which means that eventually the Earth is going to run out of fossil fuels. Resources that are being used up and not replaced are called non-renewable resources. Resources that can be replaced are called renewable, for example plants.

The burning of fossil fuels has caused problems such as pollution. As we do not have an endless supply of fossil fuels, scientists are looking at using renewable energy to run our modern technology and allow for a cleaner environment.

In this lesson you will:

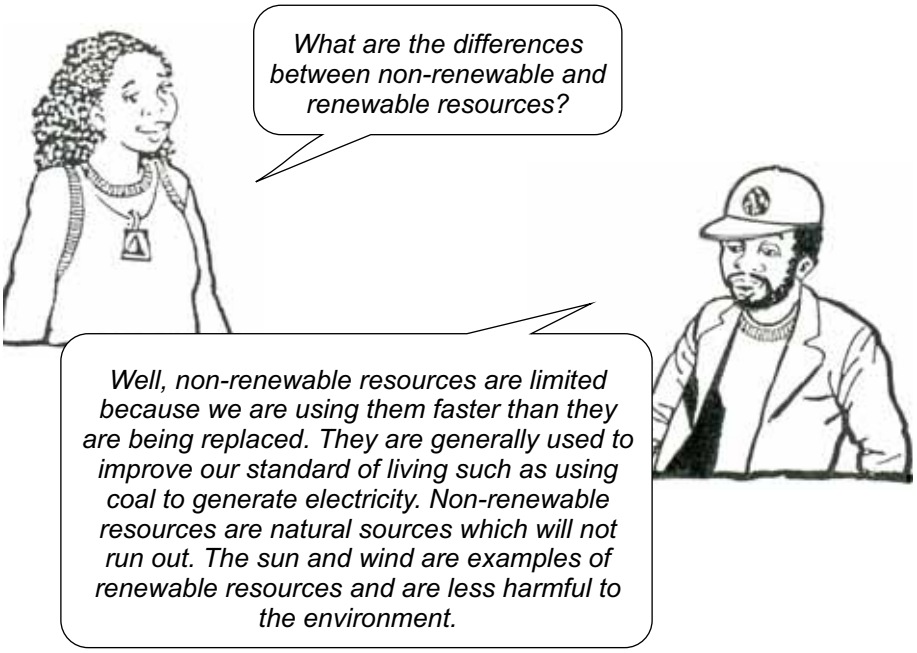
- distinguish between non-renewable (coal, oil, natural gas and minerals)and renewable (plants, animals and water) natural resources
- understand how coal, oil and natural gas are formed
- list uses for coal, oil and natural gas
- explain the importance of mining in South Africa, list some minerals that are mined in South Africa, and describe how they are used
- describe how people use plants, animals and water
- explain why it is important to manage resources sustainably.

Natural resources

Did you know that, annually, the world consumes an amount of fossil fuels that took nature about 1 million years to produce? Fossil fuels include coal, oil and natural gas.

Planet Earth provides us with many resources which are needed to keep us alive. For instance, water, which is essential to life, is an important resource we use. We know that **non-renewable** resources take longer to be formed than the time taken to use them. We also know that we can replace some resources, such as animal products faster than we can use them. It is unlikely that renewable resources will run out, as long as they are managed properly.

Did you know that most power stations in South Africa are coal powered because the coal is of good quality and is fairly readily available?



A wind farm in the Eastern Cape

Scientists have estimated that there is enough coal in the Earth to last for the next 200-400 years. They think that oil supplies will run out in about 50 year and natural gas supplies within the next 120 years.

sustainable:
using a resource in such a way that it can be used again and does not run out.

Coal, oil and natural gas are all sources of energy, and we use them to provide electricity and fuel for transport. The energy source a country uses depends on whether they are available, the quality of the resource and its **sustainability**; the cost, the technology needed and how the resource affects the environment.

Although everyone uses the Earth's resources, there is a concern that some countries are using non-renewable resources more than others. Activity 1 introduces you to some of these concerns.

ACTIVITY 1

Use the cartoon to answer the questions:

1. Look at the first two frames. What point is the man from the 'developed' richer world making to the man from the 'poorer' world about population?

2. In the third and fourth frames, what is the main point made by the person from the 'poorer' world about resources?

3. What percentage of the Earth's resources do the richer countries consume?

4. What is the difference between renewable and non-renewable resources?

5. Whose point of view do you agree with?

6. What do you think is the solution to the problem of increasing use of resources, especially non-renewable resources?

ANSWERS ON PAGE 145

Let us look in more detail at renewable and non-renewable resources.

Coal

Coal

We have mined coal for almost 200 years. Itl is the cheapest of the fossil fuels to recover from the Earth. It comes from the fossilized remains of trees and materials such as stone and sand. Because coal is the remains of plants, it is composed mainly of Carbon, Hydrogen, Nitrogen, Sulphur and Oxygen.

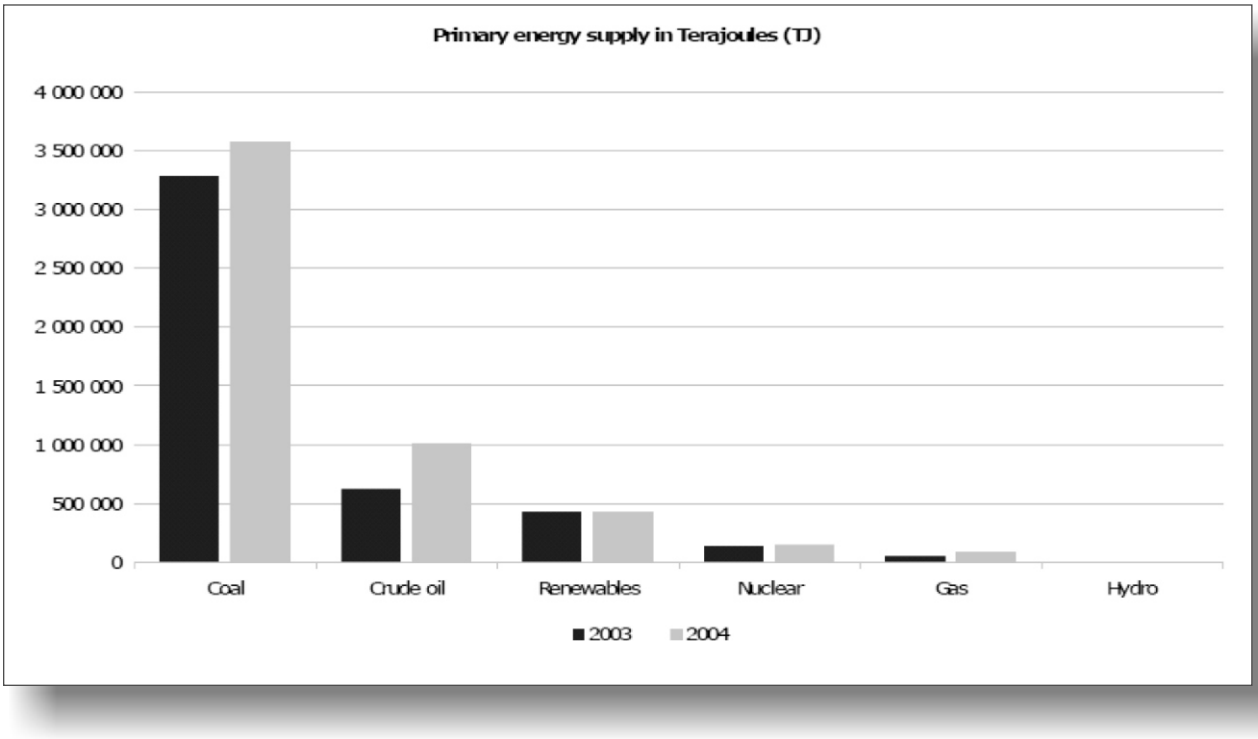
Uses of coal

South Africa has large coal reserves but very little oil. To avoid total dependence on imported oil, SASOL factories were developed to produce petrol and diesel fuels from coal. Compared to oil, coal is mainly made of Carbon so it is possible to make oil from coal by combining it with more Hydrogen. We will discuss this further in Lesson 5.

We also use coal to generate electricity.

ACTIVITY 2

The graph below shows that in South Africa our electricity is generated from coal power stations.



1. Use the graph to draw a table showing the various types of energy supply used to generate electricity in South Africa in 2003 and 2004.

2 Now answer these questions:
   a. What is the major change that happened between 2003 and 2004?
   b. Which is the second biggest source of electricity after coal?
   c. Why do you think renewable resources are used so little?

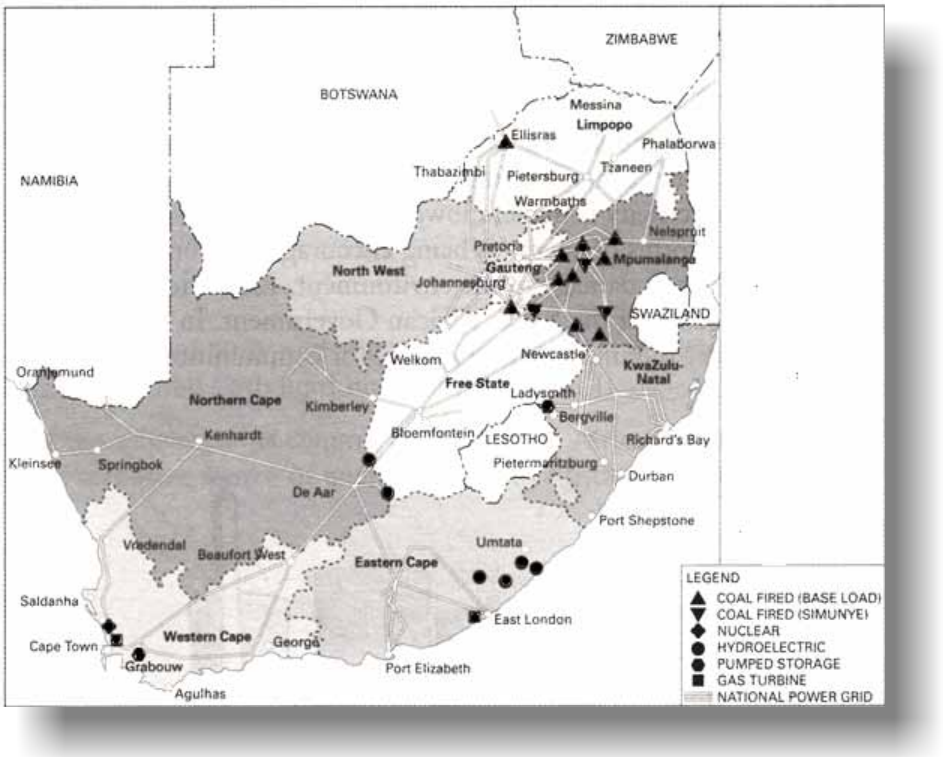
ANSWERS ON PAGE 146

Although coal is cheap it releases Sulphur Dioxide and Carbon Dioxide into the atmosphere and create environmental problems such as acid rain and climate change. Because of the bad effects burning coal has on the environment, scientists are looking at using different methods to generate electricity which do not harm the environment.

ACTIVITY 3

Power stations in South Africa

Use the map and the legend which shows where power stations are located in South Africa to answer these questions.

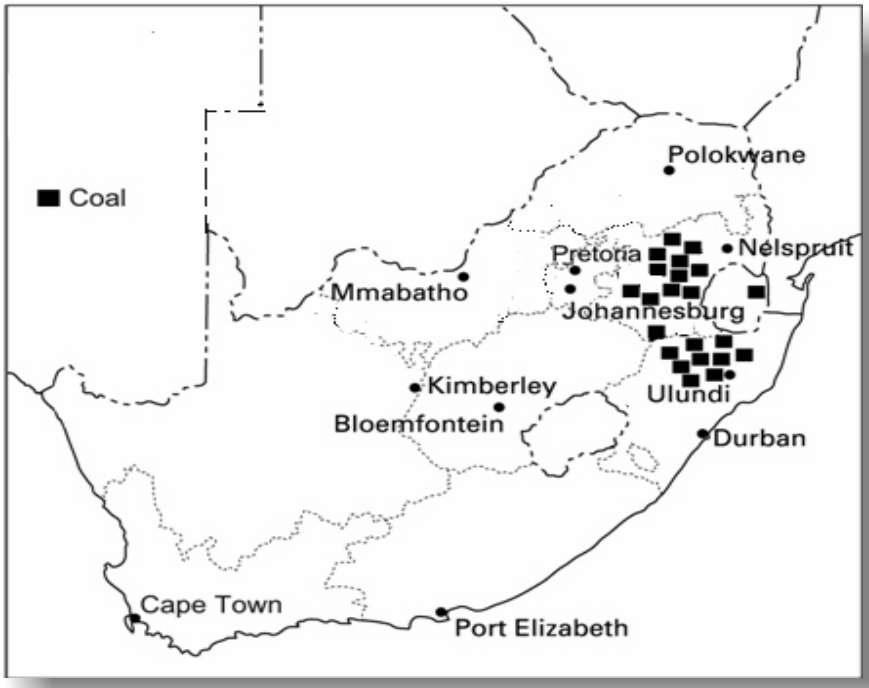


1. Is there a power station built near where you live? What kind of power station is it?

2. Where is the nuclear power station in South Africa?

3. How many coal- fired power stations are shown on the map?

4. Use the map below which shows where coal is found in Africa to explain why many coal-fired power stations are inland, in the north-eastern parts of the country.



5. Why do you think it is better to use hydroelectric and wind farms rather than coal to generate electricity?

6. The table below gives statistics showing how coal is used in South Africa.

Use of coal	Amount used (%)
Generate Electricity	43.2
Export	30
Making petrol	13.2
Making gas	3.3
Consumed as coal, e.g. for heating	9.6

   a. Draw a bar graph showing how coal is used in South Africa.
   b. What is most of our coal used for?
   c. How much coal is exported?

ANSWERS ON PAGE 146

Oil

Oil is the world's largest business and has commercial and political influence. Many of the largest, richest international companies are oil companies. As oil is such big business, OPEC (Organization of Petroleum Exporting Countries) has a big influence in fixing oil prices and deciding how much oil to produce.

Oil is found in underground deposits in many places in the world. It was formed about 300 million years ago and is thought to be the remains of marine life (sea life). The oil which is pumped up from the ground is called crude oil, a thick, dark, smelly liquid. It contains mainly carbon, hydrogen, nitrogen and sulphur.

Crude oil is often found in areas that are either far from world markets or have extreme environments, such as the Arctic (Alaska), tropical rainforests (Nigeria), deserts (Middle East), and under stormy seas (North Sea). We have had to develop technology to get to the hard-to-reach oil reserves. For instance, recovering oil from the North Sea requires very large, strong concrete platforms.

Oil is a non-renewable resource as we are pumping it out of the Earth faster than the Earth can replace it. This means countries that have oil reserves should not expect these reserves to last forever. It has been predicted that oil production in the Middle East will only last for the next 100 years. After this time all the oil will have been pumped out. Most world reserves are a lot smaller than those found in the Middle East and it is thought they will be used up within 30 years.

Consequences of an oil spill.

Although the burning of oil is thought to be less harmful to the environment than burning coal it still poses many threats. Oil tankers can sink during storms. When this happens they may release the oil they are carrying. This oil pollutes beaches and kills wildlife. The effects of an oil spill can be devastating, and can be felt for years after the ship has sunk.

More recently, in April 2010, the largest accidental marine oil spill occurred in the Gulf of Mexico.The oil spill was caused by an explosion on a BP oil rig, on the sea floor. Eleven people working on the platform were killed. Following the explosion, the oil well released an estimated 53 000 barrels of oil a day into the sea. It took engineers 3 months to cap the well and stop oil seeping into the sea.

Oil washed to shore from the BP oil spill.

Map showing the area where the BP oil spill occurred

By that time a total amount of 4.9 million barrels of oil had polluted the area. The oil spill caused extensive damage to marine organisms and their habitats. Both the tourist and fishing industries in the area were negatively affected.

Uses of oil

Crude oil is used to make liquid fuels, such petrol, diesel and jet fuel and is use in power stations, by industry, and for central heating and transport.

The crude oil is therefore mostly used to produce energy. A small portion of crude oil is converted into petrochemical feedstock used in the production of plastics, rubber, fertilizers and cosmetics.

ACTIVITY 4

The information in the table shows the various uses of oil in South Africa. Draw a pie chart to compare the different uses.

Activity using oil	Percentage Used
Transport	80
Agriculture	6
Residential	3
Mining	3
Industry	4
Other, non-specified	4

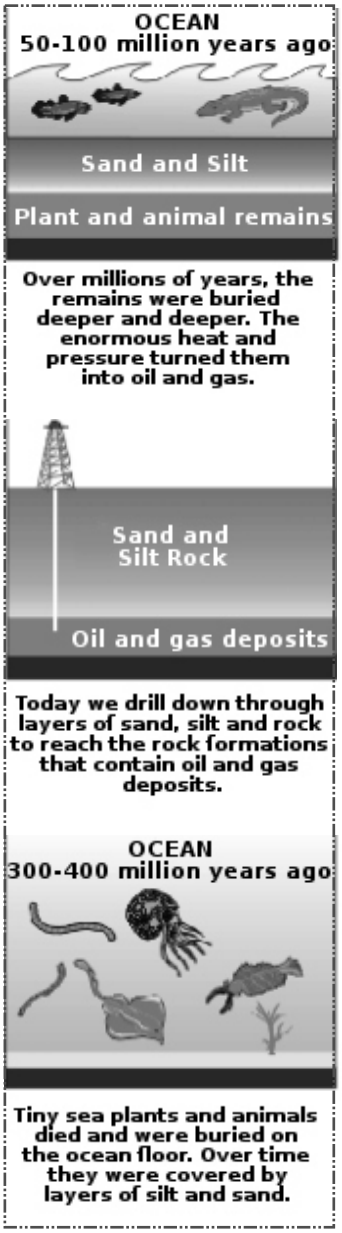
ANSWERS ON PAGE 147

Natural Gas

Like coal and oil, natural gas is a non-renewable resource. Natural gas is used to provide energy in various processes, including generating electricity. It is made of a mixture of gases (Methane, Ethane, Propane, and other Hydrocarbons). You cannot see, smell or taste natural gas.

Natural gas was formed in the sea millions of years ago. When marine plants and animals died, they sank to the bottom of the sea, were covered by sand and eventually turned into sedimentary rock. Heat and pressure turned the remains of plants and animals into natural gas. Natural gas is a fossil fuel and is non-renewable. As it took millions of years to form, we can't replace what we are using at the rate at which we are using it.

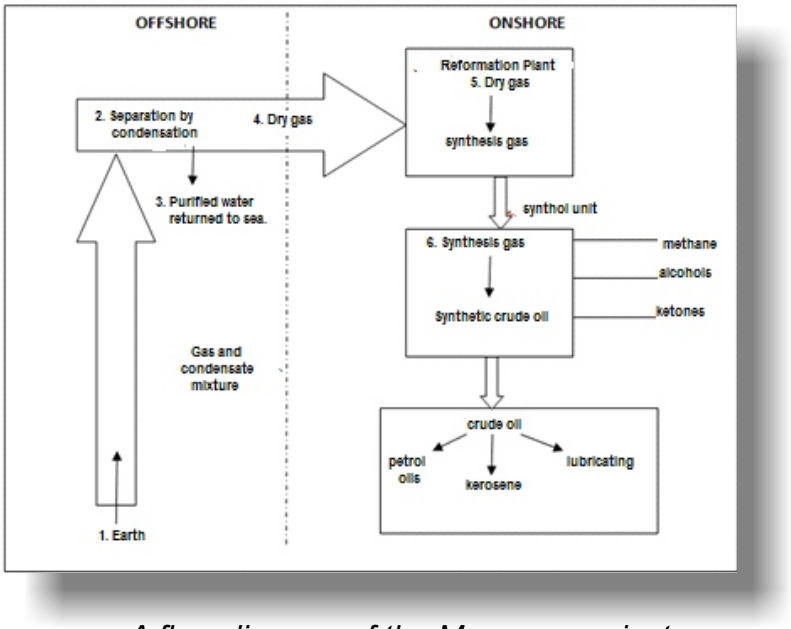
Natural gas has become the fastest-growing energy resource and provides an alternative to coal and oil. In 1998 a quarter of the world was using natural gas as a source of energy. In South Africa natural gas is extracted at Mossgas. The Mossgas plant is found 8.5km offshore, south of Mosselbay along the Western Cape Coastline.



Map of South Africa showing where Mossel Bay is

The natural gas is processed to form products such as methane, oil and petrol. The processing starts at the offshore plant and continues inland at the onshore plant. Let's consider how the natural gas is processed both off shore and then on shore.

Look at the flow chart with the description given for the offshore and onshore processing. Start at the 'Earth' which is in the bottom left-hand corner. The numbers in the description match the numbers in the flow chart.



A flow diagram of the Mossgas project

Offshore:

1. The gas and the condensate mixture are under pressure in the Earth and are pushed by this pressure up to a platform positioned in the sea.
2. The mixture is cooled separating the gas from the liquid and water by condensation.
3. Hydrocarbons are removed from the water and the water is returned to the sea.
4. The gas (called dry gas) is piped to the onshore plant.

Onshore

5. At the onshore reformation plant the dry gas is converted to synthesis gas.
6. The synthesis gas is converted using a **catalyst** of a mixture of hydrocarbons; for example, synthetic crude oil, methane and alcohols.

catalyst:
a substance usually used in small amounts compared to the reactants. It makes the rate of a reaction faster, without being used in the reaction.

Uses of natural gas

Natural gas is used to heat buildings and water, for cooking, drying clothes, lighting, and for making paper and cement. It is an ingredient in paints, glues, fertilizers, plastics and medicines. Some power plants use natural gas to generate electricity. Natural gas can be used to run cars, trucks and buses.

At present, gas is considered to be the cheapest and cleanest of the fossil fuels. Combustion of natural gas produces less carbon dioxide per unit energy than coal or oil when burnt. This helps to reduce greenhouse gas emissions from power stations.

ACTIVITY 5

1. Coal, oil and gas are all fossil fuels and sources of non-renewable energy.
   a. Why are they called fossil fuels?
   b. What problems will using non-renewable energy create in the future?
   c. List five uses of oil and gas.

ANSWERS ON PAGE 147

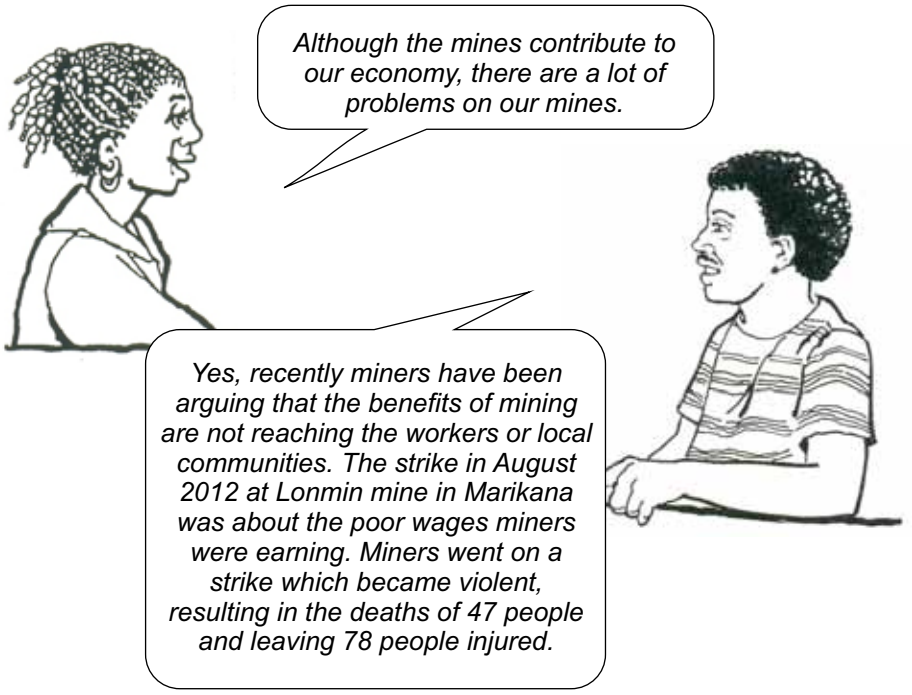
Minerals

A mineral is a naturally occurring **inorganic** substance with a definite chemical composition. South Africa has a rich supply of minerals. These minerals are extracted from the ground through mining activities. Minerals are used to produce a variety of resources, from stainless steel utensils, reading glasses, jewellery, and dental equipment, to space shuttles.

inorganic:
relates to chemical compounds that occur mainly in once-living organisms such as rocks, minerals and ceramics. Most do not have the element carbon. Inorganic compounds usually have simpler chemical formulae than organic compounds, e.g. NaCl.

South Africa's mining industry is an important sector of our economy. Mining has the potential to keep contributing positively to our economy for many years, if activities are managed sustainably. The mining industry benefits the economy directly and its effects are significant:

- it contributes many billions to the export industry
- it employs about 450 000 people.
- about 60 types of minerals are mined, of which the vast majority are exported to over 100 countries.
- it is responsible for significant infrastructure development.



Uses of minerals

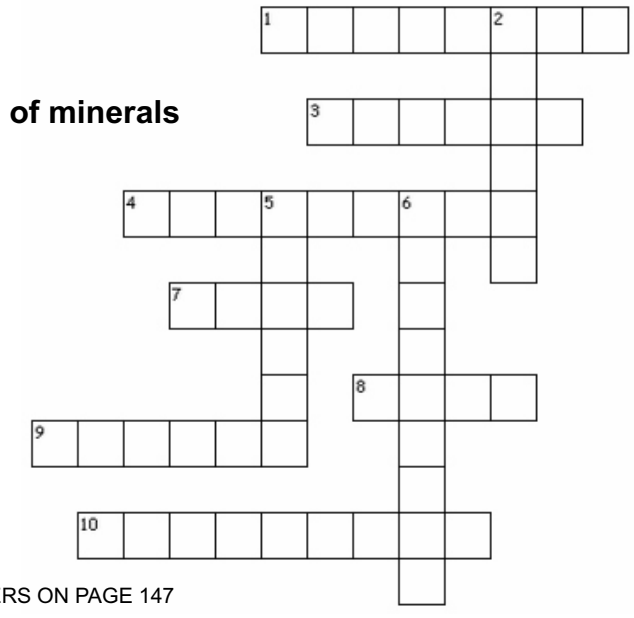
Minerals have a variety of uses in our modern society. The table below lists some of these uses. Read the table and then complete the crossword puzzle in activity 6.

Mineral	Use of mineral to man
Aluminium	Motor car and aeroplane construction; bottling and canning industries, kitchen cookware and foil.
Diamonds	Machinery, mineral services, stone and ceramic products, drilling, jewellery.
Copper	Electrical cables and wires, building construction, switches, plumbing, heating, electrical and electronic components and jewellery.
Gold	Dentistry and medicine, jewel lery and arts, medallions and coins, an electrolyte in the electroplating industry.
Iron ore	Used to manufacture steels of various types. Used in magnets and automotive parts.
Lead	Batteries, ammunition, TVs ceramics.
Magnesium	Electrical, electrolyte p roduction of chlorine, paint, thermometers and thermostats.
Nickel	An alloy to stainless steel. Aerospace industry.
Phosphate	Phosphoric acid, fertilizers, feed additives for livestock.
Platinum	A catalyst to control emissions in cars and industry, jewellery.
Silica	Computer chips, glass products, ceramics, water filtration, cements, cosmetics.
Silver	Electrical and electronic products, sterling silverware, jewellery and coins, solders.
Zinc	Protective coating for steel, an alloying metal with copper to form brass, rubber and paint industries..

ACTIVITY 6

Do the puzzle below. All the answers are minerals.

Uses of minerals



Clues across

1. Catalyst to control car emissions.
3. Used to make computer chips.
4. Fertilizer contains this chemical.
7. Important in jewellery.
8. Protective coating for steel.
9. Electrical components.
10. Used in the electrolyte production of chlorine.

Clues down

2. Alloy to stainless steel.
5. Electronic products.
6. Many soft fizzy drinks, e.g. Pepsi, are sold in cans made of this element.

ANSWERS ON PAGE 147

ACTIVITY 7

Read the extract below and then answer the questions.

> The mining industry remains a very big operation in South Africa. No other factor has had such a significant impact on the country's economic development as the discovery and exploitation of minerals during the past 100 years.

1. List two factors that favour mining in South Africa.

2. In what way has mining been significant in South Africa's development?

3. The mining industry makes millions of rands. Explain why miners at Marikana went on strike.

4. Explain why African countries should avoid basing their country's economy mainly on the sale of minerals.

ANSWERS ON PAGE 148

Let us now look at some renewable resources such as trees and plants, animals, and water.

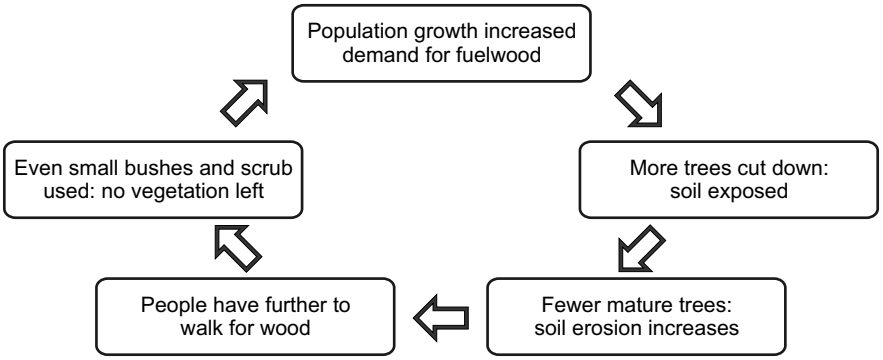
Trees and other plant materials

Trees are a sustainable resource provided that those cut down are replaced, or that there is enough time for trees to grow and reach maturity. If saplings are not planted after bigger tree are cut down, deforestation occurs which leads to soil erosion as there are no longer tree roots to hold the soil. The soil is either washed away by rain or blown away by the wind.

Collecting wood for fuel

Scientists call this the cycle of environmental depletion, as shown in the figure below.

The cycle of environmental depletion



Uses of plants

We have always used plants in one way or another. Plants provide fuel (firewood), food, clothing and even shelter. Many people have a staple diet of plants: maize, wheat or rice. Even the animals we eat are dependent on plants (grasses and grains) for their fodder. We also use plants for medicinal purposes.

A cotton plant

In Brazil people use ethanol (obtained from sugar cane) as a car fuel, instead of using petrol or diesel.

Wood is also used to build houses: window frames, doors and flooring

Trees are not the only plants we use. Other plants provide us with fibre for making cloth, rope, and paper. Cotton fibres, for example, come from the seed hairs of cotton plants

In 1998, the South African government passed a National Forest Act to ensure that we manage our forests in a sustainable way.

.

Animal products

Sheep shearing

Animals are very useful to human beings. Animals are farmed to provide meat, milk and dairy products. Animal products are found in glue and gelatine (made from cartilage and bones).

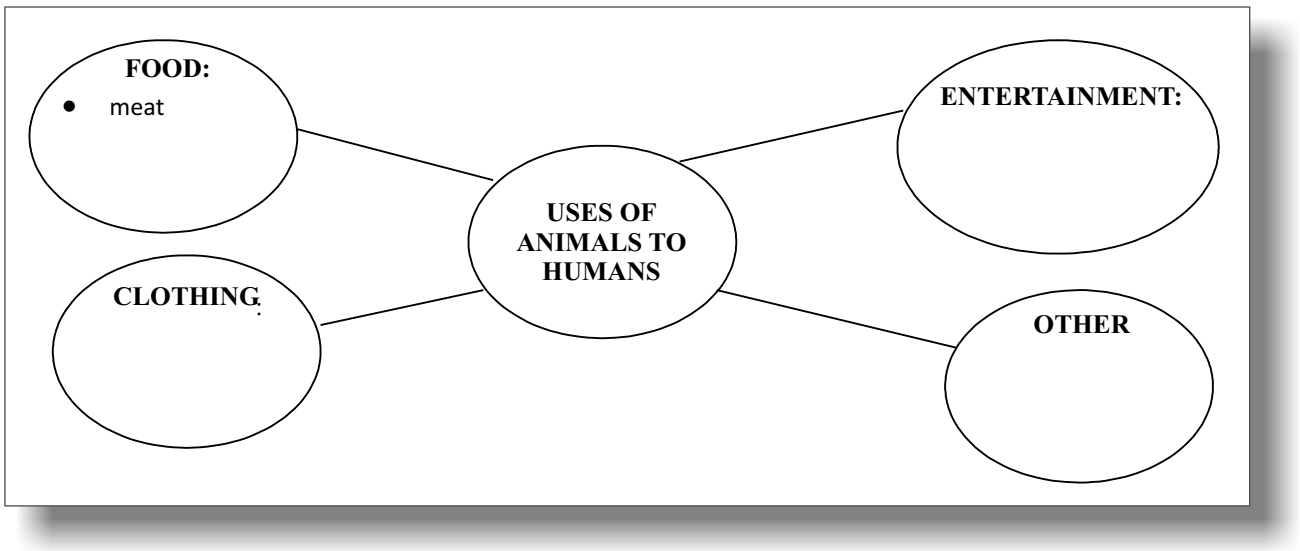
We get wool from sheep. The wool or fleece is removed from the sheep in one piece in a process called shearing. The wool is cleaned and then goes through a number of processes until it is finally spun into yarn.

When skin is removed from a dead animal it is tanned to prevent the skin from being spoiled and to give the leather its desired properties. Soft leather is used for gloves and heavy hard-wearing leather is used for the soles of shoes.

ACTIVITY 8

1. List some of the ways plants are used by people.

2. Complete the mind map on the next page which shows the various uses of animals. Under each heading write examples of animal products that fit that category. We have started the first example for you.



3. Explain why it is important that we manage our forests in a sustainable way.

ANSWERS ON PAGE 148

Water

Water covers 71% of the Earth's surface and is vital for all forms of life. 97% of the planet's water is found in the oceans, 1.7% in ground water, 1.7% in glaciers and ice caps of Antarctica and Greenland, and a small fraction in other large water bodies. Only 2.5% of the Earth's water is fresh water.

We use water for agriculture, drinking, washing, transportation, heat exchange, fire extinguishing, recreation, industrial applications and food processing.

Agriculture

Approximately 70% of fresh water is used in agriculture. The most important use for water is irrigation.

Irrigation

Drinking

The human body contains from 55% to 78% water, depending on body size. To function properly, the body needs between one and three litres of water per day to avoid dehydration. The exact amount of water required depends on the level of activity, temperature, and humidity.

Washing

Water can form solutions and emulsions (like milk) easily and is useful in various washing processes. Many industrial processes rely on chemical reactions using water and certain chemicals to extract substances. Washing is also important in personal body hygiene.

Transportation

The use of water for transporting materials along the sea, in rivers, and in canals is an important part of the world's economy.

Heat exchange

Water and steam are used as heat transfer liquids in varied heat exchange systems. This is made possible because water has a high heat capacity, both as a coolant and for heating. In most power stations water is the coolant which vaporizes and drives steam turbines to drive generators. In the nuclear power industry water is also used as coolant, where the nuclear core is covered with water to ensure sufficient cooling.

Fire extinguishers

Water drop off to extinguish a veld fire

Water has a high heat of vaporization (absorbs a lot of heat when it becomes a gas) and does not react easily, which makes it a good fire extinguishing fluid. The evaporation of water carries heat away from the fire.

Recreation

Water is used for many recreational purposes, as well as for exercising and for sports. Some of these activities include swimming, water skiing, boating, surfing and diving. Lakesides, dams and beaches are popular places for people to go to relax. Some sports (ice skating and ice hockey) are played on ice. In colder parts of the world where there is snow, it may be used for snow sports: skiing, sledding and snowboarding.

Industrial Applications

A hydroelectric plant

Water is used to generate power. Hydroelectricity, a low-cost, non-polluting, renewable energy source, is obtained from hydropower. The energy is supplied by the motion of water. Usually, a dam is constructed in a river. Water flowing out of the dam is forced through turbines that turn the generators. South Africa has a low rainfall, which limits the use of this form of energy.

Not only is water used to generate electricity, it is used extensively in industry and is used to cool machines which get very hot.

Food processing

The boiling and freezing points of water are affected by solutes as well as air pressure. Solutes in water lower water activity (its amount of energy, or its 'energy status'). This is important to know because most bacterial growth ceases at low levels of water activity. Pure distilled water has a water activity of one.

Not only does microbial growth affect food safety, but also the shelf-life of the food. Boiling, steaming and simmering are popular cooking methods that often require immersing food in water or its gaseous state, steam.

ACTIVITY 9

1. The amount of water needed for towns and cities has increased over the last 50 years. Give two reasons for this.

2. List the various ways that you use water at home for your well-being.

3. Read the extract about the Three Gorges Dam Project, and then answer the question that follows:

> The world's largest hydroelectric project is the Three Gorges Dam on the Chang Jiang in China. The project was completed in 2009 and produces 22 500 megawatts of electricity. It cost over $39 billion (about R350 billion) to construct . The dam needed for the project is some 600km long. The water level in the valley is predicted to rise by 40-50 metres, flooding over a million homes. Nearly 2 million people have been resettled in the Hudei and Sichuan provinces of China. Engineers are worried that all the river mud (silt) that flows down the river will pile up behind the dam. This will reduce the size of the lake and cut off the supply of fertile soil downstream. This is what happened behind the Aswan Dam in Egypt.

What are the main advantages and disadvantages of a scheme such as the Three Gorges Dam project?

ANSWERS ON PAGE 149

COMMENT

Our natural resources are our assets whose sustainable use is necessary for the well- being of all living creatures. Unfortunately, the continuous and ever increasing demand for basic items of survival and technological developments have caused us to explore and exploit all possible natural resources. As individuals we tend to

consume resources without giving a thought to conservation or harmful impact of over use or careless consumption. Other stake holders like industry are also driven by short term gains.

Governments across the globe have been slow to react to the risks of various stake holders and have learnt the hard way that we are coming to a point where over exploitation and mismanagement is leading to a global energy crisis and global warming.

Governments, individuals and other stake holders are now realizing the need to maintain a balance between environment and development. No doubt sustainable management of natural resources at all levels is a difficult task. We still have to adjust our requirements, individually and collectively so that the benefits of management and conservation reach the widest cross section of society and meet the needs of future generations.

CHECKLIST

Are you able to:

- ❒ explain the difference between renewable and non-renewable resources
- ❒ describe how coal, oil and natural gas are formed
- ❒ list the uses of coal, oil, and natural gases
- ❒ name minerals which are mined in South Africa and explain how they are used
- ❒ list the uses of plants and animals
- ❒ explain the importance of managing renewable resources
- ❒ list the uses of water.

LESSON 2

Food Production

About this lesson

In this lesson you are going to look at how we grow food. Large farms need machinery to grow crops and raise animals. Using machinery is helpful, but there are also disadvantages. In this lesson you will find out how farms have changed from being small **subsistence farms** to large **intensive farms**.

To produce more crops many farmers use chemical fertilizers and pesticides. Chemical fertilizers add plant nutrients such as nitrogen, phosphorus and potassium to the soil. Fertilized plants grow faster and are of a better quality. Pesticides are used to kill organisms which feed off crops. Although chemical fertilizers and pesticides increase the crops produced, their use is harmful to the environment.

In this lesson you will find out the effect that chemical fertilizers and pesticides have on the environment. You will look at why some farmers choose to use organic fertilizers instead of chemical fertilizers. This lesson also looks at the resources needed for farms to be successful. The lesson ends by looking at foods which have been changed genetically. You will consider whether genetically modified foods are an answer to solving the hunger problems the world faces.

In this lesson you will:

- compare subsistence farming with intensive farming
- consider the effects of using chemical and organic fertilizers and pesticides on farms
- compare labour-intensive farming methods with farms that use machinery
- understand how farms make use of the Earth's water and land resources
- list the resources needed for profitable grain and beef farms
- explain what is meant by genetically modified foods, and consider some arguments for and against producing these organisms.

subsistence farming: *farming where most of the crops or livestock raised is used by the farmer and his/her family. Very little, if any, of the produce is sold.*
intensive farming: *farming where most of the produce is sold for profit.*

Agricultural methods

Agriculture includes all activities farmers use to grow food. The first farms were small subsistence farms. Usually, the farmer would clear land to grow crops. If the amount of crops being produced started to decrease the farmer would allow the land to stand **fallow** and recover. The farmer would then plant crops on a new plot of land, until that plot needed to be rested.

fallow:
land that has been ploughed but left unplanted

As people moved into urban areas and the world's population increased it became necessary to use intensive farming methods. Farms which grow one type of crop or rear one type of animal tend to make a lot of money. Farms of this type are called monocultures. Many intensive farms are therefore monocultures.

Since the purpose of intensive farms is to make money, the time taken to rest the land has become shorter. Farming has become more sophisticated with the use of irrigation, fertilisers, pesticides, herbicides and genetically modified (GM) food. All of the above improve the quality and the quantity of the food farmers produce.

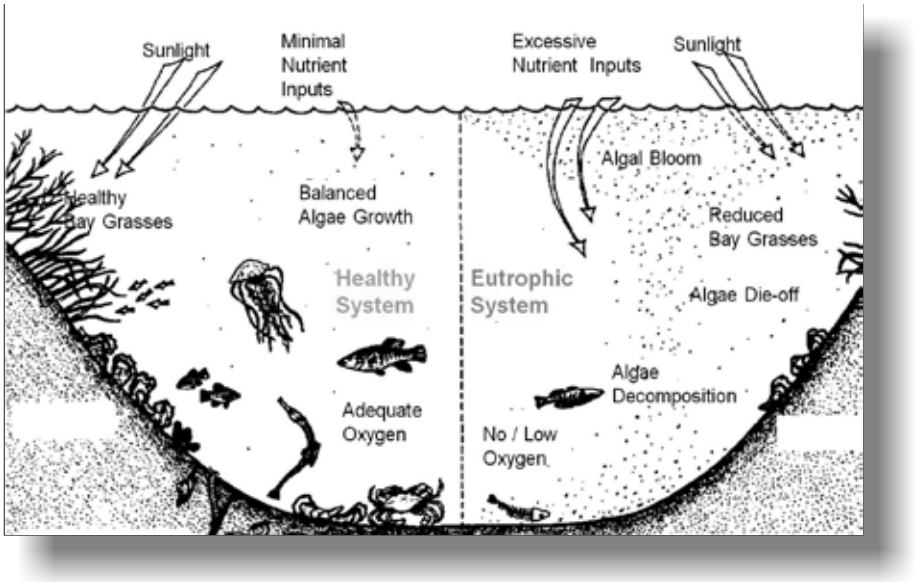
Let's take a closer look at the role of fertilizers in the growth of crops.

Chemical fertilizers contain elements such as Nitrogen, Phosphorus and Potassium, essential for plant growth. They are added to the soil to improve the quality of the plant and the amount of the crop produced (yield). Although chemical fertilizers enable plants to grow faster, they do not improve the quality of the soil. The added chemicals often kill microorganisms which improve the quality of the soil through various processes such as decomposition. When microorganisms in the soil die the soil structure breaks down. It **compacts** and is less able to hold water and nutrients.

compaction:
making something firmer by pressing it.
leach:
seep
eutrophication:
depletion of oxygen in water
excessive nutrient inputs:
nutrients which have been added to the water body, usually from chemical fertilizers

If too much fertilizer is added to the soil, some of the nutrients are not absorbed in the soil. These nutrients may **leach** into underground water supplies and rivers.

The diagrams on the next page compare two dams. The diagram on the left shows a healthy dam, where chemical fertilizers have not leached into it. The diagram on the right shows **eutrophication**. Start reading the diagram on the right at the label which says **excessive nutrient inputs**.



Extra nutrients in a water body cause algae to grow quickly to form an algal bloom. It is a thick, green, slimy mass of plants growing on the surface of a water body. The problem with this thick layer of algae is that plants growing below the surface of the water do not receive any sunlight. As these plants do not receive any sunlight, they are unable to photosynthesize, and they die. The dead plants start to decompose in the water. Decomposers use oxygen for the process of cellular respiration. As a result, the oxygen in the water body decreases, Fish start dying because of the lack of oxygen. The process described is known as eutrophication which is a result of chemical fertilizers reaching water bodies.

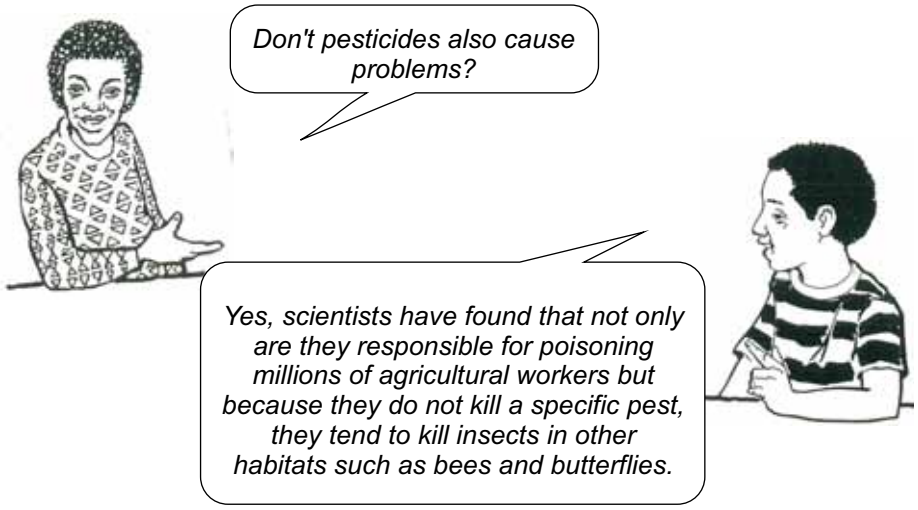
Because of the harmful effects of chemical fertilizers, some farmers have started using products and processes which are less harmful. Farms of this type are termed organic farms.

Organic farming is sustainable farming. It tries to avoid misusing the soil and water resources. Chemical fertilizers are replaced with **organic fertilizers** which are made from animal or plant material (compost) and/ or minerals made from rock salt. Organic fertilizers are considered better than chemical fertilizers, since not only do they improve the quality and quantity of the crop being produced, but also improve the quality of the soil. Organic fertilizers allow for growth of soil organisms such as earthworms and promote healthy plant root development. Another advantage of using organic fertilizers is that the organic matter in the fertilizer is broken down by soil microbes (bacteria and fungi), slowly releasing nutrients into the soil. As a consequence, organic fertilizers provide long-term steady nutrition.

Organic farming, however, also has its problems. Crop yields on these farms are less. This means, that although organic farming is helpful to the environment and less harmful to human health, its produce is more expensive to buy.

parasite:
an organism which benefits from a relationship but harms the host from which it feeds

Intensive farmers use chemical fertilizers to produce more crops of a better quality. To further increase the amount and quality of crops produced, many farmers use pesticides which are applied to crops to control pests and **parasites**. It has been estimated that without pesticides grain yields would decrease by 25% in a year and by 45% after three years.



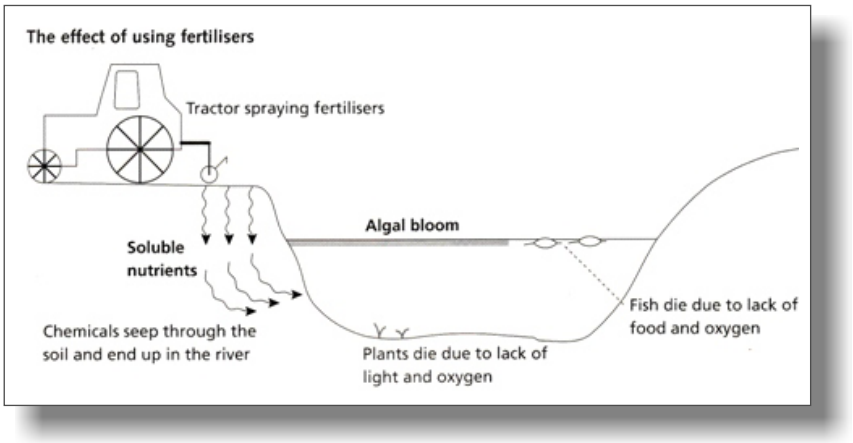
ACTIVITY 1

1. What do the following words mean?
   a. fertilizer
   b. organic fertilizer
   c. pesticide

2. Use the diagram to answer the following questions:

   a. Explain why farmer A is willing to use fertilizers and pesticides on her land.
   b. Explain what farmer B is doing to improve the quality of his soil.

3. Chemical fertilizers sprayed on the land may end up in rivers. Use the diagram to explain how this happens.



4, List **three** things that can happen when too many fertilizers dissolve in a river.

ANSWERS ON PAGE 149

Labour intensive vs. mechanised farms

Labour-intensive farming

Intensive farming is farming that is done to produce as many crops as possible and rear as many animals as possible. This means that on intensive farms there is a lot of work that needs to be done. Labour-intensive farms make use of people to do most of the work on the farm such as sowing seeds, weeding and harvesting. They generally produce fewer yields compared to large mechanised farms. Farms which are labour intensive spend a lot of money on the workers' wages. To reduce these costs, many farmers pay their workers minimum wages,

Another way of reducing labour costs is to use machines to do much of the work on the farm. These farms are called mechanised farms. Machines are used to perform the following functions: sowing, harvesting, levelling the soil, watering, spraying and weeding.

Many farmers argue that mechanized farming:

- increases produce
- does not depend on animal power to plough the fields. As animals are no longer needed to help with work on the farm, the farmer does not need to grow food to feed the animals which means there is more land available to cultivate crops
- lowers labour costs.

So, using machines on farms increases the amount of produce that the farmer can sell. Labour costs are lower, meaning that the farmer makes more money. The farmer can use this extra

ACTIVITY 2

Use the diagram of a pig farm below to answer the questions.

1. How many types of animals are kept on the farm?

2. Is there evidence that nutrients are being returned to the soil?

3. List all the ways that technology is being used on the farm.

4. What would happen if the electricity supply to the farm was cut off and there was a fuel shortage?

5. The farmer regularly feeds antibiotics to his animals. Why is this necessary?

ANSWERS ON PAGE 149

ACTIVITY 3

Use the diagrams below to answer the questions that follow:

Free range farm *Combination farm* *Mechanized farm*

1. Which of the farms is the most expensive to set up?

2. Which farm requires the most building maintenance?

3. Which chickens would require antibiotics?

4. Which farm requires the most land?

5. Which farm produces the most eggs?

6. Which type of farm requires more labour to run?

7. From which farm would the eggs and chickens be more expensive to buy?

8. From which farm might shoppers prefer to buy their eggs and chickens? Give a reason for your answer.

ANSWERS ON PAGE 150

Resources needed for various food types

So far you have looked at some of the choices farmers make when they decide to farm: the use of machinery or people to do the work or to use chemical or organic fertilizers to improve plant growth. Farmers also need to think about where their farm is and what resources they have.

arable:
suitable for growing crops

A farm is **arable** when it is on flat land and the soil has a lot of nutrients. Arable farm land is the easiest and most wanted farm land. However because of poor farming practices such as overgrazing, soil erosion and drought, arable farmland in Africa is decreasing.

Pastoral farming is the raising of animals usually on land which is less favourable to arable farming as the land is colder, wetter, steeper and higher. When farmers rear animals it is important that the farmer does not overgraze the land.

Overgrazing occurs when too many animals are kept on too small a piece of land. This means that there is not enough food for all the animals. The little grass that there is, is eaten up, leaving the soil bare. The bare soil can be blown away or washed away, leading to soil erosion.

A farmer will choose what type of crop or animal he will farm based on the available resources in an area. Some agricultural resources are natural and others are manmade. Natural resources are referred to as primary resources whilst manmade resources are called secondary resources.

Look at the tables below which give primary and secondary resources and their importance for farmers.

Primary Resources

Did you know… producing 1kg of animal protein requires about 100 times more water than producing 1kg of grain protein? It also requires more land.

Primary Source	Importance
Air	Carbon dioxide is needed for the process of photosynthesis. Oxygen is needed by plants and animals for cellular respiration.
Water	Water is needed for various biological process in plants and animals for instance it is a transport medium.
Sunlight (radiant energy)	Radiant energy is needed by plants enabling them to photosynthesize.
Natural vegetation	Natural vegetation (veld) may be used for grazing, however it does not provide enough nutrients for large numbers of livestock.
People	Agriculture relies on people to grow crops and livestock,

Secondary Resources

Secondary resources	Importance
Technology (tools)	Technology could be as simple as a hoe or complex as a combine harvester.
Fuel	Mechanised farms need fuel, e.g. oil, petrol.
Seed stocks	Seeds were once a natural resource, nowadays farmers grow particular varieties of plants from seeds obtained from seed banks.
Breeding stock.	Most breeding stock has been selected from generations of breeding.
Fertilizers	Some fertilizers used include compost or manure and are considered organic. Large scale farms rely on chemical fertilizers to add nutrients to the soil.
Pesticides	These are chemicals which are used to kill pests. These chemicals are harmful to the environment.
People	People develop technology and the skills to use it. Their knowledge, skills and experience are secondary resources.

Secondary resources which are the most expensive for grain farmers are the machinery, fuel, irrigation and pesticides. The main expenses in beef production include the feed and maintaining breeding stocks.

In the next section you will look at how farmers use water and land which are required for both crop farming and rearing cattle.

The grain industry in South Africa produces 25% of the country's gross agricultural production. The largest area is planted with maize followed by wheat, sugar cane and sunflowers.

ACTIVITY 4

1. List all the primary and secondary resources needed for farming a grain such as wheat.

2. List the primary and secondary resources needed for farming cattle.

ANSWERS ON PAGE 150

Land and water use

Most of the food we eat, for example mielies, wheat, sugar and beef, requires much water and land. In this section you will first look at some issues regarding land use, and then you will look at water use on a farm.

Farmers need to ensure that their farm land remains useable for years to come which means his farming practices need to be sustainable.

Farmers need to prevent soil erosion. Soil erosion occurs when a piece of land is cleared. Either rain water washes the top soil away or the wind blows it away. Top soil is fertile soil. Once the top soil is eroded, the land is very difficult to farm. Scientists have estimated that it takes about 500 years for the Earth to make 25mm top soil. As farmers cannot wait that long for fertile top soil to be replaced, many add chemical fertilizers. As explained in the first part of the lesson, although fertilizers add nutrients to the soil, they do not improve the quality of the soil and may result in eutrophication of nearby water bodies.

Not only do most farmers need land to farm on, all farmers need a good water supply. Agriculture is the largest global use of water. You may drink one or two litres of water a day. However, taking into account the amount of water that goes into making the food you eat in a day, that amount would go up to 3000 litres a day.

An irrigation system

While much of the water needed on farms comes from rain, some 40% of the water is supplied by irrigation systems. It has been estimated that 75% of the world's freshwater is used for irrigation. This water comes from rivers and/or ground water and may result in a drop in the level of ground water. Water used in farming is one of the causes of destruction to ecosystems.

Large mechanized farms provide us with food. However, many farmers are choosing to plant genetically modified (GM) crops.

ACTIVITY 5

Use the table below to plot a bar graph showing the least amount of water needed to produce various agricultural goods.

Agricultural Goods	Amount of water used (L)
1kg beef	16 000 - 100 000
1kg rice	3 000 – 4500
1kg wheat	1 350 - 1 500
1kg potatoes	500

Least amount of water needed to produce various agricultural goods

ANSWERS ON PAGE 151

GM Crops

Have you noticed that there are many different types of apples? A farmer who sells apples may ask a scientist to develop a red apple which is sweet and large.

Each characteristic of the apple (e.g. taste and size of the apple) will be decided or coded for by a specific **gene**. There will be one gene coding for taste and another gene coding for the size of the apple. The scientist would find the gene which codes for sweetness in the trees producing small red apples. He would cut the 'sweet' gene out using various technologies and insert the 'sweet' gene into the DNA of a cell from an apple tree which produces large apples. In this way the scientist would have created an apple tree that produces apples which are large and sweet. Scientists who are involved in changing the characteristics of plants and animals in some way work in a field called biotechnology.

gene:
a piece of DNA that codes for a specific characteristic. The DNA is found in the nucleus of the cell.

The organism from which the gene is taken is called the **donor**. In the apple example, this would be the trees producing the small sweet red apples. The organism to which the gene is transferred is called the **recipient**. In the apple example, this would be the trees producing the large red apples. Once the organism has received the gene from the donor it is called a transgenic organism or is said to be a **genetically modified organism** (GMO). The trees producing the large sweet apples would be the genetically modified organism.

Genetic modification (GM) allows scientists to insert genes into organisms, giving them characteristics which make them stronger, resistant to pests and able to survive drought. In South Africa, genes have been inserted into mielie plants, making them resistant to insects. Similar insect resistant genes have been inserted into cotton plants. Let's look at genetically modified (GM) cotton plants in more detail.

Cotton bollworm

Scientists discovered that certain bacteria called *Bacillus thuriengienis* (BT) produce a protein which cause insects to die. The gene coding for the protein is called the BT gene. Scientists cut the BT gene from the bacteria (the donor) and inserted it into cotton plants (the recipient). Bollworm is a caterpillar that feeds on cotton plants, causing much damage in cotton plantations. Bollworm that feeds off cotton plants containing the BT gene die. As a result there is a lot less damage to the cotton plants.

BT Cotton

Today, most cotton farms in South Africa farm with BT cotton successfully. The alternative to using BT cotton plants would be to use chemical insecticides which are expensive and cause damage to the environment.

There is much debate around the subject of creating and eating organisms which have been genetically modified.

People who support the continued use of GM organisms explain that it is now possible to make organisms genetically pest resistant, allow organisms to withstand extreme weather, and improve the nutritional value of the organism.

People who have serious concerns about interfering with an organism's genes argue that genetic modification cannot deliver a safe, secure food; that they are much more expensive than the non-GM crops; that GM foods may affect human health negatively and may cause harm to other organisms in the environment..

Let's look at some of the advantages and disadvantages in more detail.

Advantages

Pest resistance

Crop losses from damage caused by pests can be large. Farmers use many tons of chemical pesticides each year to control pests. Pesticides cause harm to the environment and are non-specific. Pesticides are also thought to harm human beings. An alternative to using pesticides is to grow GM crops with the BT 'pesticide' gene inserted. Insects feeding on the crop would die. In this way, growing GM foods, for example BT cotton plants, would reduce the amount of pesticides farmers use.

Herbicide tolerance

herbicide:
a substance for killing plants, especially weeds

Farmers often spray crops with large quantities of **herbicides** to get rid of weeds. But they need to ensure that the herbicide only kills the weeds and not their crops. Certain crop plants, for example mielies, have been genetically modified to be resistant to certain herbicides. This allows the farmers to control weeds effectively.

Disease resistance

There are many viruses, bacteria and fungi which cause plant disease. Researchers are working to create plants which are genetically resistant to disease.

Cold tolerance

Unexpected frost could destroy crop seedlings. An antifreeze gene found in cold-water fish has been introduced into tobacco and potato plants which allows these plants and their seedlings to tolerate cold temperatures.

Drought tolerance / salinity tolerance

As the world population increases and more land is used for housing instead of food production, farmers need to grow crops in areas unsuitable for farming. Developing plants that can withstand long periods of drought or high salt concentrations in the soil and ground water will help farmers to grow crops in unsuitable places. In countries where water is considered scarce (like South Africa) these varieties of plants will ensure **food security**.

food security:
when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy, active life

Nutrition

In some developing countries people rely on single crops, for example rice, for their staple diet. However, these crops usually do not contain all necessary nutrients to provide a balanced diet. Researchers have created a strain of rice with higher levels of beta carotene needed for Vitamin A production. This rice has been called 'golden rice'.

Diasadvantages

Failure to deliver

Genetic modification is not the answer to developing super-crops. Only two traits have made it to commercial farms: herbicide resistance (in mielie plants) and insect resistance (in BT cotton plants). It was hoped that 'golden rice' would prevent vitamin A deficiency in people whose staple diet was rice but it has not yet been produced commercially. This is because, in order to meet the daily recommended levels of vitamin A, a person would need to eat 12 bowls of rice a day.

Cost

GM crops are costing farmers and governments more money than they are making. In India, BT cotton crops were costing farmers 10% more than non-BT varieties and brought in 40% lower profits.

Breeding resistance

There are reports of pest species being resistant to GM crops. Pests (diamond-back moths and mealy bugs) have developed a resistance to BT toxin. This has resulted in farmers using more toxic pesticides to control these pests in their cotton plantations.

Health risks

The results of tests on animals exposed to GM crops give serious cause for concern over their safety. For instance, in a 2006 experiment, female rats fed on herbicide-resistant soya beans gave birth to severely stunted pups, half of which died within three weeks.

In addition, there have been reports of allergy-like symptoms among Indian labourers in BT cotton fields and sheep that were allowed to graze BT cotton crops suddenly died.

Unintended harm to other organisms

Monarch butterfly caterpillars died after eating pollen from BT maize. BT toxins kill many species of insect larvae. It is not possible to design a BT toxin that would kill certain crop pests whilst remaining harmless to other insects.

Gene transfer to non-target species

A concern is that GM crop plants engineered for herbicide tolerance will cross breed with non-GM varieties. This may result in the transfer of the herbicide resistance genes from crops to the weeds. These 'super weeds' would be herbicide resistant as well.

Genetic Sameness

Seedless watermelon

hormone:
a substance produced by plants that regulates their growth and development

Many fruits today are seedless, for example grapes, bananas, watermelon and some varieties of tomatoes. Seedless fruit have the advantage over seeded fruit as people prefer eating them and they have a longer shelf life.

Scientists found that if a plant produces the plant **hormone** auxin early, some plants produce seedless fruit. Fruits in these plants will form without sexual reproduction having occurred. Scientists found the gene coding for early auxin production and inserted it into certain tomato crops. These tomatoes do not produce seeds.

Seeds house embryos which are the result of sexual reproduction. While seedless fruit is nicer to eat than fruit with seeds, it means that these fruit do not produce offspring. Scientists have grown seedless fruit through vegetative methods such as cuttings. A cutting of a stem is taken and placed in a nutrient solution which causes roots and leaves to grow. While this method of reproduction allows genetically identical plants to be produced, it results in the problem of genetic sameness.

An advantage of sexual reproduction is that the offspring are genetically different from their parents. The offspring possess a combination of the genes from their parents. This is an advantage because it ensures survival of a species should conditions change. For example, consider what could happen if an area was to experience a drought. If all plants were genetically identical this could mean that they all would die. If, however, they were genetically different, some plants would die, some would survive the drought and the species would survive.

Farmers growing plants which produce seedless fruit need to buy seedless fruit seeds each growing season or grow the next season's plants vegetatively.

ACTIVITY 6

1. Give three reasons why some farmers want to grow GM crops and why others want to grow **organic crops**.

2. Give two reasons why some shoppers want to buy GM crops and why other shoppers want to buy organic crops.

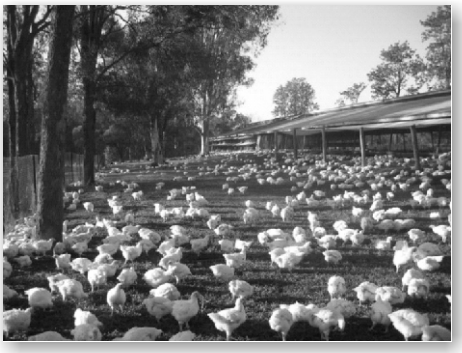
organic crops:
crops which have been grown as 'naturally' as possible. These crops have not had chemical fertilizers nor pesticides applied to them.

ANSWERS ON PAGE 151

ACTIVITY 7

Read the text about free range farms and then answer the questions:

Free Range is a term which is used to describe a method of farming where animals can roam freely for food rather than being confined to an enclosure. On many farms, the outdoor ranging area is fenced. Some free range farms use indoor housing systems. The pictures show a free range chicken farm and how free range meat is packaged for selling.



Free range chicken farm

Free range chicken

1. From the photo of the farm, would you consider this farm to be highly mechanized or labour intensive?

2. Name the primary and secondary resources needed to ensure that the farm is profitable.

3. If you were able to genetically modify chickens, what characteristics would you want to include in your 'ideal' chicken?

4. Do you think that we should try to develop a genetically modified 'ideal' chicken? Give reasons for your answers.

ANSWERS ON PAGE 151

COMMENT

The number of countries growing genetically modified crops has increased in recent years causing much debate over the safety of these products. Supporters claim it will feed the world and promote better health and ecological welfare, while others believe the food contains risks to human health.

The process of combining inter-species genes, does not have the checks and balances that are imposed by nature in traditional breeding. This means that no one can make any accurate predictions about the long-term effects of GMOs on human beings and the environment. Extensive testing is either very expensive or impractical, and there is still a great deal about the process that scientists do not understand.

This is the heart of the matter in the debate. Food is an emotional topic. It matters a great deal to all of us. We are what we eat after all.

CHECKLIST

Are you able to:

- ❒ compare the effect of using chemical and organic fertilizers on crop yield and the environment
- ❒ explain how eutrophication takes place
- ❒ discuss why pesticides are used and their impact on the environment
- ❒ list advantages and disadvantages of using machines on farms as opposed to increasing the number of farm workers
- ❒ explain how farms use both water and land
- ❒ list resources needed for grain farming and compare them to the resources needed for beef farming
- ❒ define what a genetically modified organism is
- ❒ provide an argument for using GM foods as well as an argument for **not** using GM foods.

LESSON 3

Agroforestry

About this lesson

About 40% of the earth's surface is now cultivated by some sort of agriculture. Farming has a huge impact on the environment as not only is a lot of land used, but also many resources such as water. Fortunately, there is now a growing tendency to use farming practices which are environmentally friendly. It is hoped that when damage to the environment is reduced farming will be more **sustainable**.

This lesson explores how farmers use trees (agroforestry) in their farming practices. You will look at the benefits of agroforestry to both the farmer and the environment. The lesson continues by focussing on some of the uses we have for trees. It also considers the effects of using trees from rainforests.

The lesson concludes with some problems that exotic trees have caused to the local environment.

In this lesson you will:

- find out what is meant by agroforestry and how it plays a role in making farms more sustainable
- name some uses of forests
- discuss the social and environmental effects of the destruction of rain forests
- explain the social and environmental effects of planting exotic tree species near rivers.

sustainable:
using a resource so that the resource is not used up or damaged and is available for future use.

Agroforestry

Pinus radiata *is a pine tree which farmers use together with traditional crops.*

Uses: *poles and shelter for animals. They serve as wind-breaks and as ornamental trees. They can be planted together with pastures, fruit orchards and other agricultural crops.*

Agroforestry is a system of developing agricultural land in combination with trees. Agroforestry means that a farmer grows crops or raises livestock together with growing trees or shrubs on her farm. By growing trees and shrubs the farmer should be able to make more money as well as making the farm sustainable.

For example, a fruit farmer may plant tall pine trees which serve as wind-breaks to protect his orchards. These pine trees, when tall enough, may serve as a source of poles and firewood.

The advantage of planting trees is that they increase the biodiversity of an area since they provide a habitat and food for many animals. Trees also help in preventing what is called land degradation which occurs when plants are removed from an area and soil erosion occurs. Trees help prevent land degradation as their roots hold the top soil. Trees also serve as effective wind-breaks, preventing soil erosion caused by wind. The leaves which fall from the trees form humus, which returns nutrients to the soil and improves the quality of the soil.

Agroforestry is not as simple as planting trees on farmland. Farmers need to select tree species carefully. The farmer would need to manage both trees and crops or livestock well in order to minimize the effects of **competition**. It would serve little point if trees which have been planted to serve as wind-breaks, absorb most of the nutrients from the soil. The crops (for example, mielies) planted between the trees would be badly affected if they were unable to absorb the nutrients they required.

When two species require the same resource which is limited at the same time ***competition*** *for the resource will result.*

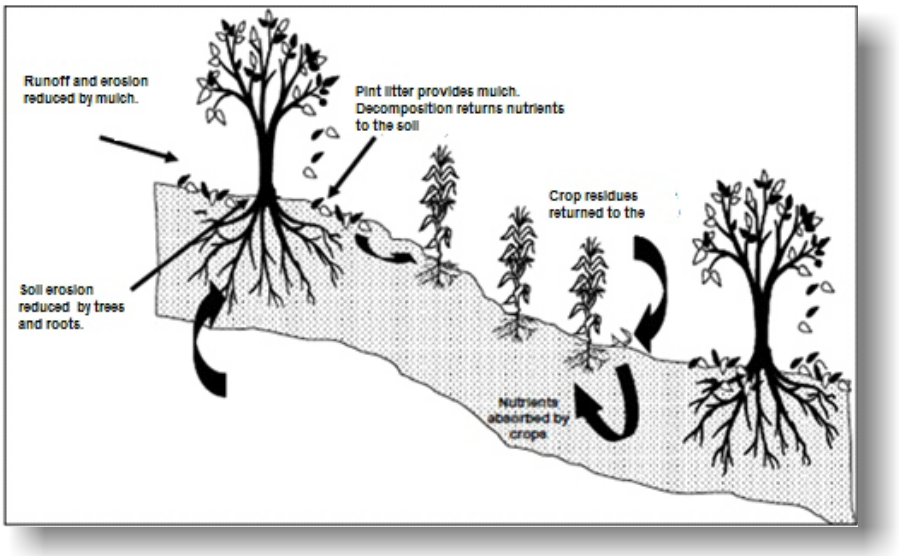
The aim of agroforestry is to develop a farming system which will:

- prevent land degradation,
- increase the biodiversity of an area
- maintain or increase agricultural production

The result should be a more profitable farming enterprise which is environmentally friendly. Correctly managed agroforests should be sustainable in that they should last for more than a few years.

ACTIVITY 1

Use the diagram below to answer the questions that follow:



1. Would you consider the above farming to practice "agroforestry"? Give a reason for your answer.

2. From the diagram, name **two** advantages that planting trees next to the crops has.

3. Name another advantage that planting trees could have.

4. What is a possible disadvantage of planting the trees so close to the crops?

ANSWERS ON PAGE 152

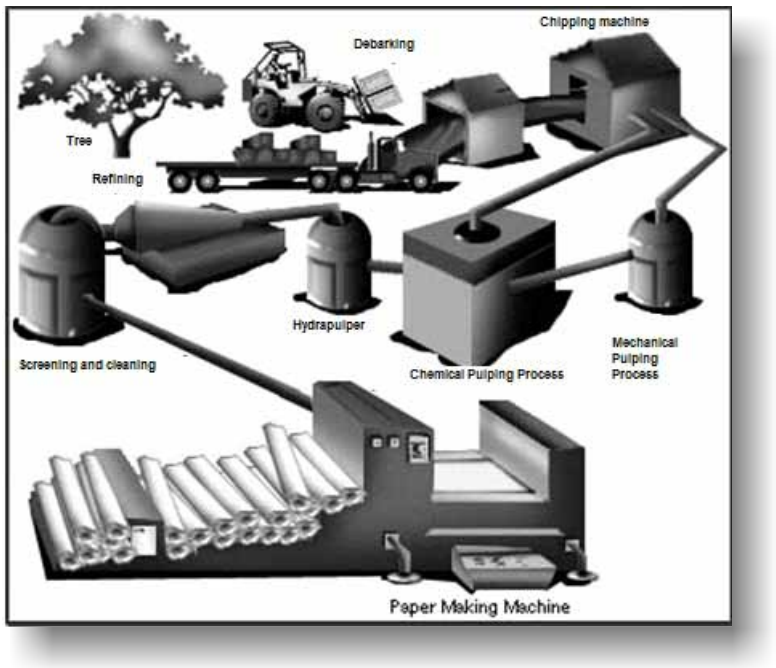
Let's look at further uses for trees, apart from being beneficial to ecosystems.

Uses of forests by man

We have used forests for a long time. Early humans used forests to obtain food, to build shelters and to make clothes. Today we still depend on forests to provide us with wood. The wood is used to make paper, furniture, building material and some wood is used as a fuel.

Wood is used as a **building material**. Roof trusses, doors, window frames and floors are often made of wood.

Many trees are planted in order to produce paper. The picture below shows how paper is made. Use the picture and the explanation to understand how paper is made. To make paper, trees are cut down. The bark is removed in a process called de-barking. The tree trunk and branches are chopped up into small pieces by a chipping machine. The chips are then sent through to the pulping process, where water and other chemicals are added to make the wood chips a sloppy mush. The wet mush is then spread out into thin sheets, which are cleaned. Following cleaning, the 'wet' paper is sent to be pressed flat and cut to size.



How paper is made today

In 2000 it was estimated that the average South African used 40kg of paper per year, whereas the average American used 332kg and the average Indian 4kg.

indigenous:
organisms which occur naturally in an area.
exotic:
an organism introduced from another area.

Wood is used to make **furniture**. It is used because it is beautiful, lasts a long time, and is easy to work with. It is relatively easy to carve the shape you want from wood. Wood from **indigenous** forests such as yellow wood tends to be more expensive as these trees are usually slow-growing. Wood from **exotic** trees such as pine and blue gum is much cheaper, as these trees grow much faster.

Wood is an important **source of energy** for cooking and heating. The wood used is usually smaller dry stems which are easy to collect and carry.

With the very many uses for wood, there is a continuous need to chop down trees. In some instances fast-growing exotic trees are planted to meet the demand. Should indigenous trees be cut down, an area could be devastated, since many indigenous trees grow very slowly.

We will now look at the effects of cutting down natural rain forests and the effect exotic trees have on our water table.

Social and environmental effects of using different types of forests

Cutting down rainforests

Before considering the effect of cutting down trees in rainforests, let's look at the important role rainforests play in maintaining various systems on Earth.

Rainforests provide a **habitat** for many plant and animal species. 70% of the Earth's land plants and animals live in forests. They help to maintain a rich **biodiversity.**

bio-diversity:
many different plant and animal species

Rainforests help **stabilize the world's environment** by absorbing carbon dioxide from the environment. These large trees with their very many leaves absorb a lot of carbon dioxide which they use during the process of photosynthesis. Increasing carbon dioxide levels in the atmosphere is thought to contribute to climate change.

What makes a rainforest?
- *Location: lies in the 'tropics'.*
- *Receives at least 2000mm of rain per year.*
- *Has a canopy (tree top cover), which is a layer of branches and leaves formed by closely spaced trees. Most of the plants and animals live in the canopy.*
- *a high level of biodiversity.*

Rainforests help **maintain the water cycle**. With so many leaves losing water through the process of transpiration, this moisture contributes to the formation of clouds. When rainforests are cut down, less moisture goes into the atmosphere and less rain falls, which may lead to drought.

Rainforests reduce **soil erosion**. The roots of trees help anchor the soil. When trees are cleared soil is easily washed or blown away.

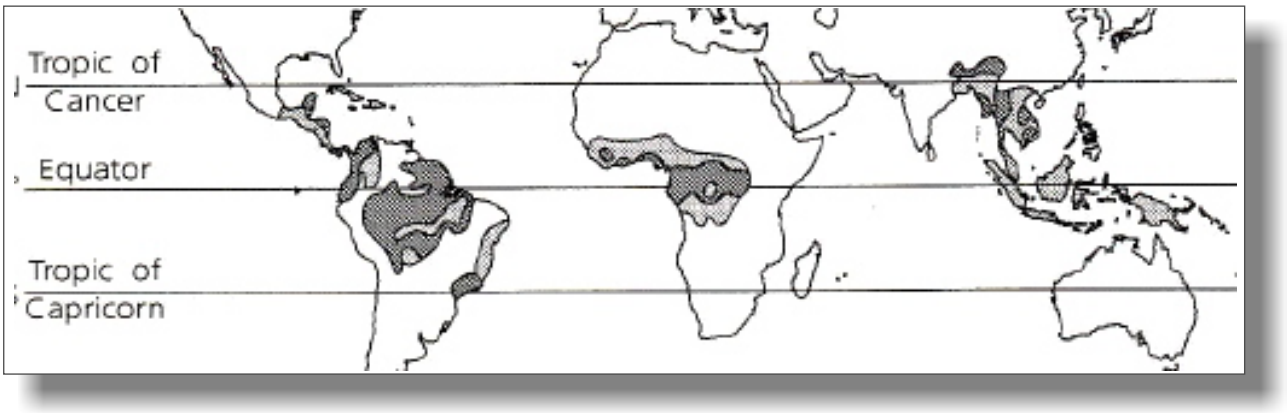
Rainforests are also important as:
- many species possess various chemicals which can be used to treat diseases.
- indigenous people are still found living in rainforests.

It is evident from the above discussion that rainforests are valuable habitats yet every year large areas of rainforests are cut down. In 2005, about 60 000km^2 of rainforests were cleared worldwide. That works out to about 5 billion trees.

One of the leading causes of rainforest destruction is logging. Logging usually involves cutting down large trees quickly. The trees are dragged through the forest to a site where they will be cut to size and transported away. As the trees are dragged through the forest, they cause further damage to the habitat. Clearing large forests areas is called deforestation. As long as there is a demand for wood from rainforests, logging will continue.

Deforestation

ACTIVITY 2



1. The map shows areas in the world where rainforests occurred and where they are still found. Which continent has the largest cover of rainforests?

2. List **three** reasons to explain why trees in rainforests are logged.

3. Explain possible environmental consequences if logging is allowed to continue without restriction.

ANSWERS ON PAGE 152

Planting water-hungry exotic trees

Many exotic trees have been brought into South Africa for various purposes, including the need for poles, fire wood, animal feed, fruit production, shelter, shade, and as **ornamentals**.

ornamentals:
plants which are planted to make gardens look pretty
transpiration:
the loss of water from the aerial parts of the plant

Many people argue that we should be planting indigenous trees instead of exotic trees as indigenous trees provide a habitat for local vegetation and use less water. Some scientists think that certain exotic trees absorb more water than indigenous trees. However, the argument that exotic trees absorb more water than indigenous trees is not as easy and straightforward as this.

Not all scientists agree that exotic trees absorb more water than indigenous trees. Some scientists argue that the amount of water a tree absorbs is linked to how much water it loses through **transpiration**. The amount of water a tree loses through transpiration is determined by many factors, including the age of a tree, the size of the leaves and the number of leaves. Trees with small, thick needle-like leaves do not lose water as quickly as trees with leaves that are flat and large.

These scientists think that factors such as the age of the tree and the characteristics of the leaf influence how much water a plant absorbs more than where the tree came from.

ACTIVITY 3

Read the following arguments regarding the future of Jacaranda trees in Pretoria and then answer the question which follows.

Jacaranda City

Adapted from: http://news.nationalgeographic.com/news/2005/09/0916_050916_triffidweed_2.html

National geographic news 28 October 2010

Jacaranda trees are an import from Argentina. They were first brought to Pretoria in 1888. A hundred years later, more than 50,000 Jacarandas are found growing in the city's streets, parks, and gardens.

South Africa's parliament passed an act that declared 198 exotic species as "weed and invader" plants. Officials recently listed the Jacaranda under a special category of invasive species, which allows the city to keep existing trees but not to replant them when they die. Pretoria would then be rid of this exotic tree. Local residents have put up such a fight that city authorities may have to allow residents to replace dead trees.

Jacaranda-Xenophobia in the name of Environment Management?
Ronnie Kasrils MP South African Minister of Water Affairs

Adapted from :http://news.nationalgeographic.com/news/2005/09/0916_050916_triffidweed_2.html

National geographic news 28 October 2010

According to available information, the Jacaranda first struck root in South African soil in 1888 when two trees were planted at a school in Arcadia. Ultimately the Jacaranda became so popular and widely planted that Pretoria became known as the Jacaranda City. It is estimated that some 55 000 Jacaranda trees occur within Pretoria. *Jacaranda mimosifolia* is a native to north-eastern Argentina where it occurs mainly along rivers in warmer-temperate sub-humid areas. Here in South Africa the tree has adapted well to warm parts of the country. It is very hardy to drought, surviving well in the northern and north-western parts of the country without much need for care and maintenance. Apart from its popularity as an ornamental and shade tree, Jacaranda also yields an attractive light coloured timber that works well and can be used for cabinet making and office furniture.

In terms of water use it is not possible to say whether Jacaranda absorbs more water than indigenous trees. Research to accurately determine the amount of water a Jacaranda tree absorbs has not been done. It is, however, generally known that deciduous trees (trees that lose their leaves in winter) are much less demanding in their water needs than their evergreen counterparts.

Write a report to the Mayor of Tshwane stating why you think Jacaranda trees should or shouldn't be eradicated from Pretoria.

ANSWERS ON PAGE 153

COMMENT

Although agroforestry is practiced worldwide in both tropical and temperate regions, agroforestry has been most extensively practiced in developing nations.
Once people started to consider the negative impacts they were having on the environment, agroforestry could help replenish natural resources. and prevent soil erosion.

CHECKLIST

Are you able to:

- ❒ define the term 'agroforestry'.
- ❒ explain how agroforestry improves the sustainability of farms.
- ❒ list some uses of forests.
- ❒ discuss the social and environmental effects of the destruction of rain forests.
- ❒ discuss the social and environmental effects of planting exotic trees, especially near rivers.

LESSON 4

Mining

About this lesson

South Africa has a large gold, diamond and platinum and copper mining industry. These minerals occur naturally in the ground as ores in the form of hard rock. Usually the desirable mineral of an ore, such as copper, must be separated from the other minerals in the ore. In this lesson you will look at various processes used to separate the mineral deposit.

You will also explore both the positive and negative aspects mining has on our economy. You will see that the mining industry generates huge income for the country, creates jobs, and spends a lot of money buying goods such as steel and paying for services such as electricity.

You will also see how mines are not safe places to work, that strikes affect the economy and the damage mining does to the environment.

In this lesson you will:

- define terms and name minerals which are mined in South Africa
- explain the difference between surface and underground mines and compare the problems associated with these mines
- explain how minerals are separated from their ores
- discuss extraction
- discuss reduction of iron
- explain the Bayer Process
- describe how aluminium oxide is electrolysed
- list ways mining has influenced the South African economy
- describe the impact mining has had on the environment
- consider whether the devastation caused by mines is outweighed by the positive economic benefits mining brings.

South African Minerals

sediment:
loose clay, silt and other soil particles originating from weathering and erosion. Sediments usually settle at the bottom of a body of water.
crystalline:
a solid substance that is shaped like a crystal.
element:
a pure substance and cannot be broken down using chemical methods.
compound:
a substance formed by the reaction of two or more chemical elements.

Mining is the action of taking minerals from the Earth. **Minerals** are naturally occurring inorganic substances found in rocks, soils or **sediment**. They have physical properties and are usually in **crystalline** form. A few minerals such as gold occur as **elements**, but most are **compounds**. Mineral deposits that are large enough to be mined profitably are called **ores**. Aluminium, copper and iron are examples of ores that we mine.

Mining is a cornerstone of the South African economy. We extract different minerals, including gold, platinum group metals, diamonds and coal from 780 mines and quarries. South Africa is one of the world's main sources of gold, platinum and chrome and we export about 78% of all mineral production to other countries.

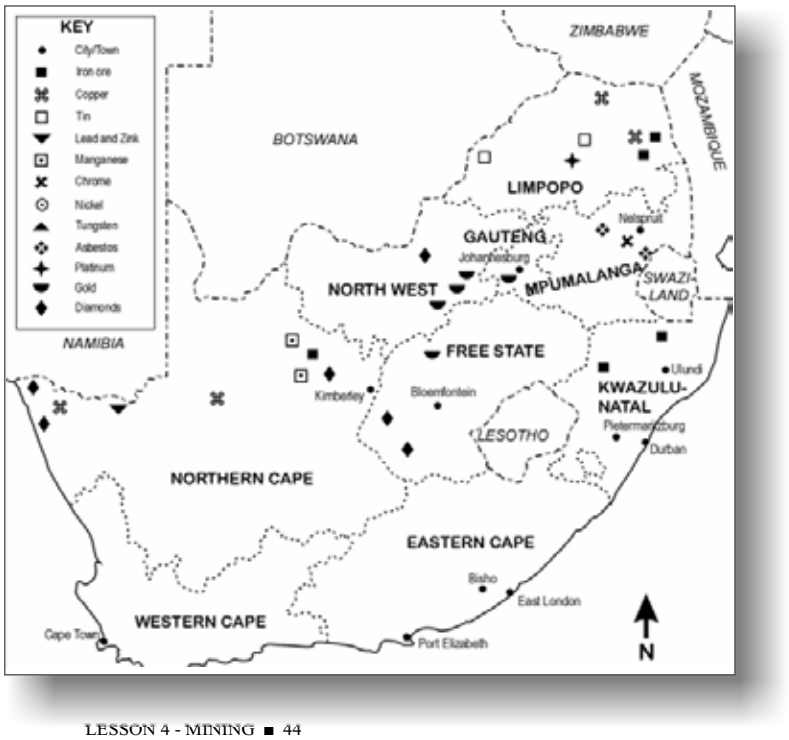
ACTIVITY 1

1. Use the map below to list the minerals mined in your province.

2. Name two economic uses for gold, coal, platinum, diamonds, iron and copper. You will find answers in Lesson 1.

3. Write a paragraph which shows how mining has benefitted your province.

4. Name two problems that mining has caused to the environment.



ANSWERS ON PAGE 153

Types of mines

Before a mining company opens a mine it needs to find out whether there is a good supply of the mineral, the depth of the mineral, whether it is cost effective to run the mine and of course follow all the mining laws laid down by government.

Once the mine begins operation, it needs to separate the ore from the rock and refine it into the pure metal. To help you understand the process of extracting ore from the rock, do the following investigation where you will model the mining process.

ACTIVITY 2

Investigation: Modelling the mining process.
You will need:
a hardboiled egg
a few toothpicks
a plastic knife
a teaspoon
a plastic drinking straw

models:
scientists and engineers use models to help them understand ideas and relationships

1. Think about how you can use the egg to model the mineral mining process. To do this you will need to think about things such as: How long will it take to extract the ore? What will you do with the waste material you don't want? When the ore has been extracted, will you be able to return the surface of the area back to its original state?

2. Ask yourself:
   a. Which part(s) of the egg could represent a mineral deposit? Why is that?
   b. What could the rest of the egg represent?
   c. Write out a method of how you propose to mine the 'mineral' deposit.
   d. How could you measure the success of your mining company when you are finished?

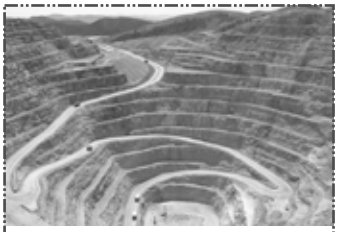
3. Put your mining plan into action. Keep a record of important data, such as the time it takes to carry out parts of the plan, how successful your mine was, and what difficulties you had. Now answer the following questions:
   e How did the egg illustrate key issues in the mining of minerals?
   f. How was the egg model unlike the mining process?
   g. What do mining companies need to think about when they decide to mine in a particular area?

ANSWERS ON PAGE 154

Mining of Ores

The deepest mines in the world are the gold mines in South Africa. Some of these mines extend 3km below the Earth's surface.

There are many methods used to mine ore, depending on where and how the ore is found. Some minerals are mined relatively cheaply because they can be found near the Earth's surface. Some minerals are found far beneath the surface and are removed by tunnelling deep underground. In some instances, the mineral to be mined may be located beneath oceans, lakes and rivers.



Open pit mining

Ores that occur near the Earth's surface are mined in **surface mines** such as open pit mining and quarrying. Coal and granite are mined in some parts of South Africa using this method. The rock is blasted, or drilled out of the earth and taken to a mill or treatment plant where the desired mineral is removed.

A quarry

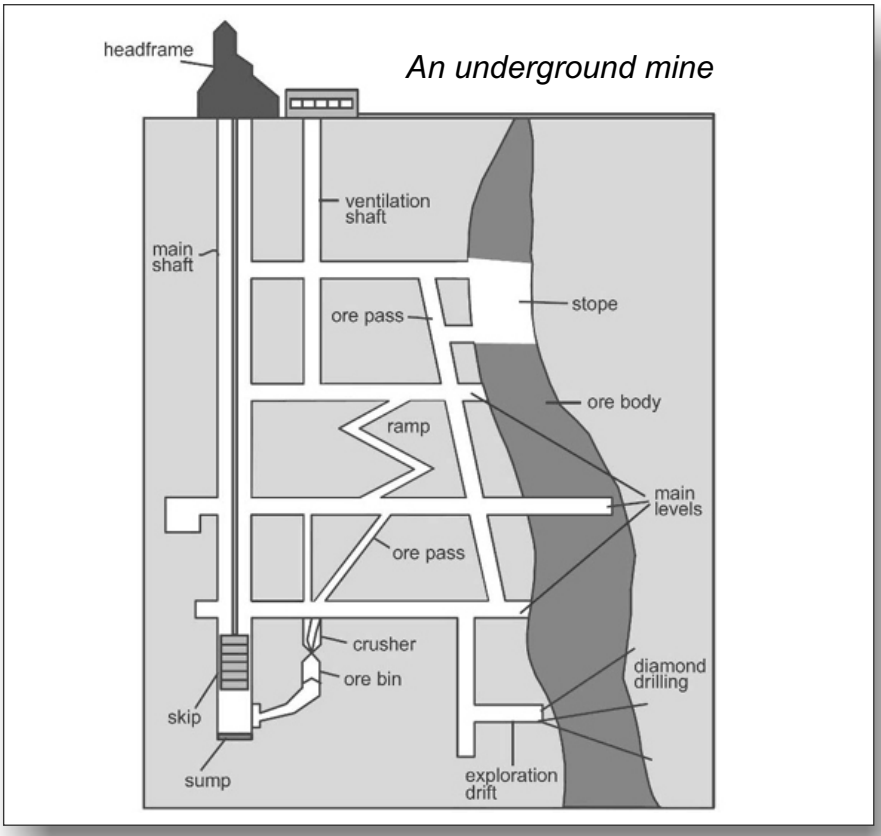
Surface mining makes huge holes on the earth's surface, which look unattractive and destroy the natural habitats of plants and animals

If ores occur below the Earth's surface, they are mined in **underground mines**. Ore containing gold is mined underground. **Shafts** are dug into the ground, often to great depths. To make sure that miners have fresh air ventilation shafts are drilled to help remove dust and poisonous gases from underground.

shafts:
tunnels

stope:
removal of unwanted ore from an underground mine, leaving an open space behind the stope.

An underground mine



As in surface mines, the rock needs to be blasted or drilled into smaller pieces of rock which are transported to an extraction plant to remove the mineral.

Underground mines have problems. Rock falls are a constant danger as are sinkholes. Mines damage the environment as plants cannot grow on the waste rock and sand which are deposited in unattractive dumps on the Earth's surface.

Factors that determine the type of mining method used

Mining engineers consider the following factors when deciding to open a mine:

- Is the deposit deep or close to the surface?
- The extent and spread of the deposit. If the deposit is in a small contained area, deep mining would be considered.
- The type of mineral found.
- Can the mineral be sold for more than it costs to mine?
- How will the material be transported and processed?
- How will the mine affect the environment?

ACTIVITY 3

1. What dangers are associated with mining at great depths?

2. How are miners provided with oxygen when working underground?

3. Why must ore be crushed before it is brought to the surface?

4. Discuss the advantages and disadvantages of surface mining.

ANSWERS ON PAGE 154

Methods of extracting and separating minerals from their ores

There are many techniques used to separate a mineral from the ore. The decision on which technique to use depends on the mineral's physical and chemical properties. Let's look at how these techniques work in a little more detail.

Density

The crushed material is put into a liquid with a density that lies between the density of the desired mineral and the density of the unwanted materials. The mineral floats or sinks, and the unwanted materials do the opposite. This is called float-sink separation.

Chemical Properties

The crushed material is put into a solvent. The desired mineral dissolves into this solvent and is poured off in solution. The unwanted material is left behind.

Fracture Properties

With some ores, the desired mineral tends to break into either larger or smaller particles than the unwanted minerals. The material is passed through a sieve or a filter to separate the ore minerals from the unwanted minerals by particle size.

Froth Flotation

hydrophobic:
a chemical that does not mix with water

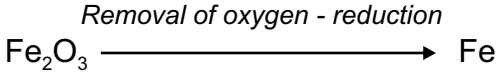
The ore is first crushed and treated with a chemical that causes the desired mineral to stick to certain particles. These particles will make the mineral hydrophobic. A **hydrophobic** particle does not mix with water, as when oil mixes with water. The oil is said to be hydrophobic because it does not mix with the water. So, for example, pine oil is used to bind copper compounds, but not the unwanted rocky material.

The treated ore (pine oil and copper compounds) is then put in a large bath of water containing a foaming agent (a soap or detergent of some kind). Air is blown through the mixture to make a lot of bubbles. Because the mineral is hydrophobic, the coated particles of the metal compound tend to be picked up by the air bubbles. The bubbles float to the top of the bath and are allowed to flow out over the sides. The rest of the rocky material stays in the bath.

Reducing the metal compound to the metal

It is sometimes possible to separate a mineral from its rock by reducing the metal compound. At its simplest, the ore is reduced because oxygen is removed.

In the example below iron is produced by reducing haematite (Fe_2O_3).



In the next example, aluminium is produced by reducing bauxite (Al_3O_2).

Removal of oxygen - reduction

$$Al_2O_3 \longrightarrow Al$$

It is much more helpful to use the definition of **reduction** in terms of addition of electrons. To a reasonable approximation, ores can be thought of as containing positive metal ions. To change them to a metal, electrons need to be added – a reduction. The two examples above can be written as follows:

> ***oxidation:***
> *a chemical reaction in which electrons are lost from an atom or ion.*
> ***reduction:***
> *a chemical reaction in which electron/s are added to an atom or ion.*

Addition of electrons = reduction

$$Fe^{3+} + 3e^- \longrightarrow Fe$$

Addition of electrons = reduction

$$Al^{3+} + 3e^- \longrightarrow Al$$

The chemical which donates the electrons for the reduction reaction is called the reducing agent. Carbon is sometimes used as a reducing agent. In other instances, a more reactive metal such as sodium (Na) or magnesium (Mg) could be used. Let's look at both carbon reduction and reduction using a reactive metal in more detail.

Carbon Reduction

Carbon (as charcoal) is cheap and is often used as a reducing agent. (The carbon donates the electrons.) Carbon also has the advantage that it can act as the fuel to provide heat for the reaction.

Reduction using a more reactive metal

Titanium is produced by reducing titanium (IV) chloride using a more reactive metal such as sodium or magnesium.

$$TiCl_4 + 2Mg \longrightarrow Ti + 2MgCl_2$$

The more reactive magnesium releases electrons easily as it forms its ions:

$$2Mg \longrightarrow 2Mg^{2+} + 4e^-$$

These electrons are used to reduce the titanium (IV)chloride:

$$TiCl_4 + 4e^- \longrightarrow Ti + 4Cl^-$$

It is expensive to use reactive metals and so the extraction of titanium expensive.

Reduction by electrolysis

molten:
melted, usually by a great amount of heat
emersed:
standing out of or rising above the surface of a fluid
electrolysis:
breaking down of chemical compounds using electricity

Electrolysis is a common extraction process for the more reactive metals, for example sodium. The diagram below shows the electrolysis of sodium chloride.

A source of direct current is connected to a pair of electrodes **emersed** in **molten** sodium chloride (NaCl). As the salt has been heated to melt it, the Na^+ ions flow toward the negative electrode and the Cl^- flow towards the positive electrode.

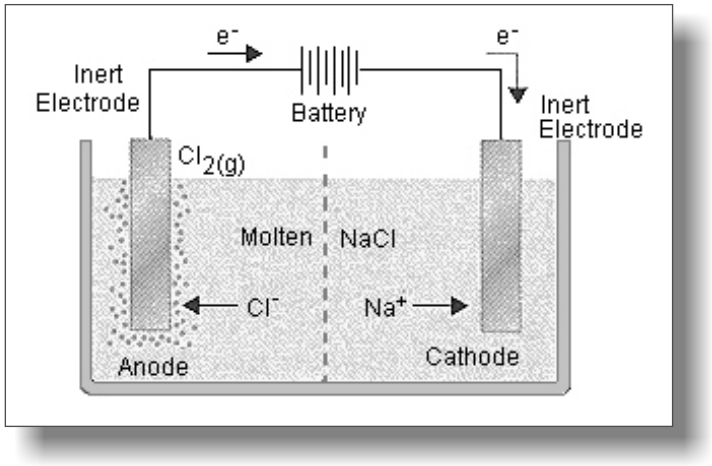


Diagram showing electrolysis of molten NaCl

When Na^+ ions collide with the negative electrode (cathode) the battery carries a large enough potential to force these ions to pick up electrons to form sodium metal.

At the cathode: $Na^+ + e^- \rightarrow Na$

Cl^- ions that collide with the positive electrode (anode) are oxidized to Cl_2 gas, which bubbles off at this electrode.

At the anode: $2Cl^- + \rightarrow Cl_2 + 2e^-$

(l) means that the chemical occurs as a liquid.
(g) means that the chemical occurs as a gas.

The net effect of passing an electric current through the molten salt (NaCl) is to decompose sodium chloride into its elements, sodium and chlorine gas. This example explains why this process is called electrolysis. Electrolysis uses an electric current to split a compound into its elements.

$2NaCl_{(l)} \rightarrow 2Na_{(l)} + Cl2_{(g)}$

As you can see from the above descriptions, there are a lot of techniques which can be used to separate minerals from their ores. When deciding which method to use, mining engineers take into consideration various factors, including the reactivity of mineral they want to extract.

The table below shows the reactivity of metals and the methods of separation that are used for each metal.

Reactivity	Name of metal	Symbol	Method of separation
Most reactive	Sodium	Na	Electrolysis of molten compound.
	Calcium	Ca	
	Magnesium	Mg	
	Aluminium	Al	
	Zinc	Zn	Reduction of ore using carbon.
	Iron	Fe	
	Nickel	Ni	
	Tin	Sn	
	Lead	Pb	
	Copper	Cu	Heating ore in air.
	Mercury	Hg	
	Silver	Ag	Occur as elements in the ground.
Least reactive	Gold	Au	

In the process of extracting and separating minerals from their ores mines produce a lot of waste material. Ore which is not needed is called the gangue material and remains as a loose material, the **tailings**. Sometimes the tailings are buried back in the ground, but often they are left on the surface as waste. Rainwater can leach toxic chemicals from the tailings left on the surface. These chemicals may find their way into streams and rivers. Protecting the environment from the effects of tailings is an important goal in mining.

ACTIVITY 4

Can you separate a mixture of salt and sand?
If you know some differences between the substances in the mixture, you can separate substances.

Problem: You have a mixture of salt and sand. How can you get pure salt from this mixture of salt and sand?

Apparatus: funnel, beaker, evaporating dish, test tube, Bunsen burner/ spirit burner, water, salt, sand, filter paper, teaspoon, matches.

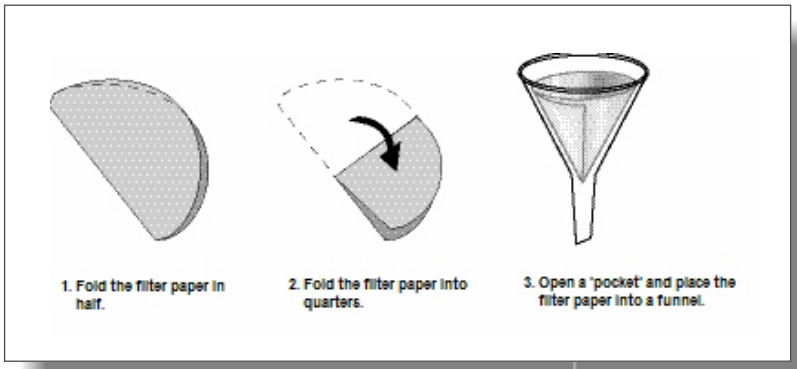
Method:

1. Place two teaspoons of salt and sand in a beaker.

2. Add about half a test tube full of water to the mixture in the beaker.

3. Stir the water for about 1 minute until all the salt is dissolved.

4. Fold the filter paper as shown in the diagram below.



5. Put the filter paper in the funnel.

6. Slowly pour the muddy water onto the filter paper in the funnel.

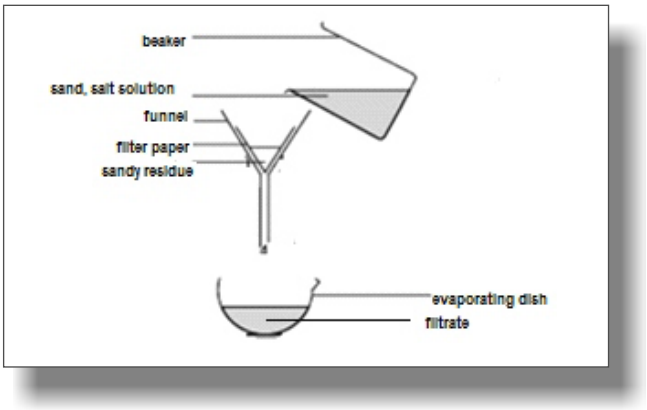


Diagram showing how to filter muddy, salty water

7. Observe the water in the evaporating dish. Answer the questions that follow:
   a. Describe the water in the evaporating dish.
   b. Where is the mud?
   c. The water in the evaporating dish is called the filtrate. What does the word filtrate mean?
   d. The mud on the filter paper is called the residue. What does the word residue mean?

e. Complete the sentences below:
   i. Mud and water are made up of particles. The difference between mud and water is that mud particles are _____ (bigger/ smaller).
   ii. The holes in the filter paper are _____ (bigger/ smaller) than the mud particles. But the holes in the filter paper are _____ (bigger / smaller) than water particles.

8. Pour out about half of the filtrate (salt solution) from the evaporating dish.

9. Heat the remaining solution in the evaporating dish. Keep on heating until you see a white powder on the sides of the basin.

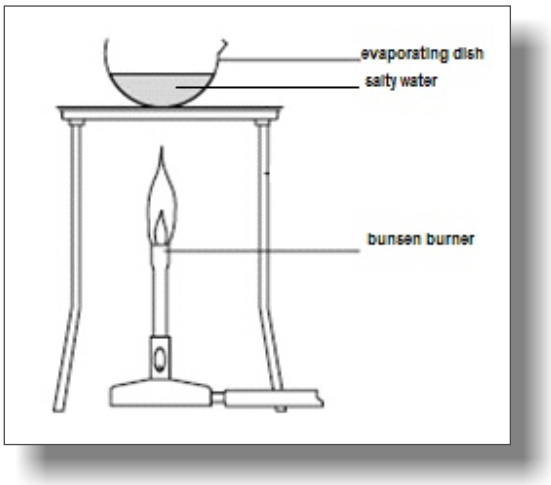


Diagram showing how to separate salt from water

10. Answer the questions that follow:
   a. Make a hypothesis for this experiment. The white powder is _____ (salt/a substance from the flame, dry water.)
   b. The white powder tastes _____ (sweet/sour/bitter/salty).
   c. Why do you need water to separate the salt from the sand and water mixture?
   d. The **difference between salt and sand** is that salt _____ in water but sand cannot _____ in water.
   e. The **difference between salt and wate**r is that _____ evaporates but _____ does not evaporate.

ANSWERS ON PAGE 155

Specific mineral extraction and separation

Having looked at some of the general techniques used to separate minerals from the ores, you will now look at how some minerals are extracted. The minerals you will look at in more detail are iron, copper, gold and aluminium.

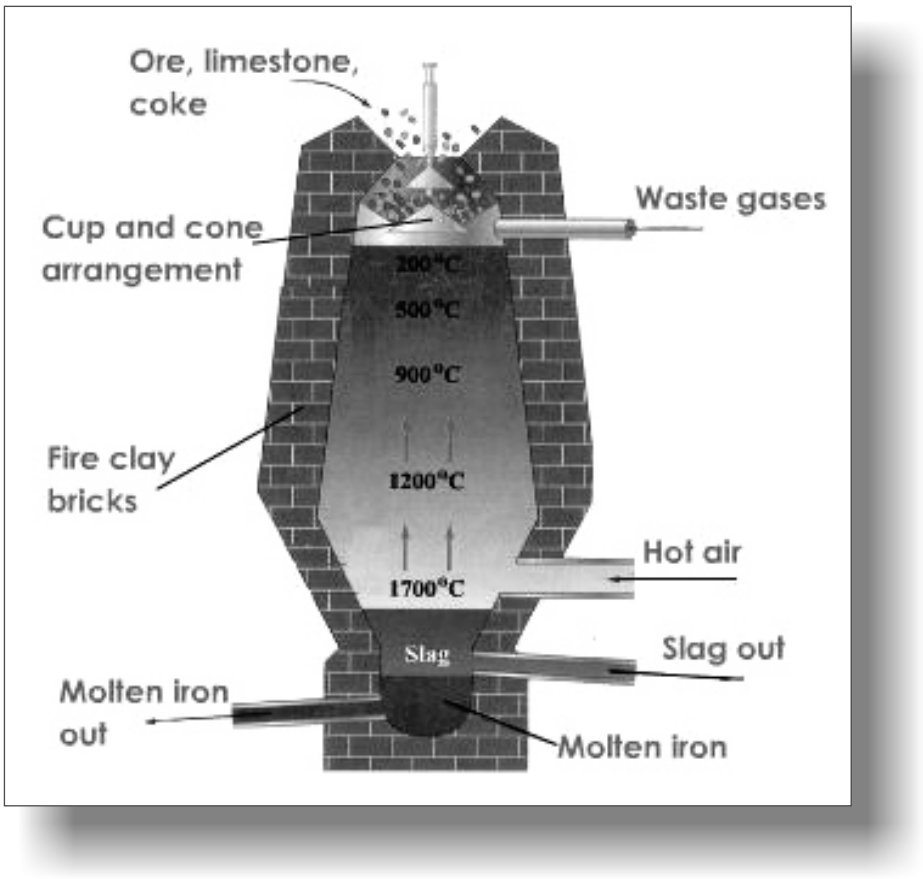
Iron

***Coke** is produced by heating coal in the absence of air. Coke is cheap and provides both the reducing agent for the reaction and also the heat source.*

The common ores of iron are iron oxides. Iron is extracted from iron ore using a blast furnace. Iron processing requires very high temperatures and has to react with something that will remove the oxygen from the ore. The reduction of iron can be achieved by heating iron ore with carbon (e.g. **coke**). The most commonly used iron ore is haematite Fe_2O_3.

Let's see how to extract iron from haematite in a blast furnace.

The Blast furnace



Iron ore, coke and limestone are dropped into the top of the blast furnace. Hot air, which comes from the hot waste gases, is blown into the bottom of the furnace. The coke burns in the blast furnace, forming carbon dioxide.

This is a strongly exothermic reaction, giving off a lot of heat. Temperature in a blast furnace can reach 2 200 °C.

The reaction of coke burning

$$C + O_2 \longrightarrow CO_2$$

is the main source of heat in the furnace.

At such high temperatures, carbon dioxide reacts with carbon to produce carbon monoxide.

$$C+CO_2 \longrightarrow 2CO$$

It is the carbon monoxide which is the main reducing agent in the furnace.

$$Fe_2O_3 +3CO \longrightarrow 2Fe +3CO_2$$

The carbon dioxide escapes through the top of the furnace. In the hotter parts of the furnace, the carbon itself also acts as a reducing agent. Fe is produced by reducing the haematite (Fe_2O_3).

$$Fe_2O_3 +3C \longrightarrow 2Fe +3CO$$

The temperature of the furnace is so hot it melts the iron. The iron trickles down to the bottom of the furnace where it is collected.

The limestone ($CaCO_3$) which was added to the furnace with the ore and coke decomposes to form calcium oxide (CaO).

$$CaCO_3 \longrightarrow CaO + CO_2$$

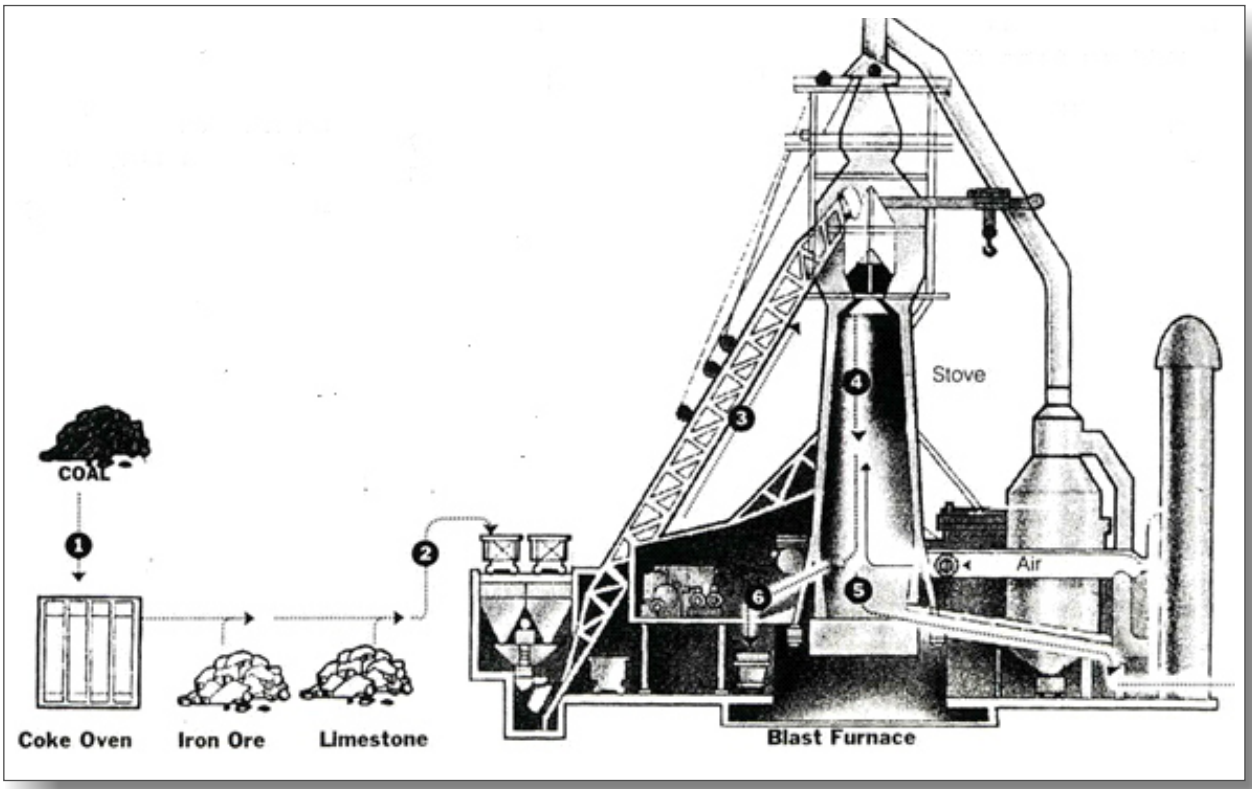
The CaO reacts with sand, air and other substances to form slag. The molten slag falls to the bottom of the furnace where it floats on top of the molten iron. The slag is tapped off and used to make cement.

The iron which has been extracted from the ore is used to make the iron **alloys**: cast iron and steel. Cast iron is used to make manhole covers, drain pipes and car engines and steel is used in buildings houses, railway tracks, and in kitchen appliances.

alloy:
a mixture of metals whose composition varies widely, unlike a compound. This is why one cannot write down the composition of an alloy as a chemical formula.

ACTIVITY 5

Use the numbers in the diagram to explain each step in the extraction of iron from iron ore.



ANSWERS ON PAGE 155

Copper

In South Africa, chalcopyrite ($CuFeS_2$) is the most common ore that copper is found in. Chalcopyrite is mined and processed extensively in the northern parts of South Africa (see the map in Activity 1 of this lesson). Chalcopyrite usually contains low percentages of copper. The copper has to be extracted and separated from its ore using the following processes:

- Froth flotation
- Roasting
- Electrolysis

Froth flotation

slurry:
a semi-liquid mixture typically of fine particles mixed with water

- The first stage of extracting copper from chalcopyrite involves grinding the ore to produce small particles.
- The ore is then wetted and suspended in a **slurry**.
- The slurry is mixed with reagents which make the copper sulphide particles hydrophobic.
- The treated slurry is placed in a water aeration tank. The chemicals in the aeration tank cause froth to form. Air is forced through the treated slurry.

- The air bubbles attach to the hydrophobic copper sulphide particles and move to the top of the aeration tank.
- Once the bubbles reach the surface a froth is formed which is collected, concentrated in a launder, filtered and then sent to a copper smelter, where it is roasted.
- The part of the slurry which did not float is either removed as tailings or processed to extract other metals.

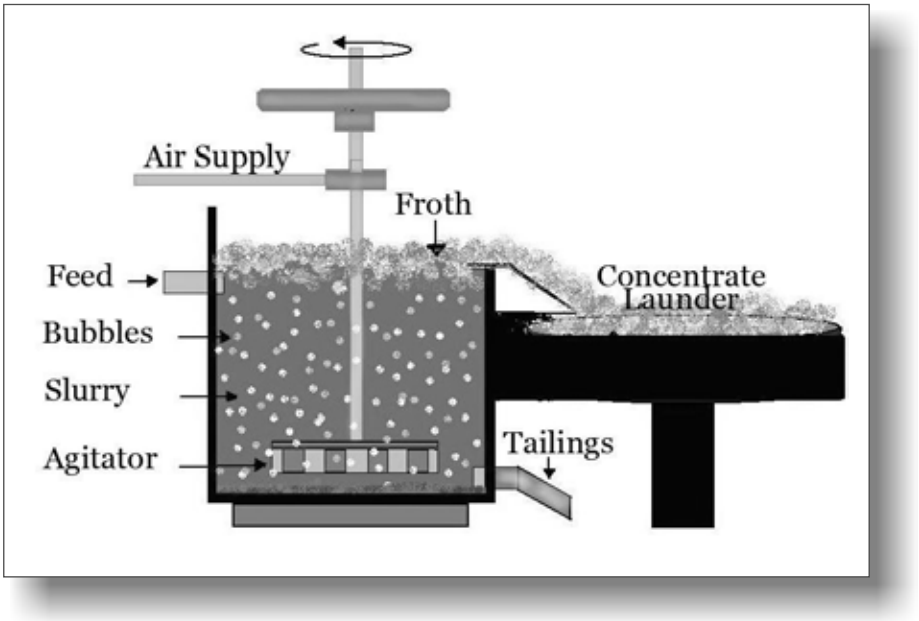


Diagram showing froth flotation

Roasting

The concentrated copper is heated with silicon dioxide (silica) and air (containing oxygen) in a furnace or series of furnaces.

- The copper(II) ions (in the chalcopyrite) are reduced to copper(I) sulphide.
- Most of the sulphur in the chalcopyrite turns into sulphur dioxide gas.

$$2CuFeS_2 + 2SiO_2 + 4O_2 \longrightarrow Cu_2S + 2FeSiO_3 + 3SO_2$$

The copper(II) sulphide produced is converted to copper with a final blast of oxygen.

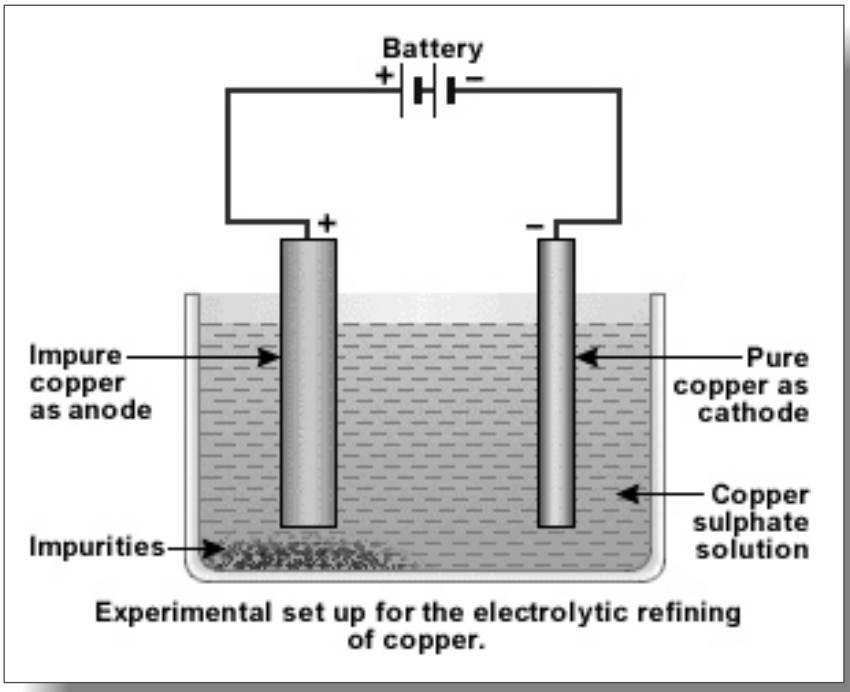
$$Cu_2S + O_2 \longrightarrow 2Cu + SO_2$$

The end product is called blister copper, a porous brittle form of copper, which is moulded into anode blocks, which are used in the next step of the copper extraction and separation: electrolysis.

Electrolysis

The impure copper is cast into a block to form the positive **anode**. The negative **cathode** is made of previously purified copper. These are placed into an **electrolyte** of Cu(II) sulphate solution.

electrolysis:
The production of chemical changes by passing current through an electrolyte.
electrode:
Conductor through which electricity flows.
electrolyte:
a substance containing free ions that make the substance electrically conductive.
anode:
The electrode where oxidation takes place.
cathode:
the electrode where reduction



Experimental set up for the electrolytic refining of copper.

When electrical current is passed through the solution, electrolysis takes place. The copper anode is oxidised, forming copper(II) ions, Cu^{2+}. The positive copper ions are attracted to the negative cathode and become reduced to copper atoms. The mass of copper dissolving at the anode equals the mass of copper depositing on the cathode. The concentration of the copper(II) sulphate remains constant.

At the cathode, copper(II) ions are deposited as copper.

$$Cu^{2+}_{(aq)} + 2e^{-} \longrightarrow Cu_{(s)}$$

(s) the chemical is in a solid state.
(aq) means that the chemical is in an aqueous solution. An aqueous solution is a solution in which water is the solvent.

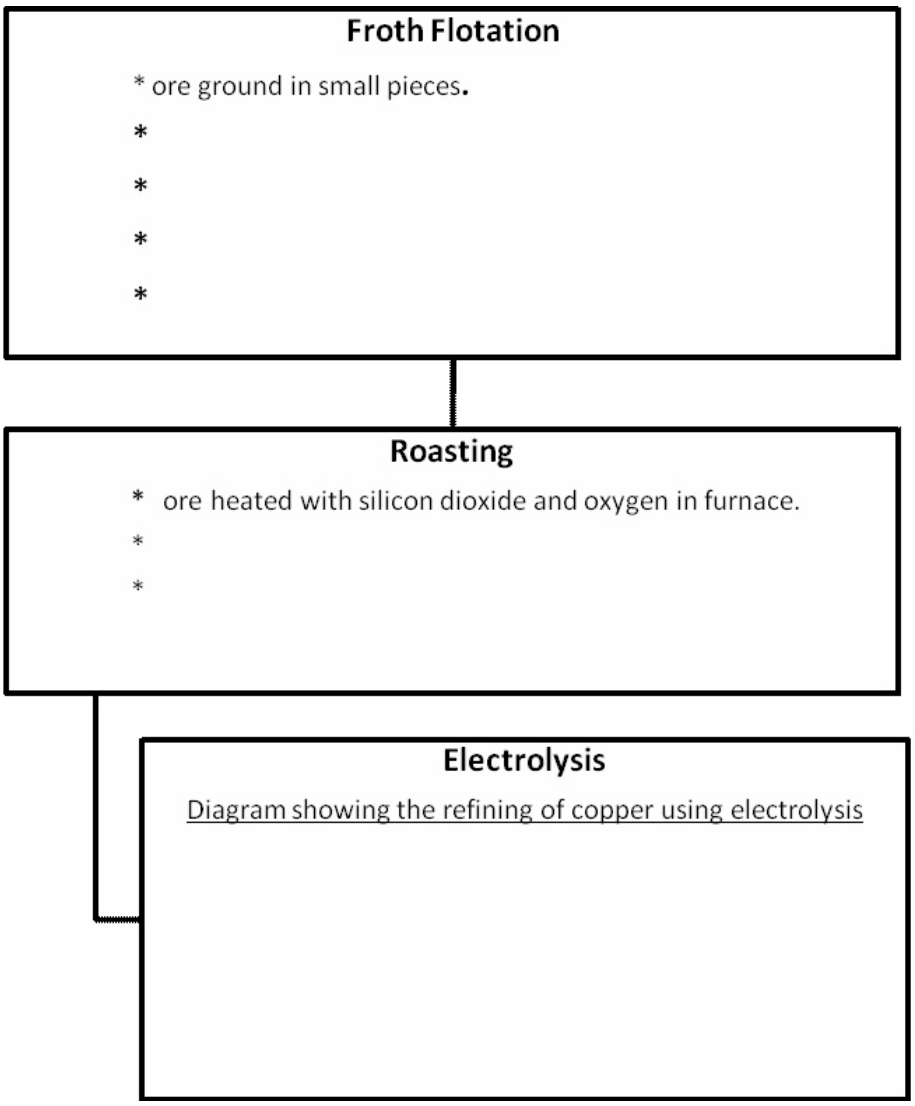
At the anode, copper goes into solution as copper(II)ions.

$$Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2e^{-}$$

Any impurities present in the impure copper anode fall to the bottom of the electrolysis cell tank. The impurity sludge is not a complete waste as it could contain valuable minerals, for example silver.

ACTIVITY 6

Complete the flow chart showing how copper is processed.
Include balanced chemical reactions.



ANSWERS ON PAGE 156

Gold

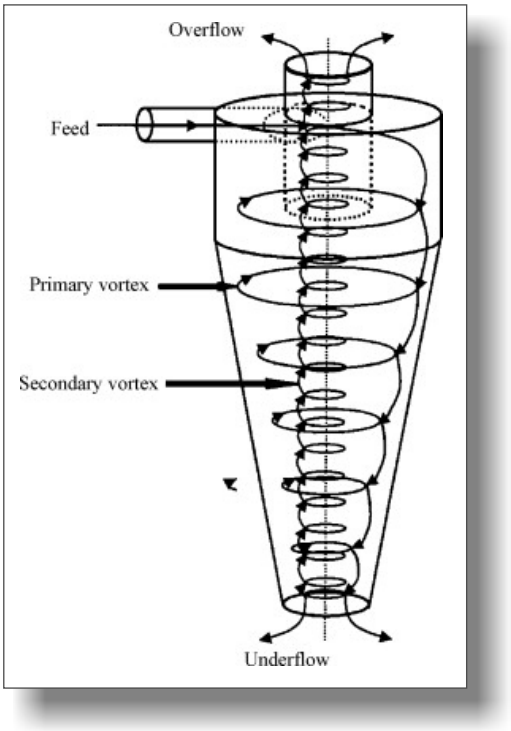
- The ore containing gold is crushed into a powder and water is added to form a slurry.
- The slurry is spun around very fast in a hydrocyclone which uses centrifugal force to separate particles by size, particle density, and particle shape. The fine particles move on for leaching; the larger particles are returned for further grinding.
- In the leaching process the particles are treated with a dilute solution of KCN (potassium **cyanide**) in the presence of atmospheric oxygen.

Gold reacts to form an aurocyanide complex ($KAu(CN)_2$):

$4Au + 8KCN + 2H_2O + O_2 \rightarrow 4KAu(CN)_2 + 4KOH$

Gold is then extracted using zinc dust.

$2KAu(CN)_2 + Zn \rightarrow K_2Zn(CN)_4 + 2Au$



A hydrocyclone

You can get cyanide poisoning from breathing in or swallowing cyanide. It is highly toxic as it stops cellular respiration. Symptoms of poisoning are dizziness, loss of consciousness and ultimately death.

ACTIVITY 7

You have been appointed as a chemical engineer on a gold mine. Gold needs to be extracted from the ore.

a. Explain the process to the mineworkers so that they will understand what they have to do.
b. Write down the names and formulae of substances present in the waste material.
c. Suggest a plan to deal with the waste as safely as possible.

ANSWERS ON PAGE 156

Aluminium

Aluminium is produced from bauxite. Bauxite contains a number of impurities, including iron oxide and silica. The ore needs to be treated to get rid of these impurities.

This requires two processes:

1. The Bayer process where aluminium oxide is separated from bauxite.
2. Aluminium metal is produced from aluminium oxide during electrolysis.

1. The Bayer process

- Crushed bauxite is treated with a sodium hydroxide solution and pumped into large tanks. In the large tanks the ore is subjected to steam heat and pressure. With hot concentrated sodium hydroxide solution, aluminium oxide reacts to give a solution of sodium tetrahydroxoaluminate ($NaAl(OH)_4$).

  $$Al_2O_3 + 2NaOH + 3H_2O \longrightarrow 2NaAl(OH)_4$$

- The impurities in the bauxite remain as solids. All of these solids are separated from the sodium tetrahydroxoaluminate solution by filtration. They form a 'red mud' which is removed.

- The sodium tetrahydroxoaluminate solution is cooled, and 'seeded' with previously produced aluminium hydroxide. This provides something for the new aluminium hydroxide to **precipitate** around:

  $$NaAl(OH)_4 \longrightarrow Al(OH)_3 + NaOH$$

- The last step of the Bayer process is the formation of aluminium oxide. Aluminium oxide (alumina) is made by heating the aluminium hydroxide ($Al(OH)_3$) to a temperature of about 1100-1200°C.

  $$2Al(OH)_3 \longrightarrow Al_2O_3 + 3H_2O$$

precipitate: *when a solid substance is separated from a solution*

The Bayer process is necessary as it results in the removal of impurities from the bauxite. The next step in the extraction of aluminium is to separate the aluminium from the alumina. This is achieved using electrolysis.

2. Conversion of the aluminium oxide into aluminium by electrolysis

*A **smelter** uses heat and a chemical reducing agent to decompose an ore. Unwanted elements are lost as gases or slag, leaving a metal behind.*

In a modern **smelter**, alumina is dissolved in reduction pots deep, rectangular steel shells lined with carbon. The pots are filled with an electrolyte, cryolite. Cryolite is a compound consisting mostly of sodium, aluminium, and fluorine (Na_3AlF_6).

The diagram below shows a very simplified version of aluminium electrolysis.

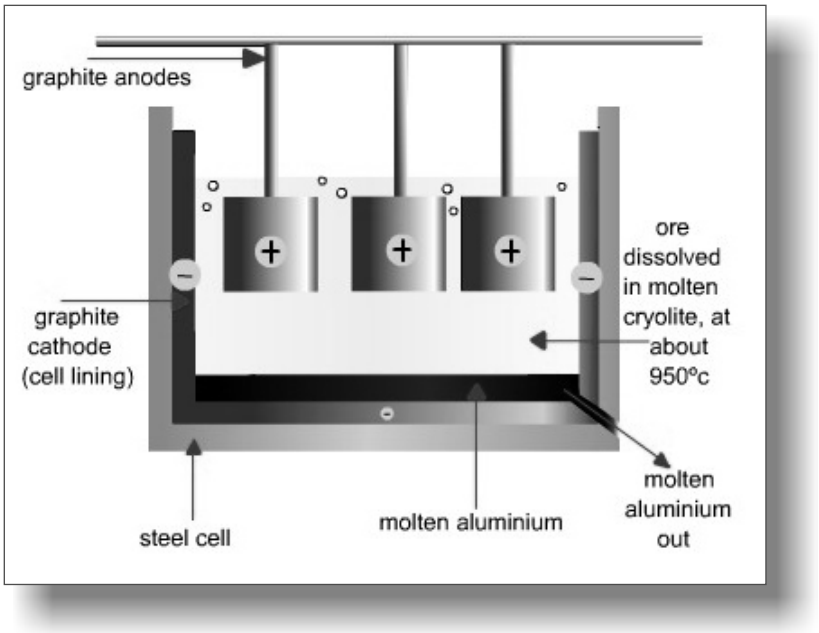


Diagram showing electrolysis of Alumina

By means of carbon anodes, direct current is passed through the electrolyte to a carbon cathode lining at the bottom of the cell. An aluminium crust forms on the surface of the molten bath. Alumina ($Al(OH)_3$) is added on top of this crust.

The cell operates at a low voltage of about 5-6 volts but at huge currents of 100 000 amperes or more. The heating effect of these large currents keeps the cell at a temperature of about 1000°C. The heat is used to keep the bath in a molten condition so that fresh alumina dissolves.

It is very expensive to extract aluminium from bauxite. The best way of producing aluminium is to recycle old aluminium which is cheaper and saves energy.

The electrode reactions:
Aluminium is released at the cathode. Aluminium ions are reduced by gaining 3 electrons.

$$Al^{3+} + 3e^- \longrightarrow Al$$

Oxygen is produced initially at the anode

$$2O^{2-} \longrightarrow O_2 + 4e^-$$

However, at the high temperatures of the cell, the carbon anodes burn in this oxygen to give carbon dioxide.

The result of electrolysis is the removal of molten aluminium on the bottom of the cell. Carbon dioxide is released at the carbon anodes.

ACTIVITY 8

1. Write a list of the chemical reactions used in the Bayer process.

2. Explain how aluminium is produced by the electrolysis of alumina (aluminium oxide).

ANSWERS ON PAGE 157

You have looked at the various processes involved in mining, extracting and separating iron, copper, gold and aluminium from their ores.

You are now going to look at the effect this mining has on both the economy and the environment.

The effect of mining on the economy

South Africa's mining industry is an important sector of our economy. Many products are made from the extracted minerals; employment is created and minerals are exported.

However mining is dangerous. When rocks are broken underground gases escape. Some of these gases, for example methane, cause explosions.

ACTIVITY 9

Read the article, which has been adapted from the *Financial Mail*, and then answer the questions that follow.

In 1980, South Africa accounted for over 70% of world gold production. In 2004, that figure was a low 14%. Chamber of Mines figures showed that SA's annual gold production the previous year slipped to its lowest level since 1931.
Chamber economist Roger Baxter says the fall in production was caused by the fall in the rand gold price due to the strong rand, and the continued upward rise in costs. Many of these costs are 'costs we do not have control over'. These include water, transport, steel and labour costs, which rose by 13% on average in 2004.

- Water prices have risen by 10% per year for the past 3 years
- Steel prices have increased.
- Spoornet's tariffs rose 35% in 2003 and 16.5% in 2004
- Labour costs, which make up 50% of production costs, rose above inflation in 2003 and 2004

At these costs, and at current rand gold prices, about 10 mines, employing 90 000 people, are not making much money.

Refer to the table on the next page showing SA's gold production in tons between 1980 and 2004.

Year	Production (t)
1980	675
1985	660
1990	600
1995	525
2000	425
2004	340
Table 1	

1. Draw a line graph to illustrate these statistics.

2. What percentage did South Africa's gold production contribute towards global production in:
   a. 1980
   b. 2004

3. Outline two reasons for this drop in gold production.

4. Briefly explain how the increased cost of resources such as water contributes towards declining profitability in gold mines.

5. Suggest a reason why the cost of steel might affect gold production.

6. Suggest what impact a decrease in gold production is likely to have on:
   a. South Africa's economy
   b. mine employees.

7. Find out what the current price of gold is. Discuss why you think gold is so expensive.

ANSWERS ON PAGE 157

The effect of mining on the environment

Mines can seriously damage the environment if they are not managed properly. Mining activities cause damage to the habitats in areas where the mine is located. It is important that the damage which the mine causes to the environment is limited. When planning a mine, part of the plan needs to include how the mining company will rehabilitate the area once the mine is closed. The damage caused by mines is not limited to habitat destruction but may also include air and water pollution.

Water is used extensively in the mining industry, to wash rock waste and recover minerals. The polluted water is unsuitable for direct reuse.

Look at the table on the next page which lists things that pollute water.

Main categories	Pollutants
Physical	Suspended solids Colour Temperature Taste and odour
Organic chemical	Coal Oils and grease Soaps and detergents Rubber
Inorganic chemical	Heavy metals (e.g. Zn, Pb, Ni) Cyanide Dissolved salts (Ca^{2+}, Cl^-)
Biological	Bacteria Viruses
Radiological	Uranium Titanium

If water from mines is left untreated it could contain heavy metals, and suspended and dissolved solids. When this water seeps into ground water, rivers, streams or dams, it pollutes these water bodies.

There is a real concern that acid mine drainage could affect drinking water on the East Rand in Gauteng. Acid mine drainage could also affect water used in irrigation. Mining companies are required to control their acid mine drainage. It is necessary that water quality is continually monitored to ensure that it remains clean.

Another potential problem that mining companies need to manage are tailings dams.

Disposal of tailings

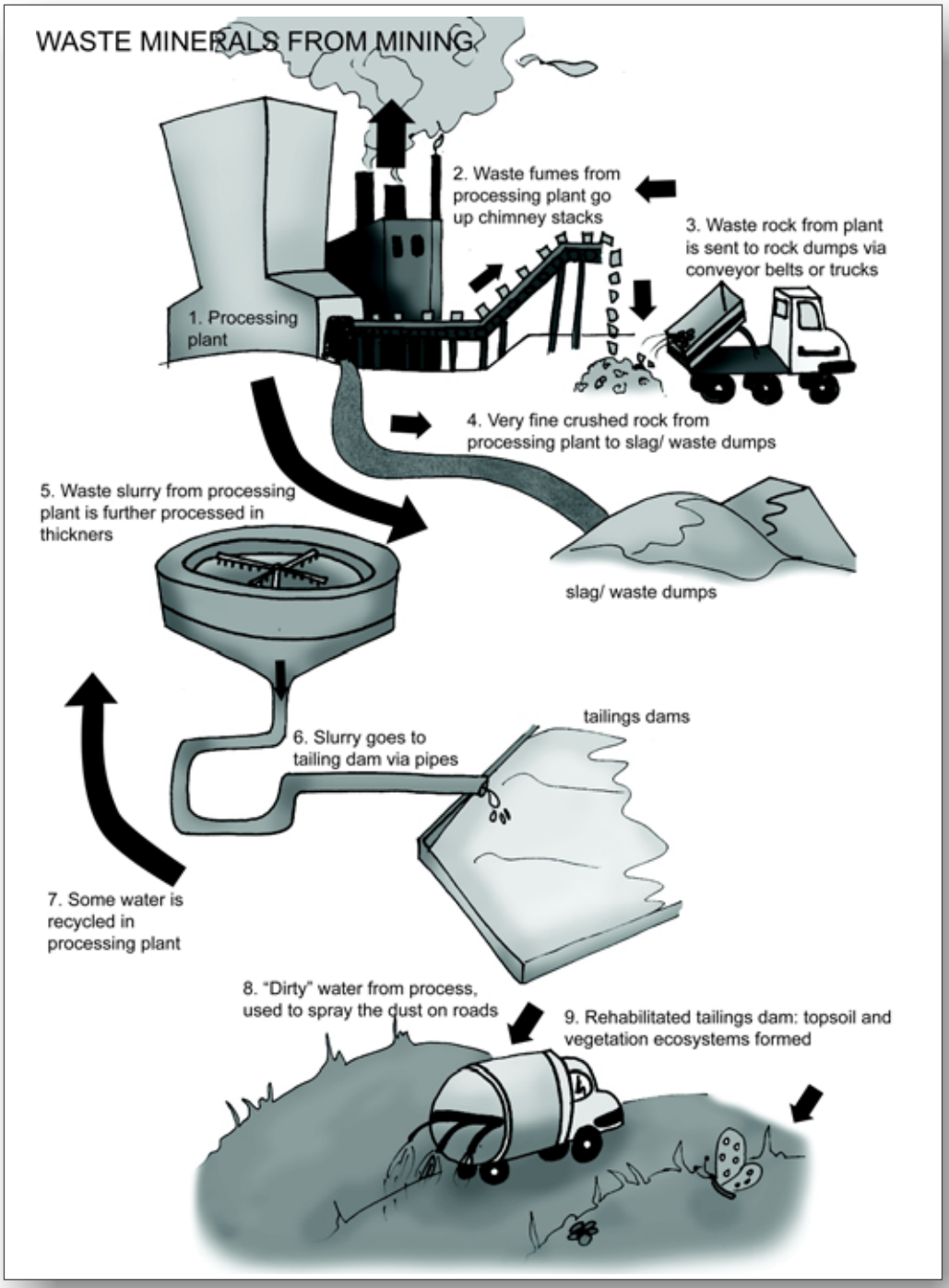
Every mine is faced with the problem of what to do with the waste material of the mine. Most tailings consist of thin mud with various chemicals dissolved in it. These chemicals are often poisonous. The harmful chemicals may seep into water bodies or the soil and may poison plants and animals.

tailings:
waste materials that result from processing an ore to extract a chemical. Often tailings contain chemicals which are harmful to human health and or the environment.

Tailings are usually stored in tailings dams which have to be looked after. A crack in the side or the wall of the tailings dam can have serious consequences: if the wall breaks, the mud from the dam can cover villages and towns and pollute water bodies and the soil.

ACTIVITY 10

Use the diagram to answer the following questions.



1 a. List **three** waste materials that come from the mine.
b. For each waste material discuss how the mining engineer could treat, minimize, dispose or recycle the waste.

2. a. What is a tailings dam?
b. How can a tailings dam be dangerous to the environment if it is not managed properly?

ANSWERS ON PAGE 158

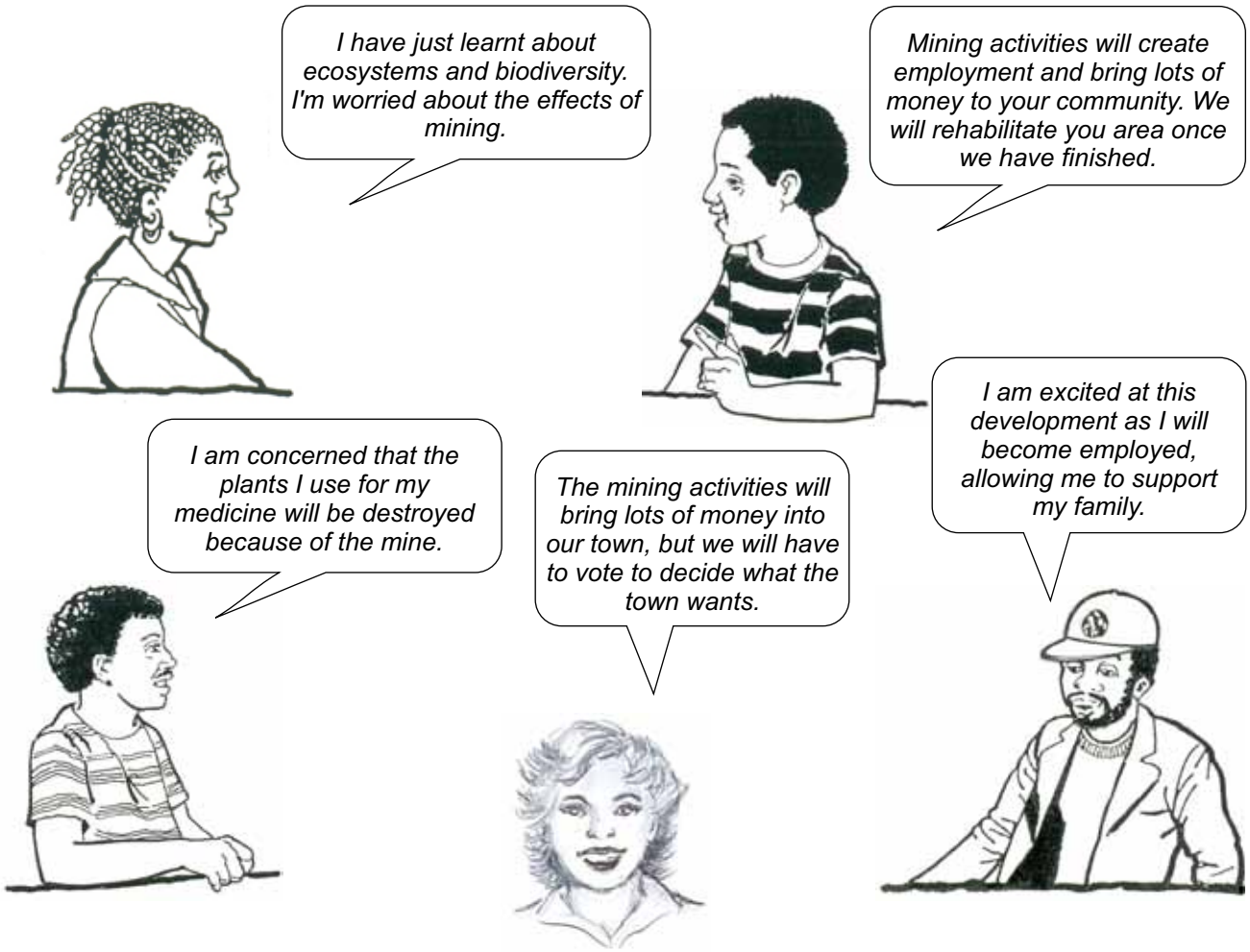
Legislation

Under our Constitution everyone has the right to an environment which is not harmful to their health or wellbeing. Government has passed laws specifically for the mining industry.

Before a company can start to mine, an environmental impact study has to be done. The general public must have an opportunity to see the results of this study and participate in any decisions made. The Department of Minerals and Energy must be satisfied that whatever disturbances the new mine will make to the environment will be rehabilitated when mining is finished. Money has to be set aside for this and everything has to be written in detail in an Environmental Management Plan.

ACTIVITY 11

A mining company has approached a community in the Karoo in the Western Cape as they have found large deposits of platinum in the area. They have held a community meeting and have presented their proposal to mine in the area. The people involved expressed the following opinions:



a. Tabulate the position of all the stakeholders in the proposed mine development.
b. Write down other issues which have not been raised by the stakeholders which could influence the decision a person in the community should consider.
c. Do you think that permission should be granted for the mine to proceed? Explain your answer.

ANSWERS ON PAGE 158

COMMENT

We have seen how mining can benefit our economy. We have also seen how important it is that mining companies mine in a way that does not impact on our environment.

CHECKLIST

Are you able to:

- ❒ explain the difference between a mineral and an ore
- ❒ determine where minerals are mined
- ❒ compare the differences between surface and underground mining and list their advantages and disadvantages
- ❒ name and define processes used to refine metal ore to obtain minerals
- ❒ explain froth flotation, reduction and electrolysis
- ❒ explain how gold is extracted from gold ore
- ❒ write a chemical equation explaining how gold is extracted using cyanide
- ❒ name the two processes used to extract aluminium
- ❒ use chemical equations to explain the Bayer process
- ❒ use a diagram to explain how aluminium is obtained during electrolysis
- ❒ list the economic benefits of mining
- ❒ explain how mining has negatively influenced the environment.

LESSON 5

Processing Natural Resources

About this lesson

In this lesson you will learn how we process natural resources to make goods which we use either in our homes or in industry. You will look at how the chemical industry processes resources, and at specific examples such as how SASOL makes liquid fuel (petrol) from coal, how sulphuric acid, nitric acid and ammonia are produced and how soaps and detergents are made.

You will then look at what polymers are, specifically at plastics as a type of polymer. Finally, you will consider what elements are found in plastics as well as the properties and various types of plastic that are manufactured.

In this lesson you will:

- list products in the chemical industry
- list factors affecting the conversion of resources into useful products and explain their significance
- explain how the chemical industry uses different types of chemical reactions
- discuss how SASOL produces liquid fuel from a solid
- discuss the manufacturing of sulphuric acid, nitric acid and ammonia
- explain the electrolysis of NaCl in the chloralkali industry to make Cl_2, H_2 and NaOH
- list uses of Cl_2, H_2 and NaOH
- compare soaps and detergents and explain how grease is removed
- explain what a polymer is
- state characteristics of plastics
- define thermoplastics and thermosets.

The chemical industry: Principles in deciding on a process

Although the manufacturing industry is divided into sectors we are going to look at the chemical sector which gets its products using chemical reactions. Examples of products from the chemical sector include:

cement	glass	paper
detergents	lubricants (e.g. oil)	pesticides
dyes	medicines	plastics
fertilisers	metals	preservatives
food colourants	textiles (e.g. cotton)	paint

ACTIVITY 1

Look around your home and make a list of 10 items that are made by the chemical industry. Decide which group from the list of products given above each item belongs to.

ANSWERS ON PAGE 159

dissociate: *separate*
reactants: *resources, sometimes in a partially processed form*

Chemists see the Earth as an abundant source of atoms and molecules. Chemists **dissociate**, rearrange or otherwise change atoms and molecules to make a desired chemical substance. The chemical process used to change the molecules needs to be done as cheaply as possible and should have as little impact on the environment as possible. When deciding which chemical process to use, chemists need to look at:

a. the location of the factory.
b. the costs of resources.
c. the process the factory employs.

a. The location of the plant

The factory will probably be receiving reactants and needs to be close to where the **reactants** come from. For instance, as coal is a reactant needed by SASOL to make liquid fuel, it makes sense for SASOL plants to be situated near coal mines. The factory will need to sell its products. If it is located too far away from cities and towns, this will increase transport costs, which will increase the price of the produce. Other location factors which are considered are the cost of land for the factory, access to water and electricity, the impact on the environment and the number of people needed to work at the factory. The factory therefore needs to be built close to where people stay or the company will have to provide accommodation.

b. The cost of the resources

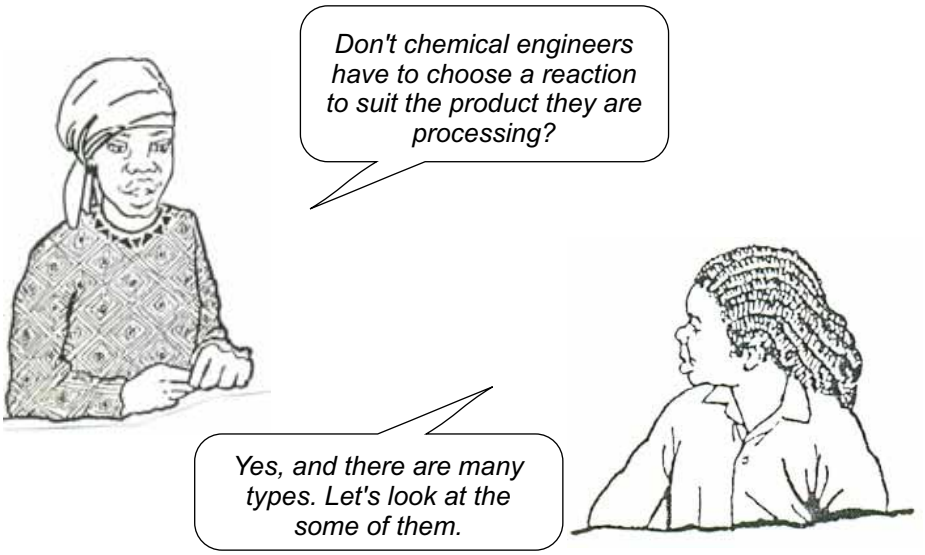
Cost will determine whether it is worthwhile processing the resource. The cost of the resource is affected by:

- how readily available the resource is.
- where the resource is found.
- how much of the resource is needed.

It is obviously better to locate the factory in an area where the resource occurs in a high concentration, even if it is over a smaller area.

c. The process the factory employs

Chemical engineers will select a process for producing the product by looking at the operating costs. Processes requiring a lot of energy are more expensive. Chemical engineers also look at the by-products which the reaction generates and whether the by-products can be sold or used in the production process. By-products which cannot be sold or re-used need to be disposed of, which will add to the operating costs of the production. If there is air pollution, the plant has to have emission controls, which further add to the costs of the operation.



Types of reactions used in the chemical industry

The main types of chemical reactions used in the chemical sector are: acid-base, redox, and organic reactions.

The chemical industry uses **acid-base reactions** extensively. They are used in the production of ammonium nitrate fertilizer from ammonia.

NH_3 *(g)* + HNO_3 *(aq)* → NH_4NO_3 *(aq)*.

In order to process natural resources chemists use **redox reactions**. Redox reactions are used in the manufacture of sulphuric and nitric acid.

A common mnemonic for remembering oxidation and reduction is "LEO the lion says GER": losing electrons is oxidation; gaining electrons is reduction.

In any redox reaction, both oxidation and reduction must occur together. If one substance is oxidized, another must be reduced. The substance that makes it possible for another substance to be oxidized is called either the **oxidizing agent** or the **oxidant**. The oxidizing agent gains electrons from the other substance and so it is reduced. A **reducing agent** or **reductant** is a substance that gives up electrons, thereby causing another substance to be reduced.

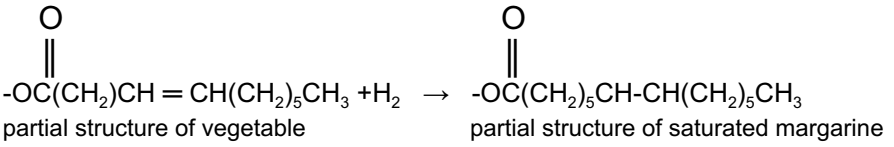
About 20% of the atmosphere consists of oxygen. As a result many natural resources available to us are in an oxidised state. To obtain substances we need requires a reduction of these sources (that is, oxygen needs to be removed). In many instances coal and oil are used as reducing agents.

Substitution, addition and elimination reactions are used in organic chemistry.

An **addition** reaction occurs when two or more reactants combine to form a final product. This product will contain all the atoms that were present in the reactants. The following is a general equation for this type of reaction:

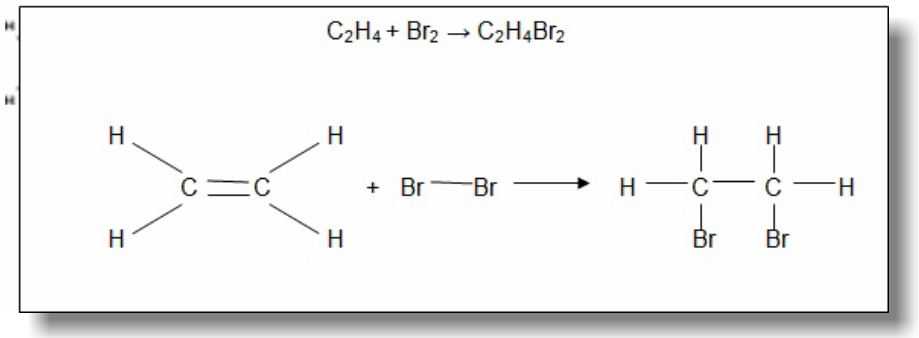
$$A+B \rightarrow C$$

You can see that C is the final product with neither A nor B remaining as a residue. Addition reactions are used to make margarine from vegetable oil.



Look at the following example:

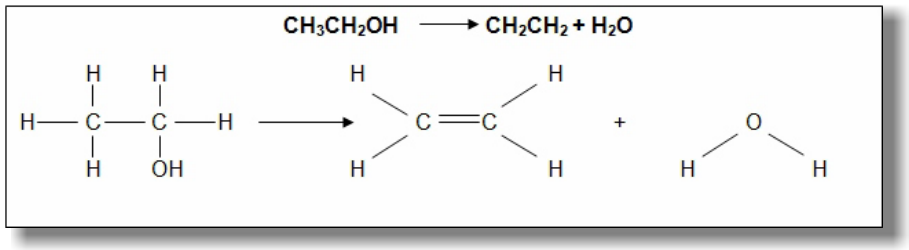
The reaction between ethene and bromine is an example of an addition reaction. The reaction between ethene and bromine forms 1,2-dibromoethane.



An **elimination reaction** occurs when a reactant is broken up into two products. The general form of the equation is as follows:

$$A \rightarrow B + C$$

The example of the dehydration of alcohol will help explain what is meant by an elimination reaction. Two hydrogen atoms and one oxygen atom are eliminated and a molecule of water is formed as a product in the reaction, along with an alkene.



A substitution reaction occurs when an exchange of elements in the reactants takes place. The initial reactants are transformed or 'swopped around' to give a final product. This is a simple example of a reaction:

$$AB + CD \rightarrow AC + BD$$

Look at the example of a substitution reaction:

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

The petrochemical industry (e.g. SASOL) uses these types of reactions extensively in their production processes.

In the next section you will look at how SASOL converts solid fuel to liquid fuel.

Liquid from solid fuel

SASOL produces liquid fuel from low-grade coal mined at Secunda. The conversion of coal to liquid fuel occurs through a process called the Fischer-Tropsch process (F-T process). Low-grade coal has a low percentage of carbon and contains other impurities. The conversion of coal to liquid fuel involves the addition of hydrogen.

This is a simplified equation of the overall process:

$$nC(s) + (n+1)H_2(g) \longrightarrow C_nH_{2n}+_2\ (l)$$

Coal and hydrogen are convertedd to liquid fuel in a series of reactions:

Step 1 The gasification of coal
Coal is heated with steam at high pressure. Adding steam prevents the complete combustion of coal. This causes most of the coal to separate into a gaseous mixture consisting of hydrogen, carbon monoxide and carbon dioxide.

$$C(s) + H_2O \longrightarrow CO(g) + H_2(g)$$

$$CO(g) + H_2O(g) \longrightarrow CO_2(g) + H_2(g)$$

The two reactions are reversible. It is possible to vary the proportions of CO, CO_2 and H_2 in the gas mixture.

The next step involves purifying the synthesised gas (CO/H_2 mixture) by washing it with methanol at low temperatures. CO_2 is removed from the mixture. We use the gasification process to produce ammonia, tars and pitch, xylenols and phenols. The synthesised gas (syngas) remains and moves to the Sasol Advanced Synthol Reactor (SAS). The gas is called a syngas because it is a mixture of more than one gas.

Step 2 Synthesis in SASOL advanced Synthol Reactors (SAS)

catalyst:
a substance that allows a chemical reaction to proceed at a faster rate than would be otherwise possible.

The hydrogen (H_2) and carbon monoxide (CO) are subjected to high pressures and high temperatures (350°C) in the presence of an iron-based **catalyst**. This results in the production of a high percentage of hydrocarbons. The reaction can be represented as follows:

$$nCO(g) + (2n+1)H_2(g) \longrightarrow C_nH_{2n}+_2(g) + nH_2O\ (g)$$

The use of “n” in the equations implies that there are many varied reactions resulting in various products. However, the products produced are alkanes and water. The alkane is much the same as natural petroleum. The products have been represented as gases, as when they come from the reactor they are in the gaseous state. However, at normal temperatures some alkanes remain as gases whilst others change to liquids and some become partly solid.

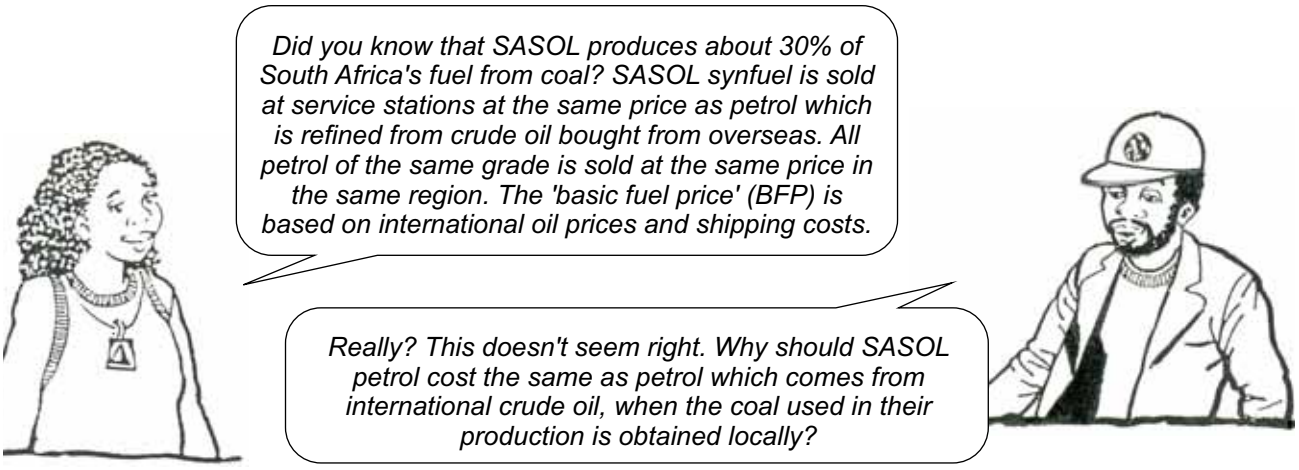
The alkane mixture produced needs to be purified, and this is done using fractional distillation, since the various alkanes produced have different boiling points.

- The C_4-C_{20} oil is purified to recover the olefins including 1-hexene and 1-octene, which are sold directly to Sasol customers, as liquid fuel.
- Some of the olefins are used to manufacture soaps.
- Propylene is recovered and used in the Secunda polypropylene plant.
- The C_2 is converted to ethylene and ethane. Ethylene is used to manufacture polyethylene.

ACTIVITY 2

1. What is syngas?
2. What is the starting material for the production of syngas?
3. Where do chemists get this starting material?
4. Write balanced equations to show the gasification of coal.
5. How is the syngas purified in the gasification process?
6. Name some by products SASOL produces other than petrol.
7. Name the reactor that produces large numbers of oxygenated hydrocarbons.

ANSWERS ON PAGE 159



Acid production (sulphuric and nitric)

Sulphuric acid Production

The **contact process** is used to make sulphuric acid (H_2SO_4) from sulphur in three steps:

1. Yellow sulphur is burnt in oxygen to form sulphur dioxide gas.
   $S(s) + O_2\ (g) \longrightarrow SO_2(g)$;

2. Sulphur dioxide and oxygen are mixed in a converter. The reaction is catalyzed using vanadium (V) oxide. During the reaction sulphur trioxide is formed on the surface of the catalyst. This is why the process is called the contact process.
   $2SO_2(g) + O_2(g) \leftrightarrow 2SO_3\ (g)$;

   In this step in the contact process the temperature should be about 450°C and the catalyst vanadium pentoxide (V_2O_5) is needed to increase the rate of the reaction.

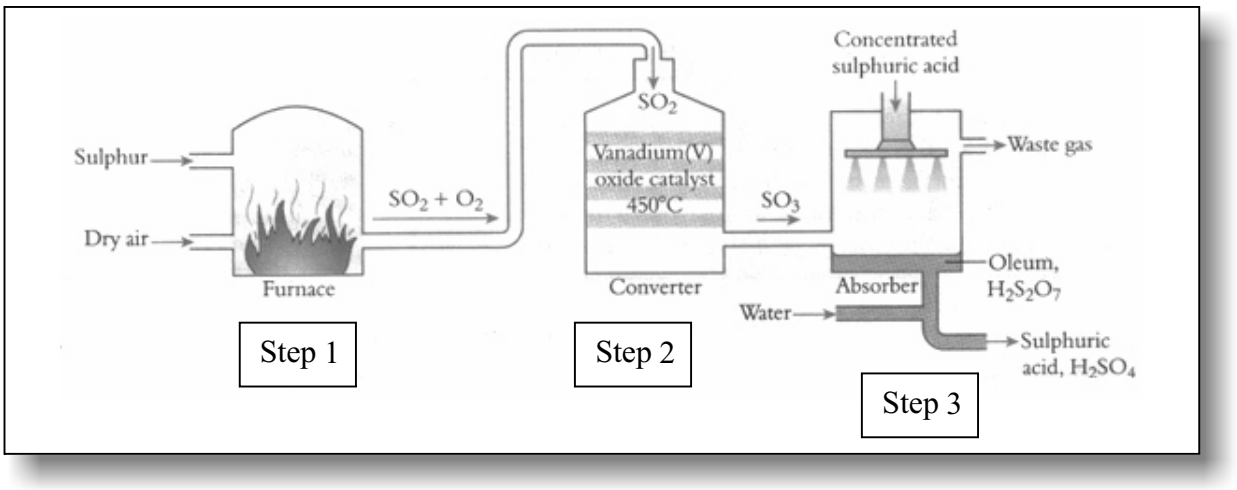
3. SO_3 does not dissolve easily in water, and is therefore dissolved in sulphuric acid ($H2_2SO_4$) to produce oleum ($H_2S_2O_7$).

   $SO3(g) + H_2SO_4(l)$ $H_2S_2O_7(l)$

   When water is added to the oleum, sulphuric acid is formed.

   $H_2S_2O2_7(l) + H_2O\ (l)$ $2H_2SO_4(l)$

The diagram below shows the three steps of the Contact Process.

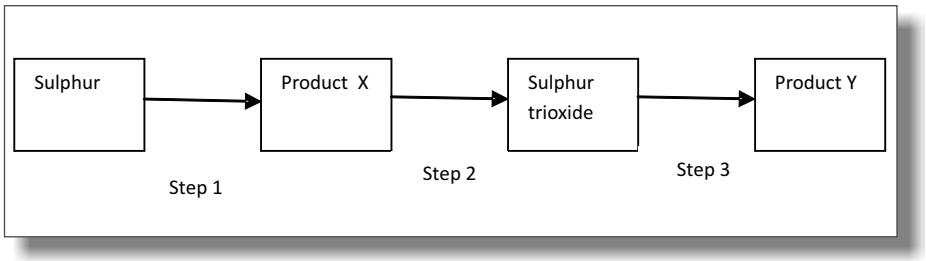


The manufacturing of sulphuric acid can be summed up as follows: SO_2 is obtained by burning sulphur. Sulphur dioxide is then oxidized to SO_3 , using a catalyst such as vanadium oxide (V_2O_5). The SO_3 is dissolved in H_2SO_4 because it does not dissolve quickly in water. Oleum ($H_2S_2O_7$) is formed. Water is added to the oleum to form H_2SO_4.

Sulphuric acid is a dense, colourless, oily liquid which boils at 340°C. It is a good dehydrating agent and a moderately good oxidizing agent. Sulphuric acid is one of the largest of any chemicals produced industrially and is used in some way in almost all manufacturing processes.

ACTIVITY 3

Look at a simplified diagram of the contact and answer the questions:



1. Name product X and Y.

2. Write a balanced equation for
   a. step 1.
   b. step 2.
   c. step 3.

3. Name the catalyst used in step 2.

4. Explain what happens in step 3.

ANSWERS ON PAGE 159

Nitric acid Production

Nitric acid is used in the production of nylon, plastics, drugs, fertilizers and explosives. Explosives such as nitroglycerin or trinitrotoluene (TNT) are made from nitric acid.

The **Ostwald process** is used to make nitric acid (HNO_3) from ammonia (NH_3). Although the process takes place in the same reaction vessel, it is easier to understand the sequence of reactions if they are separated into three steps:

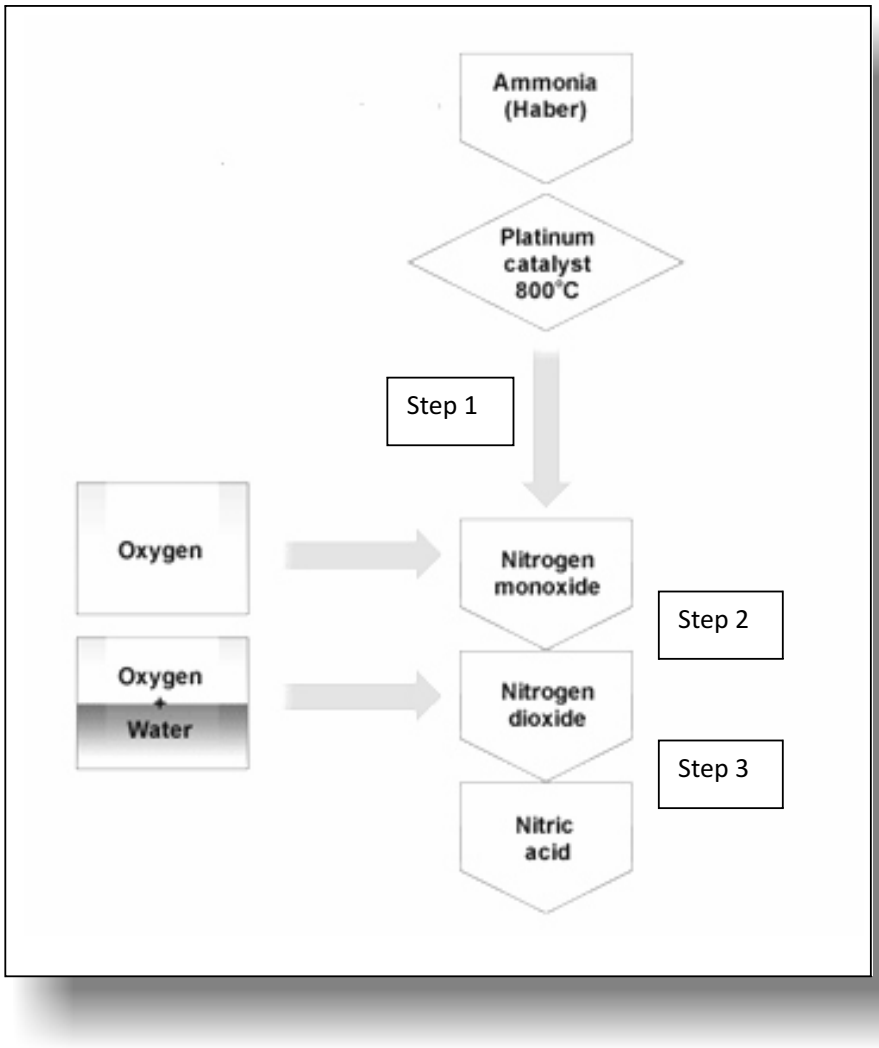
1. Catalytic oxidation of ammonia. In this reaction ammonia reacts with oxygen under high temperatures (850°C) and high pressure. Platinum or rhodium acts as the catalyst in the reaction. Ammonia is oxidised to nitrogen monoxide.

   $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$

2. Oxidation of nitrogen monoxide. NO *(g)* is cooled and mixed with oxygen, forming nitrogen dioxide:
   $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

3. Reaction of nitrogen dioxide with water, forming nitric acid (HNO_3)
   $3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$

   The overall reaction can be represented by:
   $NH_3(g) + 2O_2(g) \longrightarrow HNO_3(l) + H_2O(l)$



The Ostwald process

ACTIVITY 4

There are three steps in the Ostwald process that is used to make nitric acid.

Step 1 $4NH_3(g) + \ldots \longrightarrow \ldots + 6H_2O\ (g)$

Step 2 $\ldots + O_2\ (g) \longrightarrow \ldots$

Step 3 $\ldots + 2H_2O\ (l) \longrightarrow 2HNO_3(aq) + \ldots$

Complete and balance the equations.

ANSWERS ON PAGE 160

Having looked at how sulphuric acid and nitric acid are produced, we will now look at how ammonia is produced.

Ammonia Production

Ammonia is a colourless, poisonous gas that has a strong smell. SASOL produces most of the ammonia in South Africa using the Haber process.

From 1850, farmers in Europe started to import sodium nitrate from Chile in South America to fertilise their land. However, the European farmers wanted to be able to make their own fertilisier. Nitrogen was the obvious starting point. Every country has plenty of nitrogen in the air. The problem was that, since nitrogen is so unreactive, it is difficult to convert it to nitrogen compounds. The problem was solved in 1908 by a German chemist called Frits Haber. He managed to get atmospheric nitrogen to combine with hydrogen to form ammonia.

During World War 1 the ammonia that was produced through the Haber process was used to make explosives.

The Haber Process

Nitrogen (N_2) is obtained by separating it from gases in the atmosphere, using fractional distillation which is the separation of a mixture of liquids by making use of their differing boiling points. This means that air needs to be **liquefied**. This is done by cooling the air down in a refrigeration process. Once in a liquid state, the nitrogen is boiled off at –196°C.

liquefaction:
the process of turning gas into liquid. Liquefaction is usually achieved by compression of vapours or refrigeration.

In the Haber process, nitrogen and hydrogen are pumped into a reaction vessel filled with fine iron powder. The iron acts as a catalyst in the reaction. The temperature and pressure are critical to ensure that a reasonable amount of ammonia is produced.

The operating conditions for the Haber process are:

- Temperatures of about 450°C.
- Pressure of 200-300 atmospheres.
- Addition of an iron oxide catalyst to increase the rate of forward reaction.
- N_2 and H_2 need to be removed from the reaction chamber all the time.

The ammonia (NH_3) liquefies more easily at a higher temperature and lower pressure than N_2 and H_2. This is used to separate it from the other gases in the cooling unit.

The overall reaction is:

$N_2(g) + 3H_2(g) \longrightarrow 2NH_3\ (g)$

ACTIVITY 5

The production of ammonia requires both hydrogen and nitrogen.

1. Name the source of both hydrogen and nitrogen for this reaction.

2. What conditions are required to cause nitrogen to react with hydrogen to form ammonia?

3. Provide a balanced reaction showing how nitrogen reacts with hydrogen to form ammonia.

4. Explain why the reaction is carried out at a temperature of 400° C to 500° C.

5. Ammonia is constantly removed from the reaction vessel. Explain how this is done.

ANSWERS ON PAGE 160

Chlor-alkali industry

You now look at how chlorine (Cl_2), hydrogen (H_2) and sodium hydroxide (NaOH) are produced as they are all products of the Chlor-alkali industry.

Chlorine is used as a disinfectant for water, for example in swimming pools or household cleaning agents like bleach. Chlorine is also used to purify drinking water. It is used in the production of plastic called polyvinylchloride (PVC) as well as in the production of hydrochloric acid (HCl) which is used to clean metal in the iron and steel industry.

Hydrogen is used to manufacture HCl and is a reactant in the manufacture of ammonia.

Sodium hydroxide (NaOH) is used in reactions to remove sulphur dioxide and carbon dioxide. This prevents their release into the environment. NaOH reacts with fats to form soap and is used to help clean drains.

The chlor-alkali industry uses the electrolysis of sodium chloride also called brine. Let's recap on how electrolysis works.

Electrolytic cells change reactants into products by using electric current. They are made up of an electrolyte and two electrodes, the cathode and the anode. An electrolytic cell is activated by applying an external electrical current. This creates an electrical potential across the cathode and anode, and forces a chemical reaction to take place in the electrolyte. Cations flow towards the cathode and are reduced. Anions flow to the anode and are oxidised. Usually two products are formed, one product at the cathode and one at the anode. The products formed in the electrolysis of NaCl are chlorine (Cl_2) (at the anode) and hydrogen (H_2) (at the cathode). Sodium hydroxide (NaOH) is formed in the electrolyte.

In the solution: The sodium chloride dissociates into sodium and chloride ions.

$$2NaCl \longrightarrow 2Na^{2+} + 2Cl^{-}$$

At the anode, chloride ions are oxidised to chlorine gas:

Anode: $2Cl^{-} \longrightarrow Cl_2 + 2é$ *oxidation*

At the cathode water is reduced to form hydrogen gas and hydroxide ions.

Cathode:

$2H_2O + 2é \longrightarrow H_2 + 2OH^{-}$ *oxidation*

The hydroxide ions combine with the sodium ions and form sodium hydroxide.

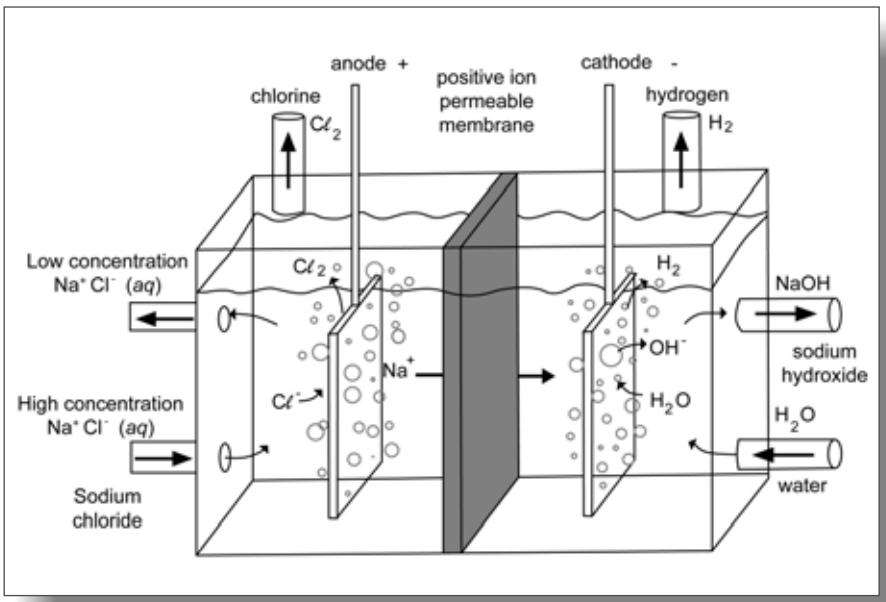
$$2Na^{+} + 2OH^{-} \longrightarrow 2NaOH$$

Overall reaction:

$$2NaCl + ..2H_2O \longrightarrow 2NaOH + H_2 + Cl_2$$

The membrane cell

A positive ion membrane separates the cell in two halves. It enables electrical conduction between the two halves, but only allows positive ions to move through it.



Schematic diagram of a membrane cell

*A **positive ion permeable** membrane allows only cations to pass through.*

A concentrated brine solution (Na^+ and Cl^- ions) is pumped into the anode compartment. The Cl^- ions are attracted to the anode and oxidation takes place:

$$2Cl^-(aq) \longrightarrow Cl_2(g) + 2\,e^-$$

Chlorine gas bubbles to the top of the cell and is removed. The NaCl*(aq)* is constantly replaced.

The material of the anode and cathode do not take part in the half reactions.

Water enters the cathode compartment where it is reduced to H_2. The following reduction takes place at the cathode:

$$2H_2O\ (l) + 2e^- \qquad H_2(g) + 2OH^-\ (aq).$$

The hydrogen gas bubbles to the top and is removed. OH^- ions remain in the water. The selective ion-exchange membrane between the two compartments is permeable to cations and a small amount of water but not to anions. The membrane keeps the Cl_2 gs and the OH^- ions separate but allows the Na^+ ions to flow into the cathode compartment, allowing current to flow and maintaining electrical neutrality in the compartments.

Hydrogen gas bubbles to the top of the cell and is removed. Na^+ and OH^- ions are left in solution and removed from the cell.

The overall reaction is determined as follows:

Reduction: $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

Oxidation: $2Cl^- \longrightarrow Cl_2 + 2e^-$

Net ionic: $2H_2O + 2Cl^- \longrightarrow H_2 + 2OH^- + 2Cl_2$

*A **spectator ion** is an ion that exists as a reactant and a product in a chemical equation. As the name implies, spectator ions simply "watch" the other ions react.*

Adding Na^+ **spectator ions** and the appropriate phases gives the following overall cell equation.

$$2H_2O(l) + 2Cl^-(aq) + 2Na^{2+}(aq) \longrightarrow H_2(g) + 2OH^-(aq) + 2Na^+(aq) + Cl_2(g)$$

ACTIVITY 6

The chlor-alkali process uses the electrolysis of a brine solution.

1. What is brine?

2. Write the equation for the net oxidation half-reaction.

3. Write down the equation for the net reduction half reaction.

4. Write down the net equation for the reaction.

5. Which ion is the spectator ion?

ANSWERS ON PAGE 160

At the beginning of this lesson we mentioned various products of the chemical sector such as detergents and plastics.

Soaps and detergents are chemicals which are important for our general hygiene. Let's look at how they work.

Soaps and detergents

- We use soaps and detergents to keep ourselves and our environment clean. Soaps are defined as a metallic salt of a fatty acid. The metal is either an alkali metal (Na or K) or an alkali earth metal (Ca or Mg). The fatty acid often comes wither from plants or animals. Detergents, however, are generally synthetic. The advantage of using detergents instead of soaps is that they do not form a scum when used in **hard water**.

hard water:
water containing dissolved salts of calcium or magnesium

Let's look at the process of making soaps (**saponification**).

- They are made by boiling animal fat or plant oils with a strong base such as sodium or potassium hydroxide.
- Tallow, an animal fat and plant oils such as palm oil and coconut oil are used.
- Fats and oils hydrolyse when they are heated with a strong base (e.g. NaOH). The products are glycerol and sodium salts of the fatty acid. The sodium salts are processed to manufacture soap.
  Fat + sodium hydroxide ⟶ soap + glycerol

How do soaps and detergents work?

hydrolysis:
to break down when mixed with water

Water has a high surface tension and does not wet all surfaces equally. It also does not dissolve grease. Soaps and detergents are called **surfactants**, since they act on the surface of a chemical, in this instance water. Surfactants act as wetting agents by lowering the surface tension of water. This means the water spreads more easily over the surface to be cleaned. This makes the water wet a surface better and the detergent or soap can spread more easily across the surface to be cleaned.

You can see this in action by doing a simple experiment.

ACTIVITY 7

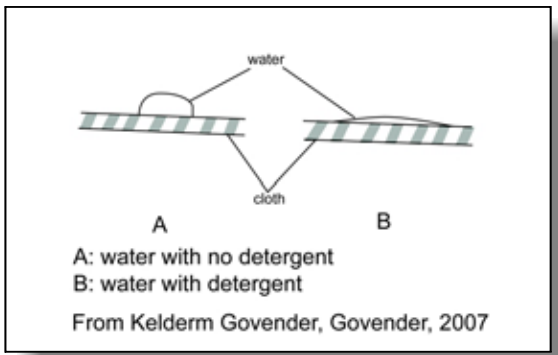
You will need:
a small piece of fabric (an old T-shirt).
a drop of water.
a small amount of dishwashing liquid.

1. Place a drop of water on a piece of fabric. Look at what happens to the drop.

2. Add a small amount of detergent on top of the drop. See how quickly the water drop soaks into the fabric.

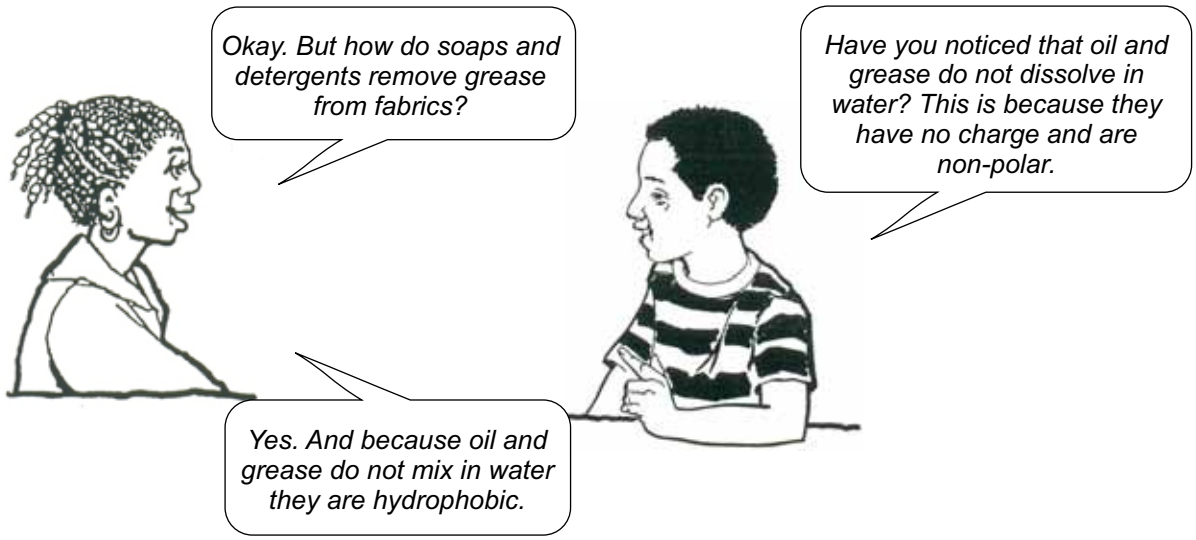
ANSWERS ON PAGE 160

The diagram below shows how a detergent makes water spread more over a surface.



A: water with no detergent
B: water with detergent

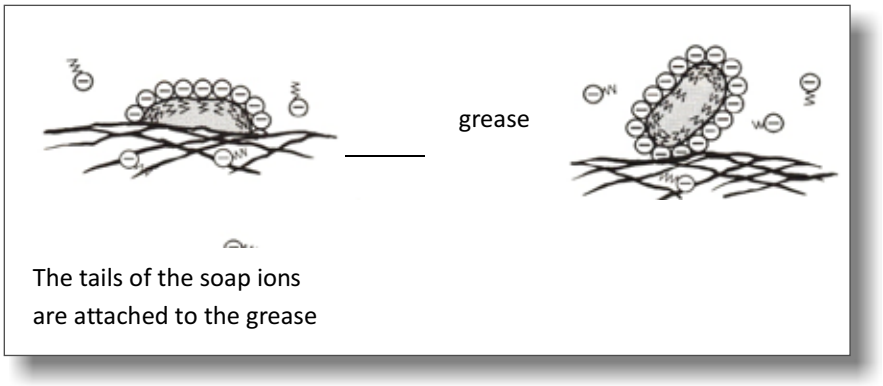
From Kelderm Govender, Govender, 2007



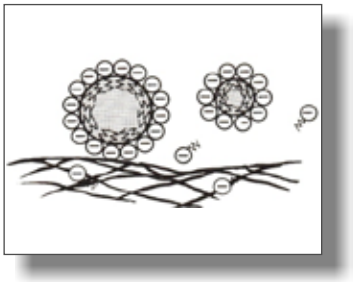
Detergents and soaps, however, are made up of two parts: those which love water (**hydrophilic**), and those which fear water (**hydrophobic**). The hydrophilic head is a CO_2- group, whereas the tail is made up of a long chain of CH_2 group.

CH_2 CO_2

The detergent molecule acts as a go-between, between the grease and water. The long hydrophobic tails attach to the grease and the head dissolves in water.



The heads of the soap ions are attached to the water.
The soap, therefore, forms a bridge between the grease and the water. As the dirty clothes swirl around during washing, soap ions surround the blob of grease, and free the grease from the cloth. Droplets of grease do not join because their surfaces are negatively charged. Finally the cloth is rinsed in clean water and the grease is removed.



ACTIVITY 8

1. What are the ingredients necessary to produce soap?
2. What is the process of soap-making called?
3. Explain the difference between soaps and detergents.
4. What is the role of a surfactant?
5. Explain how a detergent works.

ANSWERS ON PAGE 160

COMMENT

That was very interesting. Let's now look at polymers and in particular plastics, which are synthetic polymers.

Polymers and Plastics

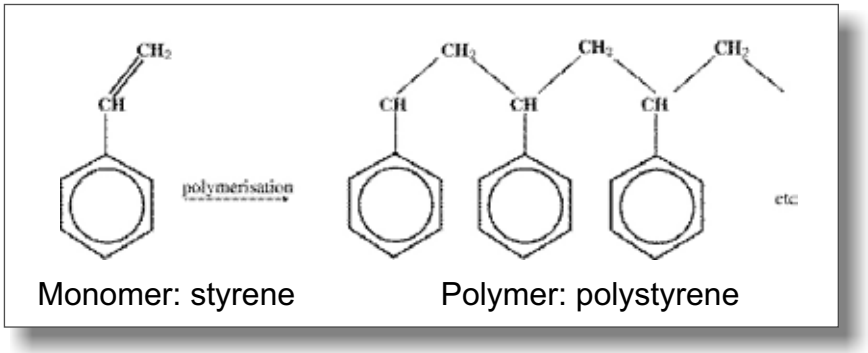
Plastics are **polymers**. A polymer is something which is made up of many repeated units (monomer). Think of a polymer as a chain. For instance, you could consider a single paper clip an example of a monomer. By hooking many paper clips together it is possible to form a paperclip chain. This entire chain is the polymer.

The structure of polymers

A paper clip chain

Many classes of polymers are made up of hydrocarbons. These polymers are made of small units bonded into long chains. Polystyrene is a common plastic that is used in model kits, to package fast foods and for disposable drinking cups.

In the polystyrene polymer, the monomer is styrene.



Styrene is a liquid hydrocarbon manufactured from petroleum. While the basic makeup of many polymers is carbon and hydrogen, other elements can also be involved: oxygen, fluorine, chlorine, nitrogen, silicon, phosphorous and sulphur.

For example, polyvinyl chloride (PVC) contains chlorine. Teflon contains fluorine. Polyester contains oxygen.

Look at the table that summarises the formula, properties and uses of some common plastics:

Name	Formula	Monomer	Properties	Uses
Polyethene (low density)	-(CH_2-CH_2)n-	CH_2? CH_2	Soft, waxy solid	Film wrap Plastic bags
Polyethene (high density)	-(CH_2-CH_2)n-	CH_2? CH_2	Rigid	Electrical insulation, bottles and toys
Polypropene	-[CH_2-$CH(CH_3)$]n-	CH_2? $CHCH_3$	Different grades: some are soft and some are hard.	Carpets and upholstery
Polyvinylchloride (PVC)	-(CH_2-CHCl)n-	CH_2? CHCl	Strong, rigid	Pipes, flooring
Polystyrene	-[CH_2-$CH(C_6H_5)$]n	CH_2? CHC_6H_5	Hard, rigid	Toys, packaging
Polytetrafluroethylene (Teflon)	-(CF_2-CF_2)n-	CF_2? CF_2	Resistant, smooth, solid	Non-stick surfaces, electrical insulation

Polymers can be characterized as being transparent or opaque. If the polymer is transparent the polymers have no form and are said to be amorphous polymers. They are arranged something like spaghetti on a plate. This is an important characteristic for many applications, for example food wrap and contact lenses.

Polymer chains that are translucent and opaque are in a more crystalline arrangement. The higher the degree of crystallinity, the less light can pass through the polymer. Therefore the degree of translucence or opaqueness of the polymer is directly affected by its crystallinity.

Spaghetti on a plate looks similar to how polymer molecules arrange if they are amorphous.

Plastics

Thermoplastics

Thermoset plastics

Look around you, and the chances are that a variety of the things that you can see are made of plastics. There are hard plastics and soft plastics, clear ones, colourful ones. All plastics were soft and mouldable during their production; that is why they are called plastics. All plastics are synthetic materials as they are artificial or manufactured.

Characteristics of plastic polymers

- Plastics can be resistant to chemicals. Look at how many cleaning chemicals are packaged in plastic.
- Plastics can be both thermal and electrical insulators. For example, electric chords and plug points are often made of plastic as are pot and pan handles.
- Generally, plastics are light in mass with varying degrees of strength. Think of the very strong toys made from plastic.
- Plastics can be moulded into bottles, or mixed with solvents to become an adhesive or paint.
- Plastics can be flexible, pliable and stretchy such as cling film.

Plastics are arranged into two categories according to what happens when they are heated to high temperatures.

Thermoplastics keep their plastic properties at high temperatures. This means that once the polymer is formed it can be heated and reformed over and over again. Thermoplastics can be recycled.

Thermosets cannot be remelted. Once these polymers are formed, reheating will cause the material to crack. The reason for the difference in behaviour is a difference in structure. Thermoplastics consist of long polymer chains and the forces of attraction between the chains are weak. Thermosetting plastics, however, have a different structure.

When a thermosetting plastic is softened and moulded, the chains react with one another. Cross-links are formed and a large 3D structure is built. This is why thermosetting plastics can only be formed once.

Examples of thermosetting plastics are epoxy resins (used as glues), polyester resins (used in glass reinforced plastics), melamine (used in kitchen surfaces), and bakelite (used in electrical fittings).

COMMENT

The chemical industry uses different types of chemical reactions and specific processes to convert natural resources into useful products, ranging from soaps, detergents, and plastics, to fuels, paints, preservatives, and disinfectants. These products play an important part in our daily lives, and make a significant contribution to society in areas such as health, hygiene, construction, manufacturing, and transport.

ACTIVITY 9

1. Explain the difference between a monomer and a polymer.

2. a. Name the two main elements most plastics are made of.
   b. Name other elements which may be found in various plastics other than the two already mentioned .

3. How do plastics with amorphous polymers differ from plastics with a crystalline arrangement?

4. Compare thermoplastics with thermosets.

5. Read the text on biodegradable plastics on the next page and then answer the questions below.

   a. In your own words explain what is meant by 'biodegradable plastic".

   b. Using your knowledge of chemical bonding, explain why some polymers are biodegradable and others not.

   c. If you were a consumer (shopper) would you choose to buy a biodegradable plastic rather than another? Explain your answer.

   d. What do you think could be done to make biodegradable plastics more popular with consumers?

ANSWERS ON PAGE 161

Biodegradable plastics

Our whole world seems to be wrapped in plastic. Almost every product we buy, most of the food we eat, and many of the liquids we drink come encased in plastic. Plastic packaging provides excellent protection for the product; it is cheap to manufacture and seems to last forever. Lasting forever, however, is proving to be a major environmental problem. Another problem is that traditional plastics are manufactured from non-renewable resources – oil, coal and natural gas. In an effort to overcome these problems, researchers and engineers have been trying to develop biodegradable plastics that are made from renewable resources, such as plants.

The term biodegradable means that a substance can be broken down into simpler substances by the activities of living organisms, and therefore is unlikely to remain in the environment. The reason most **plastics are not biodegradable is because their long polymer molecules are too large and too tightly** bonded together to be broken apart and used by decomposer organisms. However, plastics based on natural plant polymers that come from wheat or corn starch have molecules that can be more easily broken down by microorganisms.

Starch is a natural polymer. It is a carbohydrate produced by plants during photosynthesis and it serves as the plant's energy store. Many plants contain large amounts of starch.

Starch can be processed directly into a bioplastic but, it swells and deforms when exposed to water .This limits its use. This problem can be overcome by changing starch into a different polymer.

First, starch is harvested from corn, wheat or potatoes. Microorganisms then transform it into lactic acid, a monomer. Finally, the lactic acid is chemically treated, causing the lactic acid molecules to link up into long chains or polymers. The polymer is a plastic called polylactide (PLA).

PLA can be used for products such as plant pots and disposable nappies. It has been commercially available in some countries since 1990. It has proved successful in medical implants, sutures and drug delivery systems because they are able to dissolve away over time. However, because PLA is much more expensive than normal plastics, it has not become as popular as hoped.

CHECKLIST

Are you able to:

- ❒ list three factors which chemical engineers use to decide when processing resources into useful products
- ❒ explain how SASOL uses the Fischer-Topsch process to produce liquid fuel from coal
- ❒ explain what is meant by a redox reaction
- ❒ write out and explain balanced equations showing the contact process used to manufacture sulphuric acid
- ❒ write out and explain three balanced equations which form part of the Ostwald process used to manufacture nitric acid
- ❒ explain how the Haber process results in the production of ammonia
- ❒ List uses of Cl_2, H_2 and NaOH
- ❒ name three methods used in the chlor-alkali industry to produce Cl_2, H_2 and NaOH
- ❒ discuss electrolysis of NaOH using the membrane cell
- ❒ distinguish between a soap and a detergent
- ❒ explain how soaps and detergents remove grease from clothing
- ❒ explain the difference between a polymer and monomer
- ❒ name the elements found in plastic
- ❒ list properties of plastic
- ❒ compare amorphous polymers with plastics having a crystalline arrangement
- ❒ define the terms thermoplastic and thermoset.

NOTES

LESSON 6

Pollution and hazards associated with natural resource use

About this lesson

In this lesson you will look at the harm we have done to the environment by extracting and processing natural resources. We will discuss pollution in general and then look specifically at climate change and acid rain. We will also focus on water pollution and the damage we are causing to our land as we use and process natural resources. You will consider the effects of deforestation, monocropping and chemical fertilizers on the environment and finally examine some diseases miners risk contracting as they extract minerals from the earth.

We conclude the lesson by looking at alternative fuel sources as our non-renewable resources are not only running out, but polluting the environment.

In this lesson you will:

- define the term pollutant, explain how to determine the seriousness of pollution, and consider which human and natural activities cause air pollution
- discuss the causes and effects of acid rain
- name various types of water pollution
- discuss deforestation
- explain what is meant by crop rotation and monocropping
- define fertilizers, and explain the advantages and disadvantages of using them
- describe what is meant by 'food as a commodity'
- list the advantages and disadvantages of using biofuels as an alternative energy source
- explain what occupational diseases are, and their causes, symptoms and treatment.

Pollution

Pollution causes damage to human health, habitats and resources such as air, wind, soil and wildlife. The addition of any substance into the air, soil or water which causes harm to life is called a **pollutant**. Most pollutants are the waste products produced when a resource is extracted or processed into products.

We determine how serious pollution is by the following:

Concentration: This is determined by how much of the pollutant there is. Is the pollutant in a high concentration or is it more dilute?

Chemical nature: how reactive is it with nature?

Persistence: how long does it stay in the environment? The longer the pollution lasts, the more damage it causes.

Degradability of pollutants: are the pollutants degradable or non-degradable? If pollutants break down into less harmful substances, the pollution is generally less serious.

ACTIVITY 1

Look at the main sources of air pollution in the table below:

Source of pollutants	**% contribution pollution**
Cars and trucks	38
Household and other products	21
Industry	18
Non road engines e.g. ships	23

1. Use the information from the table todraw a bar graph showing the main sources of pollutants.

2. What is the difference between the terms pollutant and pollution?

ANSWERS ON PAGE 162

Air Pollution

Vehicle exhaust fumes

Air pollution occurs when the air contains gases, dust fumes or odours in harmful amounts. That is, the amounts of gases could be harmful to the health of humans, animals, plants and other organisms living in the habitat.

Air pollution is caused both by human activities (industries, burning of coal and oil, exhaust fumes from cars) as well as occurring naturally from dust storms, forest fires, or volcanoes.

Pollutants that are pumped into our atmosphere and directly pollute the air are called **primary pollutants**. Sulphur dioxide, which is released when coal is burnt, is an example of a primary pollutant. Sometimes further pollution arises when the primary pollutant undergoes chemical reactions. The resulting compounds are called **secondary pollutants**. For example, the sulphur dioxide released from the burning of coal reacts with water vapour in the atmosphere and forms sulphuric acid. Sulphuric acid is a secondary pollutant and contributes to acid rain.

Acid Rain

The diagram below shows how acid rain is formed. Use it together with the description that follows the diagram.

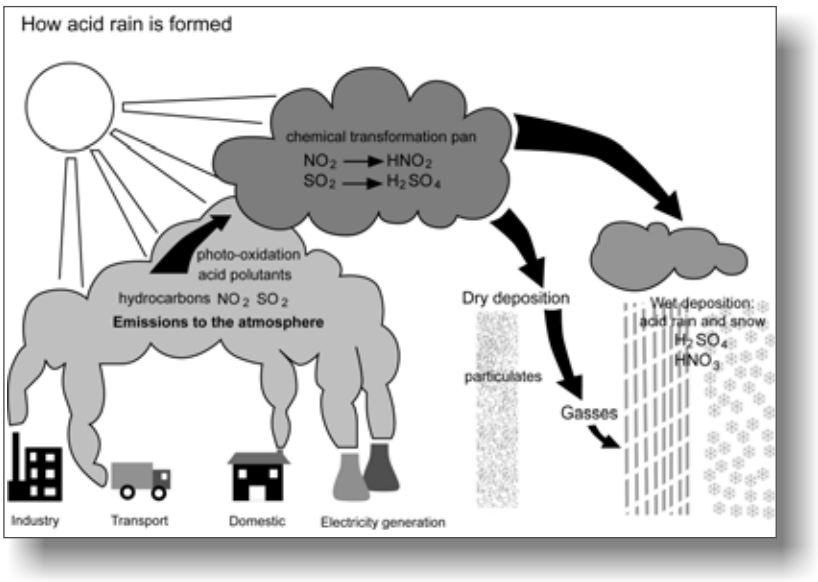
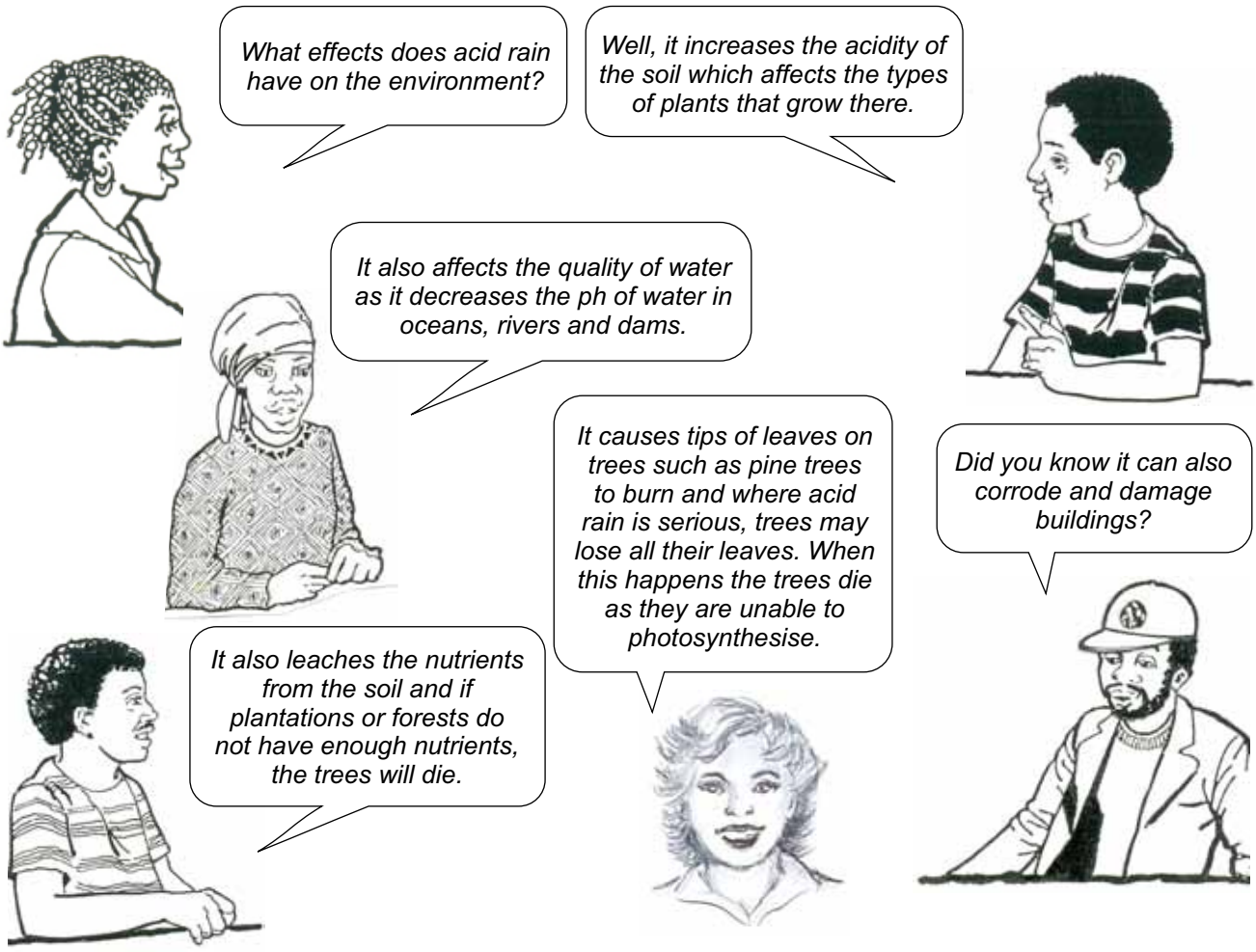


Diagram showing how acid rain is formed

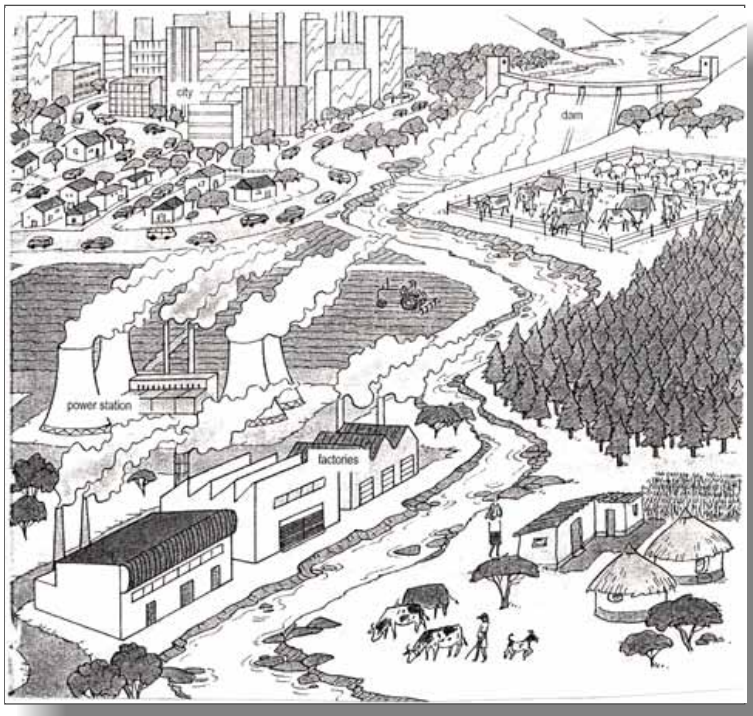
The gases nitrogen dioxide and sulphur dioxide are responsible for causing acid rain. Coal-powered power plants release huge amounts of nitrogen dioxide and sulphur dioxide into the atmosphere. Both these gases are also released from the exhausts of cars. Once released into the atmosphere, nitrogen dioxide and sulphur dioxide combine with water in the clouds, forming nitric (HNO_3) and sulphuric acid (H_2SO_4). These acids fall to the ground either as particles or with rain water.

Did you know that rain water normally has a pH of about 6 whereas acid rain has a pH of between 2 and 5?



ACTIVITY 2

Use the diagram below to answer the questions that follow:



1. What **three** human activities shown in the diagram could be the cause of acid rain?

2. How does acid rain form?

3. How would acid rain affect the city shown in the diagram?

4. You can see from the diagram that the power station and factories are a distance from the city. The people who live and work in the city have been told that the power station and factories are causing acid rain. Explain how this is possible?

5. How will acid rain affect
   - the plantations growing in a south-easterly direction from the city?
   - the river and dam just outside the city?

6. In your opinion, what can the people do to stop acid rain from destroying their environment?

ANSWERS ON PAGE 162

Water Pollution

Although much air pollution is caused from the burning of natural resources such as fossil fuels, sources of water pollution are varied. Some water pollution is caused from the processing of resources, for example in mines and industry. Other sources of water pollution come from the improper disposal of sewage, animal waste, fertilizers and pesticides. These substances find their way into water systems through ground water, streams, or rivers.

Sewage being piped into a river

Industrial Waste

Factories and industries are responsible for releasing many harmful chemicals into water bodies. These chemicals can change the pH of the water body. Many organism living in water bodies are sensitive to changes in the water's pH. For example, some species of fish are unable to hatch if the pH of the water is not correct. Many aquatic invertebrates are unable to survive changes in pH. This will result in a loss of biodiversity.

Industry is also responsible for releasing various types of chemicals into water bodies. Some of these may serve as nutrients and result in eutrophication, as discussed in Lesson 2 of this unit. Some industrial processes give off poisonous metals such as lead and mercury which may land up in rivers and dams.

Acid mine drainage entering a river

These substances kill organisms, cause cancer, and damage organs such as the lungs, heart and kidney.

Industrial water pollution may change the temperature of the water, affecting organisms living in the water. If the pollution alters the amount of light passing through the water, hydrophytes may not receive enough light to allow them to photosynthesize. These water plants will then die and this could have a knock-on effect on the animals which depend on them as a food source.

Mines

Pollution from mines may affect water quality. This was discussed in lesson 4 of this unit. You will remember that one of the biggest problems with mining is what to do with the water that seeps up from the mine, the acid mine drainage. If the acid mine drainage seeps into ground water, it has the potential to seriously affect drinking water and ecosystems coming in contact with the water.

Oils

Oil spilt from oil tankers results in serious damage to marine life. It also damages plat and wild life on the shoreline.

Sewage

When human waste lands up in water bodies, the water body becomes polluted, often resulting in the spread of diseases such as typhoid fever, cholera and gastroenteritis. This problem occurs when sewage is not managed properly. If pit latrines are too close to rivers or dams, the waste in them may leak into nearby water bodies. Heavy rain can also wash human waste into rivers and dams, when sewage is not piped away to be treated at sewage plants, or septic tanks used.

Fertilizers, household and animal waste

Fertilizers, household and animal waste are rich in nitrogen and phosphorous. When these substances land in water bodies **eutrophication** often results.

Pesticides

Farmers use pesticides to kill organisms that destroy crops. When it rains, pesticides can be washed into rivers and dams. Pesticides kill some organisms in aquatic ecosystems. They may be absorbed and stored in the tissue of animals. Pesticides may be passed from one organism to another in food chains, causing harm to animals in later trophic levels.

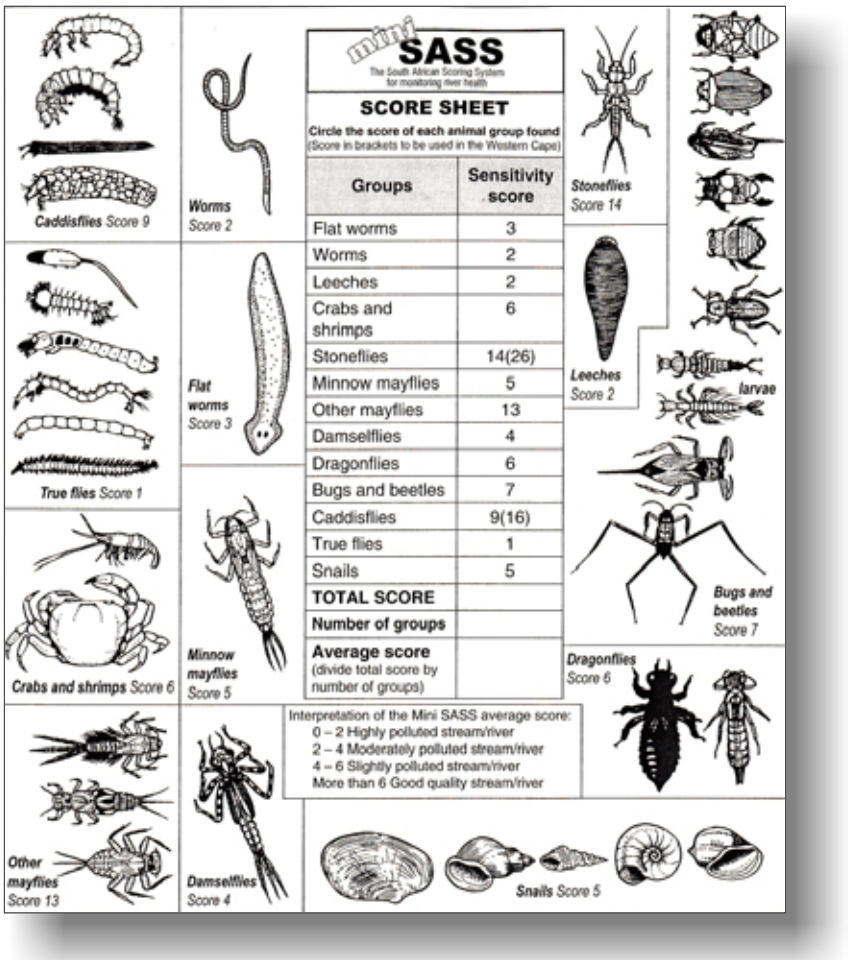
Soil

Ploughed fields and eroded areas have no plant cover. Heavy rain washes the soil from these areas into rivers and dams. The soil particles become suspended in the water and block out sunlight. Hydrophytes are affected by the lack of sunlight. Sometimes the soil settles on the bottom of dams and rivers. causing silting. Silt fills dams and blocks up the mouths of rivers.

ACTIVITY 3

Scientists have discovered that small aquatic animals are very sensitive to the quality of water. They can measure the quality of the water by the kinds of animals that they find in a river. Scientists have developed the **South African Scoring System (SASS)** for monitoring river health.

When we want to work out the water quality in a river, we use insect nets and try and catch as many animals as possible in the river. These animals are identified using the SASS sheet. Each animal is given a score. The score is based on the animal's sensitivity to pollution. So an animal which is very sensitive to pollution would get a high score. Animals which can live in polluted water get a lower score.



mini SASS
The South African Scoring System for monitoring river health

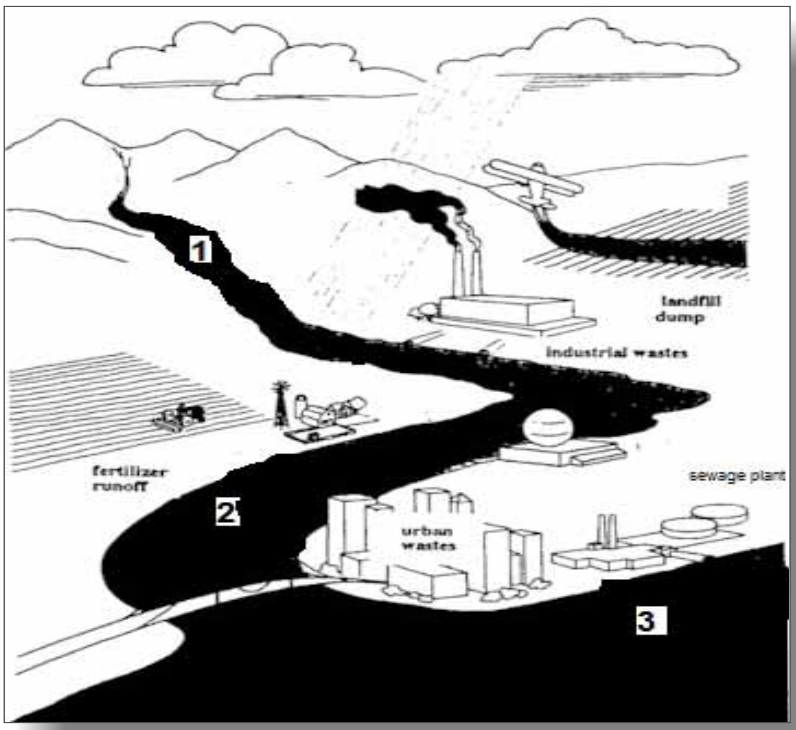
SCORE SHEET

Circle the score of each animal group found
(Score in brackets to be used in the Western Cape)

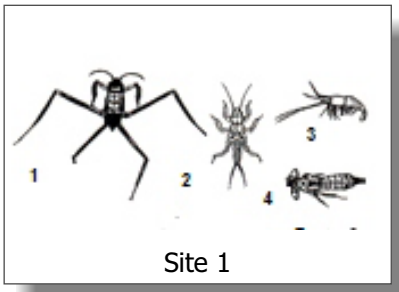
Groups	Sensitivity score
Flat worms	3
Worms	2
Leeches	2
Crabs and shrimps	6
Stoneflies	14(26)
Minnow mayflies	5
Other mayflies	13
Damselflies	4
Dragonflies	6
Bugs and beetles	7
Caddisflies	9(16)
True flies	1
Snails	5
TOTAL SCORE	
Number of groups	
Average score (divide total score by number of groups)	

Interpretation of the Mini SASS average score:
0 – 2 Highly polluted stream/river
2 – 4 Moderately polluted stream/river
4 – 6 Slightly polluted stream/river
More than 6 Good quality stream/river

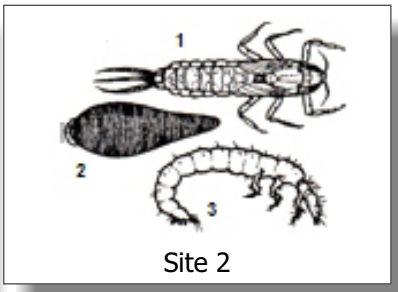
1. A scientist wanted to determine what happened to the water quality of a river. She went to three different sites along the course of the river. At each site she took samples of animal waste, collected the same volume of water at each site and caught insects and river shrimps using a net. The method of collection was the same at all the sites.



a. Find sites 1 to 3 in the river. Some of the insects and river shrimps that were found in the water at each site are shown in the diagram below.



Site 1



Site 2

The table on the next page for the first site has been completed for you. Complete the tables for sites 2 and 3.

SITE 1	
Creatures	**SASS score**
1. Bugs and beetles	7
2. Stone fly	14
3. Shrimp	6
4. Dragon fly	6
TOTAL SCORE	**33**
Number of groups of creatures	4
Average score	33/4 = 8.3

The middle of the mini SASS table has values which allow you to interpret the score. A score of 8.3 is higher than 6, which means the water from this site has a good quality. This would be expected as the water has not been influenced too much by human activities.

SITE 2	
Creatures	**SASS score**
1.	
2.	
3.	
TOTAL SCORE	
Number of groups of creatures	
Average score	

SITE 3	
Creatures	**SASS score**
1.	
2.	
3.	
TOTAL SCORE	
Number of groups of creatures	
Average score	

b. The quality of the water changes as it flows from the mountains and empties into the sea. Explain what could be causing the changes in the quality of the river.

ANSWERS ON PAGE 163

COMMENT

You can see from the activity and the discussion on air pollution that using natural resources results in much damage to the environment.

Another natural resource which man uses and exploits are forests.

Deforestation

Deforestation

The destruction (through cutting down and burning) of forested areas is called **deforestation**. When trees from commercial plantations (gum, pine and wattle trees) are removed but not replanted, this is also considered deforestation.

As a result of deforestation a lot of land which was covered by forests has been cleared. A thousand years ago forests covered 34% of the Earth's surface. Fifty years ago forests covered 32% of the Earth's surface. Today, forests cover only 12% of the Earth's surface. From these statistics it is evident that wood from the trees is a natural resource which is in demand. However, this is not the only reason why forests are cleared of their trees. In the next section you will look at why humans chop down forests.

Human activities that cause deforestation

We use wood for many different purposes. Wood may be used in the building industry, to make paper, furniture, or used as a fuel (firewood). In rural areas, where people do not have access to electricity, wood fires are used for cooking and heating water in homes.

Forests are sometimes cleared for farming purposes: to graze cattle or plant crops. Often, the cleared land is not suitable for farming (pastoral land) and lots of fertilizer needs to be added.

The effects of deforestation

- **Loss of top soil**
  Roots of trees hold the soil together. Soil which is held by the roots of trees is not usually lost by erosion. The removal of trees means that there are no longer roots to bind the soil. This soil can be blown or washed away. Removal of trees also results in loss of leaf litter. Leaf litter forms when the leaves of trees fall to the ground and start to decompose.

Leaf litter not only adds nutrients to the soil but also helps to slow the flow of rainwater. This reduces erosion of top soil. Plants struggle to grow in soil which has lost its fertile top soil. Because of the erosion in deforested areas, few, if any, plants will grow in these areas. Not only do roots and leaf litter bind the soil, but they also reduce the risk of flooding.

- **Increased flooding**
  The roots of trees, forest-floor litter and top soil have the ability to soak up rain water and release it slowly. If there are no trees and forest-floor litter, rain water flows quickly through deforested areas towards rivers and can cause flooding. Fast-flowing water washes topsoil into rivers, causing silting of rivers, dams, and estuaries.

  The diagram below shows the effect of deforestation with respect to flooding. The left hand side of the mountain shows an area which has been deforested. You can see that there is flooding at the base of the mountain. There has also been a lot of erosion on the mountain in the area where deforestation occurred.

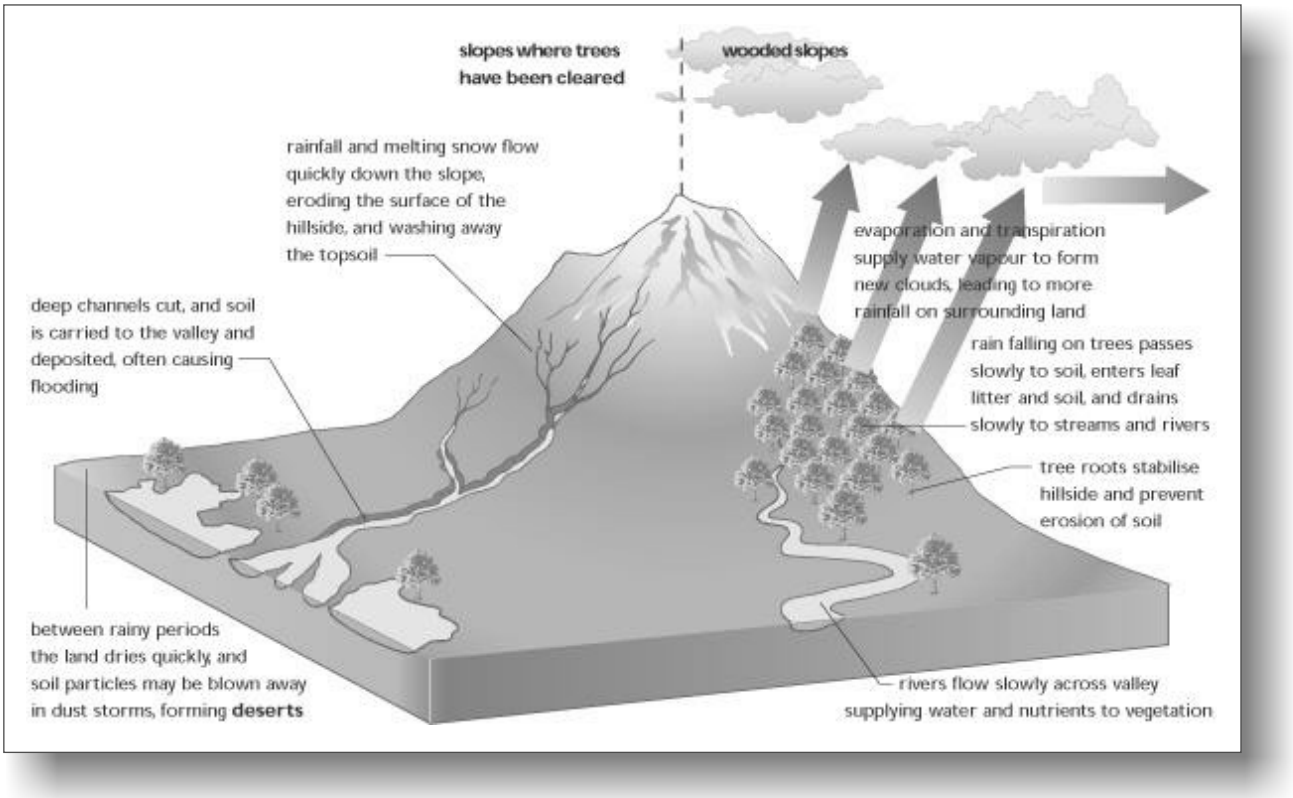


Diagram showing what happens to rain water in areas that have been deforested

- **Extinction of species**
  Deforestation results in many animal and plant species losing their natural habitats. More than half of all plant and animal species use forests as their habitats.

Destruction of forests therefore results in a loss in biodiversity of an area. These animals either need to move to new areas or run the risk of dying.

- **Increased carbon dioxide**
  Forests absorb large amounts of carbon dioxide to manufacture carbohydrates during the process of photosynthesis. They play an important role in reducing the amount of carbon dioxide in the atmosphere. With concerns about increasing global temperatures and its effects on life on Earth, it is important that we protect or replant forests, as they certainly help towards minimizing the effects of climate change. Trees have been referred to as carbon sinks, as they are capable of removing large amounts of carbon dioxide from the atmosphere.

ACTIVITY 4

1. The table below shows the percentage of wood we use.

Fuel	50%
Paper	17%
Buildings and furniture	33%

   Draw a pie chart to reresent this information.

2. 'Since global warming has become a matter of serious concern, the effect of deforestation must be urgently investigated'.

   Discuss this statement with regard to the effect of deforestation on the environment.

ANSWERS ON PAGE 164

3. Why does deforestation occur on such a large scale?

COMMENT

One of the problems with deforestation is that the soil can be eroded. This is a real concern as deforested areas are sometimes so badly managed that after a while it is impossible for any vegetation to grow on them as the soil is infertile. The soil is said to have deteriorated and been degraded.

In the next section you will look at how certain farming practices result in soil deterioration.

Soil deterioration

Natural processes such as decomposition continually add nutrients to the soil. The nutrients that plants absorb from the soil become part of the plant's body. As nutrients are removed from the soil, they need to be replaced if the soil is to keep fertile. In natural ecosystems, the nutrients are returned to the soil once the plant dies and is decomposed.

However, on farms most plants are harvested and the nutrients the plants absorbed are not returned to the soil. Farmlands run the risk of becoming infertile.

Farmers have developed various methods to help maintain soil fertility. For example, a farmer might grow maize in a field one year and soyabeans the next year. Both crops remove nutrients from the soil, but the plants have different nutrient requirements. This means that the soil does not lose the same nutrients two years in a row. Alternating two or more crops in the same field from year to year is called **crop rotation**.

The agricultural practice of growing a single crop year after year on the same land is called **monocropping**. Mielies and wheat are grown using monocropping techniques. Monocropping allows a farmer to specialize in a particular crop. This means that the farmer can invest in machinery designed specifically for that crop, resulting in increased crop production.

From an environmental perspective, monocropping is harmful for a number of reasons. Firstly, monocropping results in an increase in the number of pests and diseases in an area. To help control the pests and diseases farmers use pesticides. Pesticides often wash into water systems and affect other organisms.

Secondly, monocropping severely depletes the soil of nutrients. The same type of plant, for example mielies, will absorb the same type of nutrients. As most of the mielie plant is harvested, and little returned to the soil, the soil will become poor in certain nutrients. Farmers use chemical fertilizers to replace nutrients. Although fertilizers add nutrients to the soil, they can also be problematic.

The controversies around monocropping are complex, but are usually about the advantages and disadvantages of increasing short-term food production because of the harm it causes to the environment.

ACTIVITY 5

1. Explain the terms:
   a. crop rotation
   b. monocropping
   c. monoculture

2. List the advantages of monocropping.

ANSWERS ON PAGE 164

3. List the disadvantages of monocropping.

Chemical fertilizers

A fertilizer is any substance used to add nutrients to the soil to promote soil fertility and increase plant growth. However, the health of the soil relies on more than just having a good concentration of nutrients. Good quality soil has micro-organisms living in it. The micro-organisms play an important role in decomposition and aeration of the soil. The health of the soil is much more complicated than merely adding fertilizer to the soil.

One of the concerns raised in the use of chemical fertilizers is that the fertilizer leaches into and contaminates the ground water. Ground water contaminated with fertilizers may find its way into rivers, streams, dams or lakes. This may lead to eutrophication in water bodies which results in the death of much aquatic life because of lack of oxygen in the water.

Results of eutrophication

Another concern raised is that excess nutrients in the fertilizers cannot be absorbed by the crop plants. Nitrogen in fertilizers breaks down into nitrates. Plants use nitrates to manufacture proteins. However, if a plant absorbs more nitrates than it needs, the plants will store the excess nitrate. Animals and humans who eat these nitrate-rich plants will have a high intake of nitrate. Nitrate is poisonous to sheep, cattle and humans as it interferes with the ability of blood to transport oxygen.

Ammonium-based fertilisers cause soil acidification. Soil organisms convert the ammonium in the soil to nitrate. During this process hydrogen is released. Many plants are unable to absorb certain elements such as phosphorous if the soil is acidic.

Some fertilizers made from waste products obtained from the petrochemical and steel industries contain heavy metals such as lead, mercury, and arsenic. In high enough concentrations, heavy metals pose a serious health risk to both humans and animals.

ACTIVITY 6

1. Draw a diagram showing how eutrophication takes place in a dam.

2. How does ammonium-based fertilizer cause soil acidification?

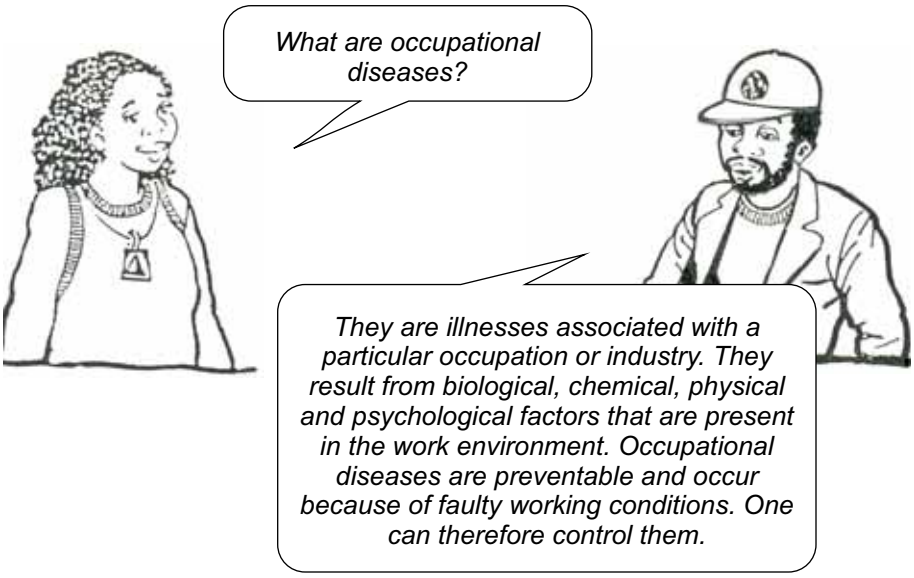
3. Explain why farmers use chemical fertilizers when there are many disadvantages associated with their use.

ANSWERS ON PAGE 165

COMMENT

You have considered some of the problems we have created by extracting and processing natural resources. Sometimes, however, working to extract the natural resource such as a mineral can be harm us. In the next section you will consider some of the diseases miners run the risk of getting because of the nature of their work.

Diseases associated with mines



Because of the dangerous nature of their work, miners are faced with many issues related to their health. Many miners suffer from lung and respiratory disorders caused by the amount of dust they inhale. Various factors determine how serious and for how long the lung and respiratory disease lasts.

These factors include:

- the length of time and the extent to which the miner is exposed to the dust
- the size of the dust particles
- the type and amount of dust inhaled

Coalminers run the risk of suffering from coal workers' **pneumoconiosis** after continuous inhalation of coal dust. The coal dust particles land up in the lungs and make breathing difficult.

Miners who work on mines where the coal is of a high grade run the risk of contracting **silicosis**. Like pneumoconiosis, symptoms of silicosis include coughing, which may be related to a chronic bronchitis and difficulty breathing. Miners with silicosis are at risk of contracting tuberculosis (TB), emphysema and pneumonia. There is no treatment available for silicosis.

The mining of asbestos is a controversial issue facing many countries. Asbestos is the name given to a group of naturally occurring fibrous materials. Asbestos minerals have long, strong, flexible fibres that can be spun and woven and are heat resistant. Because of these characteristics, asbestos material has been used in building materials such as roof coatings, ceiling and floor tiles and friction products such as the car clutch and brake.

It has been found that high level exposure to asbestos can cause **asbestosis**. Once asbestos fibres reach the lung they cause much damage, including scarring. Scarring causes the lungs to stiffen. Symptoms of asbestosis include a shortness of breath and a dry cough and can lead to death.

Because of the dangers associated with asbestos mining, all South African asbestos mines have been closed. However, both Swaziland and Zimbabwe continue to mine asbestos, which places the health of the miners at serious risk.

ACTIVITY 7

Draw up a table comparing three diseases miners may be exposed to: pneumoconiosis, silicosis and asbestosis.

ANSWERS ON PAGE 165

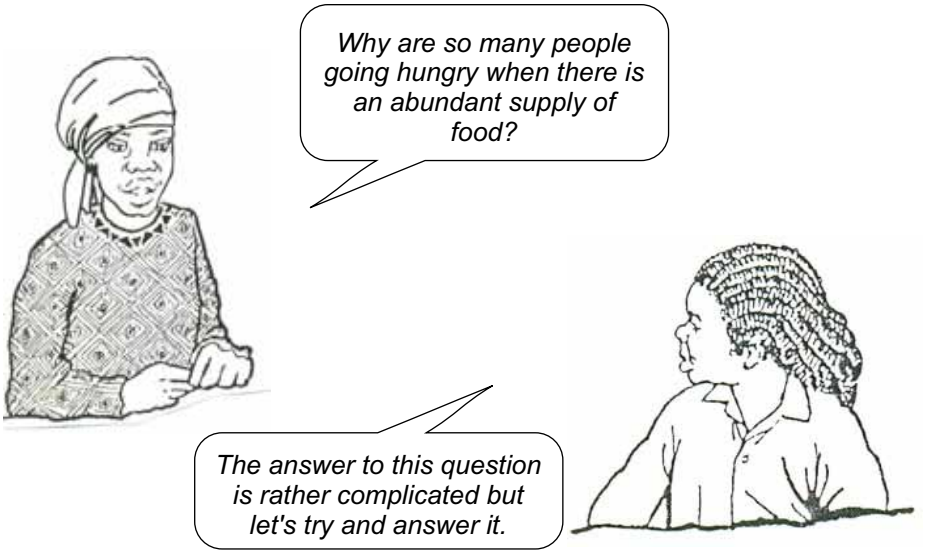
COMMENT

Much of this unit has focussed on how humans extract, process and use natural resources. Many of the resources which we use are essential for life, for example food and water. Because the human population has been increasing, the demand for resources has also increased. Farmers have developed various techniques to supply enough food to feed people. However, farmers need to sell food in order to pay their own expenses on the farm. This has resulted in an argument about whether food − needed to sustain life − should be regarded as a **commodity**.

***commodity**:*
an article of trade which is either an unprocessed or partially processed item, for example, fruit, vegetables, grain and minerals.
***malnutrition**:*
incorrect nutrition owing to inadequate or unbalanced intake of nutrients.

The tension between food for human life and food as a commodity

Food is a basic human need. A balanced diet is essential for healthy growth and development. Although food is plentiful throughout the world, **malnutrition** is common. This contradiction between plentiful global food supplies and widespread malnutrition arises from food being considered a commodity.



We can start to answer the question by looking at capitalist societies. The driving force in capitalist societies is profit. Money is earned by selling goods or providing services. Goods need to be sold at prices higher than it costs to produce them.

More and more of the natural world, including food and water supplies, is being sold to make money rather than to supply the needs of people. However, there is a contradiction when a basic human need is produced and sold as a commodity.

The commodity nature of food results in food price levels far above many people's means. When food is sold as a commodity the poor have few options. They may purchase more food with a lower nutritional value or less food with a higher nutritional value. They may skip meals or receive food from charities The United Nations estimates that there are close to one billion people worldwide who suffer from malnutrition. This leads to severe health problems and death for millions.

As food is sold to make money, suppliers need to ensure that their goods are sold. To do this, suppliers advertise their food products, especially processed food. These high-calorie, low nutritional foods, for example sugary breakfast cereals, are relatively inexpensive and readily available. As adverts promote eating of processed food, people buy and eat them. Eating a lot of processed food results in obesity. Companies which make money from selling inexpensive, well-marketed processed foods are thought to be the reason for the surge in obesity, especially amongst the poor.

In a world of plenty, a large number of people go hungry. The causes of hunger are related to the causes of poverty. Poverty means that people are unable to afford food and hence they go hungry.

ACTIVITY 8

Read the extract below and then answer the questions that follow:

> You would not expect The Gap to manufacture clothes, Adidas to manufacture shoes, or IBM to provide computers for those people earning less than $1.00 (about R10-00) a day or less; likewise you would not expect a grocery store to provide food for them.
>
> Richard H Robbins

1. What is meant by the term 'food as a commodity'?

2. Do you think that it is the grocery store's responsibility to ensure that all people have access to nutritional food? Explain your answer.

ANSWERS ON PAGE 166

COMMENT

The last part of this lesson on pollution and hazards associated with resources looks at solving the problem of non-renewable sources of energy running out. Using energy sources other than coal, oil or gas may also cause less harm to the environment.

Alternative fuel sources

Fossil fuels such as coal, oil and gas are a limited resource. They are used to provide energy for heat, light and power in industry and households. As you will remember, fossil fuels are the products of what were once vegetation and other living matter. Since we are using fossil fuels at a rate faster than they can be replaced, they are said to be non-renewable.

Fossil fuels can damage the environment when they are burnt as they release large amounts of carbon dioxide, nitrogen dioxide and sulphur dioxide into the atmosphere. You learnt in unit 5, lesson 8 that carbon dioxide is responsible for the enhanced greenhouse effect. You saw earlier in this lesson that nitrogen dioxide and sulphur dioxide are responsible for acid rain. To try and reduce our carbon dioxide, nitrogen dioxide and sulphur dioxide emissions, South Africa is investigating sources of energy that will not run out.

Scientists are looking at producing what they call biodiesel and bio-ethanol from mielie plants. The biofuel which comes from mielie plants is a special type of alcohol that is produced by yeast cells fermenting sugar found in the plant cells.

Use the diagram below to help you understand the process.

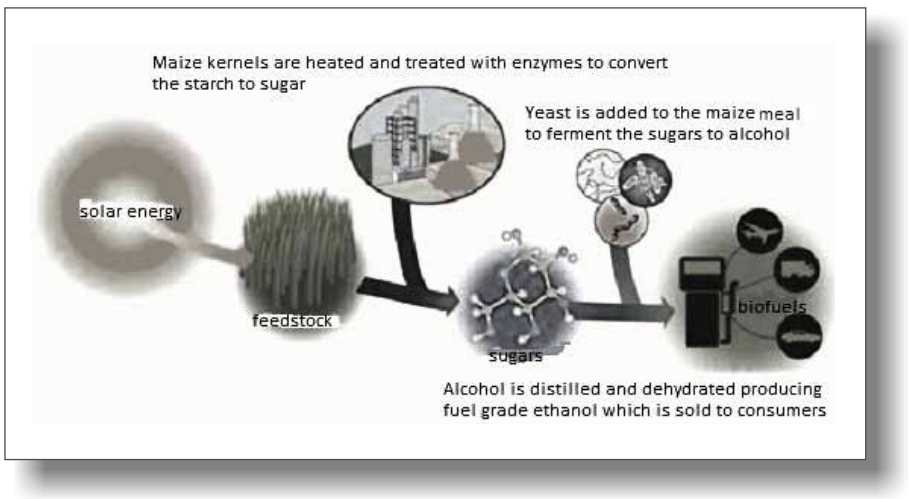


Diagram showing how biofuel is produced

The entire mielie kernel is ground to flour and is called meal. Water and enzymes are added to the meal to change the starch into the sugar dextrose. The meal is now called mash and is heated to kill any microorganisms which may be present. The mash is cooled and yeast is added. Yeast cells ferment the dextrose, producing ethanol and carbon dioxide. The ethanol is distilled, producing a biofuel which is used to run cars, trucks and even aeroplane engines. The carbon dioxide which is produced during the fermentation process is used to make fizzy drinks.

It is thought that many thousands of new jobs could be created in the cultivation, harvesting and processing of mielie plants into biofuels.

Advantages of using biofuels

Less carbon dioxide would be released into the atmosphere, we would not have to be concerned when fossil fuels are all used up and we would not be dependent on other countries to supply us with oil.

Disadvantages of using biofuels

A food crop is being used to provide fuel which could result in an increase in food prices and the price of livestock feed. Some scientists argue that producing biofuel uses a lot of fossil fuels and is just as harmful to the environment as the burning of fossil fuels. Biofuel does not transport well as it is found to be corrosive on some metallic parts.

Other alternative fuel source technologies the Department of Energy is investigating include sugar-cane bagasse (the fibre that comes from crushing the sugar cane), landfill gas extraction, mini-hydroelectric schemes, and solar water heaters.

ACTIVITY 9

1. Draw a bar graph showing the carbon emissions from the burning of fossil fuels for the various countries from the data provided. The figures given represent how many million tons of carbon dioxide were produced in 1998: United States (1495), China (740), Japan (288), India (253), Germany (228), France (107), South Africa (102).

2. Read the article on the next page and answer the question.

Ethanol Biofuel in Brazil

Today almost 50% of Brazilian cars are able to use 100% ethanol biofuel. Flex fuel engines are able to work with all ethanol, all petrol or any mixture of both, giving the buyer a choice between price and performance. Currently the main feedstock in the United States for the production of ethanol biofuel is mielies. While much of the mielie turns into ethanol, some of the mielie also gives by-products which can be used to feed livestock, e.g. cattle.

Mielies are an energy-rich intensive crop that requires mechanized farming practices. These machines are usually petrol or diesel driven. Farmers could save on money if they feed by-products of the mielies to their cattle and use the cattle dung to fertilize their crops.

There appears to be considerable dispute about the net energy benefit of producing ethanol from food crops including mielies. There is evidence that ethanol biofuel is not a sustainable strategy because it uses more fossil fuel than it makes. Producing ethanol from mielies takes 29% more energy in fossil fuels than it produces.

The South African government is committed to decreasing the amount of fossil fuels used in energy production. There has been some promise to use mielies to produce biofuels which may be used instead of petroleum to drive car engines.

Decide whether you think the Department of Energy should pursue the use of biofuels as a source of energy to drive motor vehicles. Write a letter to the Minister of Energy in which you explain your decision.

ANSWERS ON PAGE 166

COMMENT

The chemical industry uses different types of chemical reactions and specific processes to convert natural resources into useful products, ranging from soaps, detergents, and plastics, to fuels, paints, preservatives, and disinfectants. These products play an important part in our daily lives, and make a significant contribution to society in areas such as health, hygiene, construction, manufacturing, and transport.

CHECKLIST

Are you able to:

- ❒ define the terms pollutant and deforestation
- ❒ name the air pollutants responsible for causing photochemical smog, acid rain, climate change and ozone shield destruction
- ❒ explain what is meant by climate change, and the effects of climate change
- ❒ discuss what causes acid rain and its effect on Earth.
- ❒ discuss how sewage, fertilizer household and animal waste, soil pollution, pesticides, industrial waste and mines pollute water
- ❒ explain why deforestation has occurred and the effect deforestation has on Earth
- ❒ compare monocropping and crop rotation
- ❒ list the advantages and disadvantages of monocropping
- ❒ explain why farmers use chemical fertilizers
- ❒ list five disadvantages of using chemical fertilizers
- ❒ explain problems that have resulted because food has become a commodity in our capitalist society
- ❒ explain what a biofuel is, and state the advantages and disadvantages of using biofuels
- ❒ discuss the causes, symptoms, and treatment of pneumoconiosis, silicosis and asbestosis.

LESSON 7

Sustainability of natural resource use

About this lesson

You have looked at problems when using land as a resource in previous lessons; for example, problems associated with deforestation, soil depletion and deterioration and invasion of alien vegetation. In this lesson we look at ways of using resources in a sustainable way and ways of correcting these problems. You will see that reforestation can be used to counter some of the negative effects of deforestation. Various farming methods such as crop rotation and companion planting are ways of ensuring that a farm remains sustainable.

You will look at ways of ridding the environment of alien invasive vegetation, ways of reducing soil erosion and the sustainable use of water. You will explore how mines and industry can clean and reuse water so that water remains a resource which is available for use by generations to come.

You will also study sustainable ways to manage waste which we generate as well as a possible solution to the problem of producing sustainable fuel: biodiesel from algae.

In this lesson you will:

- define reforestation and its importance
- define and understand crop rotation and companion planting
- define and discuss ‘alien vegetation’
- discuss how loss of vegetation cover results in soil erosion and how soil erosion can be reduced
- discuss the use of water in industry and mines
- identify contaminants found in mine water
- name the hazards in industrial waste water which need to be taken into account when cleaning waste water
- explain the advantages of reusing waste water in industries and mines
- explain why recycling of waste products is important
- discuss the production of biodiesel and list advantages of deriving biodiesel from algae.

Natural resources

We use natural resources such as trees for everyday living, the construction of homes and the making of paper. However, as discussed in the previous lesson, using natural resources has in many instances resulted in the environment being harmed.

Sustainable use of land resources is achieved through reforesting areas, crop rotating, and companion planting methods. To minimize the effects of soil depletion and deterioration, various methods can be applied.

Reforestation

Reforestation involves re-planting trees in areas where they once occurred as forests and is essential in ensuring a continuous supply of wood and sustainable management of forest resources. Reforestation is also important because it preserves soil productivity, creates wildlife habitats, protects water quality and creates recreational opportunities. Finally it is an important component of the cycle of growing, harvesting and regenerating forests.

ACTIVITY 1

1. Discuss environmental problems which may arise due to deforestation.

ANSWERS ON PAGE 167

2. Why is reforestation important?

COMMENT

We need farms to provide a growing population with food. However, you have seen that many of the large mechanized farming practices are causing harm to the environment.

In the section which follows you will look at how using crop rotation and companion planting result in less damage to the environment.

Crop rotation and companion planting

Many farmers use crop rotation as a method of cultivating various crops to prevent the negative effects of monocropping. Crop rotation is a method of farming used where different plants are planted in a field following a certain order. For example, mielies may be planted in the first growing season and soya beans in the next growing season.

When deciding on the order we should follow when planting , farmers take several factors into account.

- Crops belonging to the same family, for example cauliflower and broccoli, are often attacked by the same group of pests. Therefore related crops should not be planted after each other.
- The roots of various plants grow to different depths. See the table below:

shallow (less than 600mm)	medium (600-1200mm)	deep (more than 1200mm)
broccoli	beetroot	asparagus
cabbage	carrot	parsnip
cauliflower	cucumber	pumpkin
celery	green bean	squash
garlic	mielies	sweet potato
lettuce	sorghum	tomato

Table showing the depth of root growth of various crops

Some roots grow deep into the soil, for example pumpkin roots; some grow to a medium depth, for example carrots, while some plant roots grow to shallow depths for example, cabbage. Planting crops whose roots grow to the same depth tends to exploit the same root zone. This leads to a decrease in available nutrient at that depth and plant growth will decrease.

- Crops with high nutritional requirements such as cabbage should follow a plant that adds nutrients to the soil; for example, soya beans add nitrate to the soil.

The most effective rotations combine crops with different growth strategies: deep rooting versus shallow rooting; nutrient adding versus depleting; water addition versus water consumption.

Advantages of crop rotation

Some crops have positive effects on the plants which follow in the rotation:

- rotations reduce pests and diseases
- rotations improve soil quality
- labour is better distributed throughout the year as planting and harvesting time are different for the different crops.

Therefore there may be work on the farm all year round.

Wheat and mielies are examples of grain crops which are cost-effective crops. Once farmers harvest the wheat, they plant mielie seeds. While wheat and mielie plants absorb many nutrients from the soil, their roots invade different root zones.

Once farmers harvest the mieleies, they plant sunflowers and once they harvest the sunflowers they plant sorghum seeds.

Another method farmers use to improve their sustainability is **companion planting** where different kinds of crops are planted together and will benefit each other in terms of health and nutrition, as well as interactions with weeds, insects and other organisms.

A farmer may plant a beneficial crop in a nearby field to attract certain pest insects away from the main crop. This type of companion planting is called trap cropping. In trap cropping the pests feed off plants which the farmer is not going to harvest and the farmer does not need to use pesticides on the main crop, which is better for the environment.

Another type of companion planting is called **nurse cropping** where tall plants are planted to protect more vulnerable plants through shading or by providing a wind- break. You will remember that trees are planted to act as windbreaks on some farms.

predators:
killers

Refugia is a third type of companion planting. In refugia, the companion plants provide a good environment for beneficial arthropods (insects and arachnids). These animals are useful as they are **predators** or parasites of pest species and they reduce the damage caused by the pest species. Farmers use trap cropping and refugia help reduce the amount of pesticide needed to help control pests.

ACTIVITY 2

1. What is meant by the terms:
   a. crop rotation
   b. companion planting.

2. List three advantages of companion planting.

3. What does a farmer need to consider when deciding on crops to use when rotating crops.

4. List four advantages of crop rotation.

5. A farmer has a large 100ha plot of land. You are approached to plan which crops the farmer should plant together, in an attempt to reduce the amount of fertilizer and pesticide the farmer would have to use if the farm was one large monoculture. Use the information given in the table on the next page and draw a diagram where you show which plants you would plant next to each other.

ANSWERS ON PAGE 167

Common name	Helps	Helped by	Attracts	Repels	Avoid
Alliums Onion, garlic	tomatoes, potatoes, cabbage, broccoli, carrots	carrots		slugs, aphids, cabbage worms	beans, peas, parsley
Asparagus	tomatoes	tomatoes, parsley,	encourages lady bugs		onion, garlic, potatoes
Brassicas Cabbage, broccoli	potatoes, cereals (e.g. mielies wheat)	onions, garlic,		wireworms	tomatoes, peppers
Beans	mielies, spinach, lettuce, carrots, cabbage, broccoli			California beetles	tomatoes, chili peppers, onions, garlic, cabbage, broccoli,
Carrots	tomatoes, onions, lettuce		parasitic wasps		parsnip, radish
Mielies	beans	sunflowers, legumes (beans, peas, soybeans etc.), peanuts, parsley, and potato			Tomato, Celery
Lettuce		radish, beans, carrots			celery, cabbage
Onion	tomatoes, broccoli, cabbage	Carrots		aphids	beans, lentils, peas, parsley
Potato		horseradish			carrot, cucumber, onion, , sunflower, tomato
Parsnip	fruit trees		a variety of predatory insects		
Spinach		peas, beans			
Tomatoes	roses, peppers, asparagus	basil, oregano, parsley, carrots, marigold, onions, celery,	tomato hornworm	asparagus beetle	mielies, peas, potatoes, beetroot, cabbage,

Reducing erosion

Do you remember that soil erosion is the process by which soil, and especially fertile top soil, is lost? Plants struggle to grow in eroded soil, since it is nutrient poor. Further, the soil that is lost may land up in streams and rivers.

Water erosion

Let's look at some methods that reduce soil erosion. These methods involve keeping the soil covered and controlling water runoff.

- **Mulching:** a layer of plant material such as hay is placed on the top of the soil. The hay protects the top soil from wind and water. When it rains the hay helps hold water and reduces the impact of water on the top soil. This reduces the amount of top soil lost.
- **Silt fences** are placed at the bottoms of slopes. These fences allow water but not soil to flow through them. In this way silt fences prevent top soil from being washed into streams and lakes.

Silt fences used to prevent soil erosion

Grass strips to reduce erosion

- **Planting trees and shrubs** in areas where erosion is likely ensure that the plant roots hold the soil. The leaves on the trees help slow the impact of the rain and leaf litter covers the ground, slowly releasing the rain water. Tall trees also serve as windbreaks.
- **Plant on the contour** involves planting around slopes rather than up and down the slope. This helps slow down the flow of water, allowing it to be absorbed.
- **Grassed strips** are when farmers leave small strips of grass between ploughed fields which helps to slow the flow of water.

ACTIVITY 3

1. What is soil erosion?
2. Why do we need to control soil erosion?
3. How can soil erosion be reduced?

ANSWERS ON PAGE 168

Removal of alien vegetation

Alien vegetation refers to plants that occur outside their natural habitat or country of origin. Alien invasive plants are able to outperform and outgrow indigenous species. This usually results in these plants establishing themselves in non-native habitats. Alien species are introduced into a country in many ways.

Some plants were brought into the country for practical purposes such as forestry plantations, ornamentals and food, whereas others were brought in unintentionally by road transport, winds, floods and sea transport. It does not matter how or why the alien plants were brought into an area, what does matter is that in many instances they cause a threat to the natural environment.

What is the problem with alien species?

Owing to a lack of predators and disease, many alien plants are able to grow faster, mature earlier and produce more seeds than indigenous species. Invasive alien plants can lead to loss of biodiversity and threaten water quality and quantity. After habitat loss, alien invasion has been rated as the second biggest threat to survival of ecosystems. Alien plants have claimed about 8 percent or 10 million hectares of land suitable for agricultural use in South Africa. If alien plants are not eradicated or managed, in fifteen years they could have doubled in area.

Removal of alien vegetation

Control of invasive alien plants

Currently, four methods are used to rid an environment of alien plants:

- **mechanical methods**: physically removing by cutting down or ring barking, or burning alien plants.
- **chemical methods**: using herbicides. Alien plants are sprayed with a chemical which kills them.
- **biological control**: using host-specific insects and **pathogens** from the alien plant's country of origin. Organisms which control the alien plant in its natural habitat are identified and are brought to a new habitat to control the plant. Care needs to be taken to ensure that the organism brought into the area does not become a problem in the new habitat.
- **integrated control**: combinations of these approaches.

pathogen:
a virus or bacterium that can cause disease

ACTIVITY 4

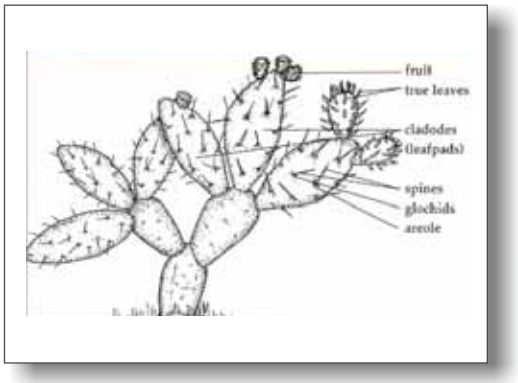
Read the case study on the next page and then answer the questions that follow.

Cactus bio control

The biological control projects against various pest cacti in South Africa have been among our country's most successful bio control projects. Most of the early South African biological control projects involved cactus species, starting with the control of prickly pear in 1913.

Prickly pears were introduced in South Africa to help fence off farms in the Karoo area. However, owing to a lack of natural enemies the plant is able to overgrow an area very quickly.

The prickly pear became so dense in these areas that some farmers were unable to make money from their farms.



A prickly pear plant

In most cases, cochineal insects or mealy bugs were the most important biological control agents, although the cactus moth has also played a role in controlling some species of the prickly pear. All these bio control agents (cochineal insects, mealy bugs and cactus moths) fed only on the prickly pear and did not threaten any other plants. The cactus family is so different from other plant families that its natural enemies never attack plants in any other families.

This has made it easy to find natural enemies that are sufficiently host-specific for release in South Africa. The biological control of cactus weed in South Africa has been exceptionally successful.

Biological control of invasive alien vegetation has been used successfully to control many species of plants. Below is a table showing the number of biological control agents released in South Africa.

Decade	Number of species released
1900-1910	0
1911-1920	1
1921-1930	0
1931-1940	5
1941-1950	2
1951-1960	2
1961-1970	9
1971-1980	20
1981-1990	43
1991-2000	29

1. Name the organism/s that are:
   a. the invasive alien vegetation
   b. the agents of biological control

2. Why did the organisms mentioned in 1a become a pest?

3. Why were the organisms mentioned in 1b successful in controlling the alien invasive organisms?

4. Draw a **histogram** using the data provided in the table.

histogram:
statistical bar graph

ANSWERS ON PAGE 168

Having looked at some of the ways we try to use land sustainably, we will now look at how mines and industry use water in a sustainable way.

Sustainable use of water by mines and industry

Because many industrial and mining processes produce large amounts of water pollution, industries and mines are now taking precautions to try and reduce their impact on the environment. Both industries and mines reuse their waste water in an attempt to ensure that their water use is sustainable.

Industrial wastewater is water produced from various processes at industrial or commercial premises. When industries reuse their processed water, they use less municipal drinking water. Waste water which can be reused includes all water released from the facilities except for sewage which needs to be treated at sewage treatment plants.

The type and amount of wastewater produced by industry varies. The quality and quantity of waste water produced depends on many factors:

- the actual process using the water. For example, is the water used to wash raw materials or wash the finished product? Is the water used for heating or cooling purposes?
- the number of times the water has been reused. Every time water is reused there is a possibility that the levels of pollutants in the water will increase. This needs to be carefully monitored.
- the type of chemical reaction in which the water may be used during the industrial or mining process.
- the temperature of the water.

Industries have many opportunities to reuse water. With appropriate management, which may include filtering, industrial water can be reused for a wide range of purposes. Some of these purposes include industrial uses such as cooling and material washing or non-industrial uses such as irrigation and toilet flushing. For example, a plant can use water from sinks, called grey water, which only needs to be filtered, to cool machinery. As long as the reused water has been cleaned it can be recycled and used in different processes in the industrial plant. Recycling water saves drinking water from being used for jobs that do not require drinkable water.

To reuse industrial water in a safe and sustainable way it is important to identify, assess and appropriately manage the risks associated with recycling the waste water. To do this, management should undertake a risk assessment to identify potential hazardous events and show the likelihood and consequences of these occurring.

Industrial water has many hazards because of the presence of chemical (some of which may be reactive), microbiological, physical and radiological agents. Without adequate protection, people or the environment can be exposed to these hazards when industrial water is reused.

Potential common hazards include:

- pathogens (disease causing organisms).
- nutrients (nitrogen and phosphorus).
- biodegradable organics (composed principally of proteins, carbohydrates and fats).
- dissolved inorganics (e.g. calcium and sodium).
- metals (e.g. arsenic, cadmium, lead, mercury and silver).

Mines have tried to recycle water to reduce the mine's impact on the environment. In mining, water is used to wash rock debris to recover valuable material.

Used mine water is unsuitable for direct reuse or application in other processes unless it is first retreated. Recycled mine water can be used in mining processes where low water quality is acceptable, for example washing ores or cooling.

The contaminants in waste water produced by a typical mining industry can be classified as follows:

Main categories	Sub categories
Physical	Suspended solids Colour Temperature Taste and odour
Organic chemical	Coal Oils and grease Soaps and detergents Rubber Dyes and phenolic compounds
Inorganic chemical	Heavy metals (e.g. Zn, Pb, Ni) Acids Alkali Cyanide Dissolved salts (Ca^{2+}, Cl^-)
Biological	Bacteria Viruses
Radiological	Uranium Titanium

ACTIVITY 5

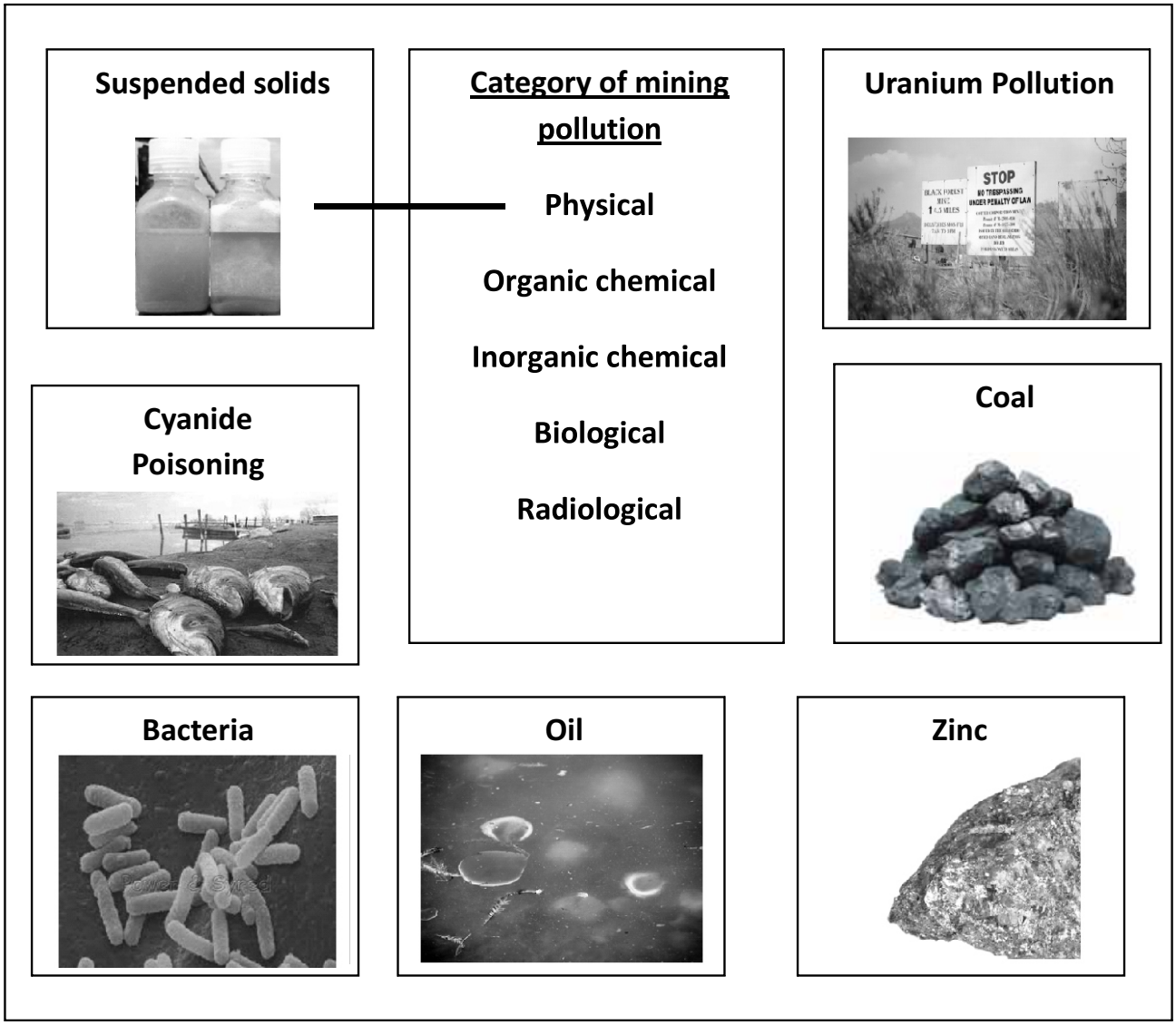
1. Why should industrial waste water be recycled?

2. Construct a table where you state the categories of common hazards of industrial waste water and provide an example for each category.

3. Name some uses of recycled industrial waste water.

4. Use the figure below to match the example of the pollution with the category of the pollutant. The first one has been done for you.

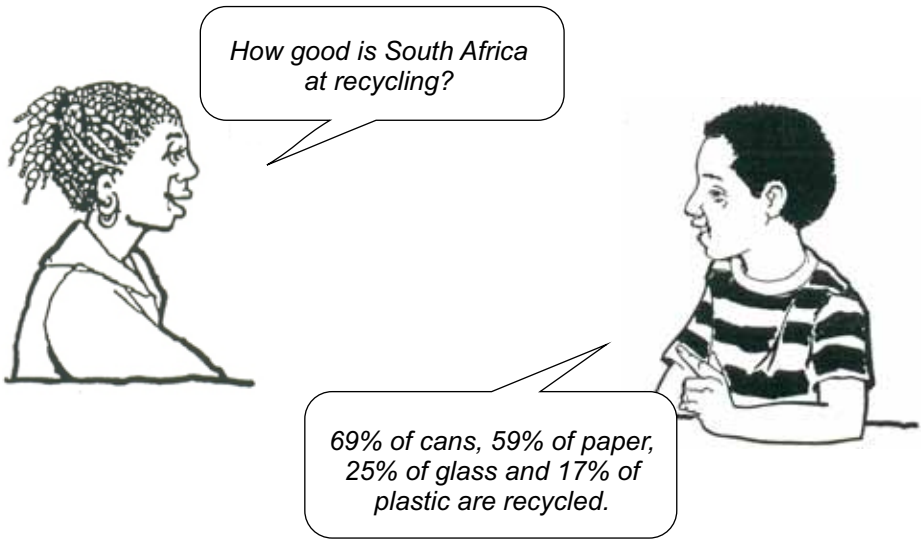
ANSWERS ON PAGE 169



Recycling of glass, tins and plastic

Waste is anything you throw away that you no longer have a use for. Waste, and how we choose to handle it, affects our world's environment. The waste we create has to be carefully controlled to be sure that it does not harm the environment and human health. By recycling glass, tins, plastic and paper, the amount of waste on landfill sites can be reduced.

These items can be remade into either the same kind of thing or new products. Making new items from recycled ones takes less energy, uses fewer resources than making products from raw materials and ensures that supplies are sustainable and will not run out.



Informal recyclers recover much of the above material from dustbins and rubbish dumps. This is not ideal, from the point of view of the health and safety of the recyclers, but also because the recyclable material is often contaminated with other waste. It would be better if households sorted through their waste so that uncontaminated recyclables could be collected.

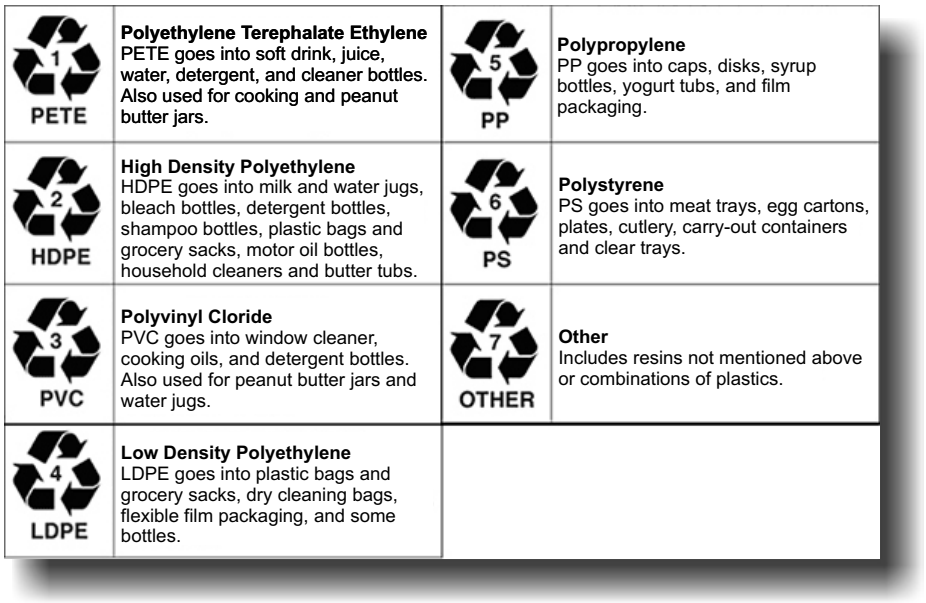
What can be recycled?

Metal: Cold drink and beer cans; food tins; metal lids of glass jars; foil and foil packaging; paint, oil and aerosol cans and rusty cans

Glass: cold drink bottles, jars and bottles
Drinking glasses and light bulbs cannot be recycled.

Paper: white office paper; magazines and books; newspapers; cardboard
Laminated or waxy paper, punch confetti, carbon paper, and stickers cannot be recycled.

Plastics: Most plastic packaging we use today is recyclable. The easiest way to determine whether a plastic product is recyclable is by looking for its recycling logo. There are seven recycling logos. See the diagram on the next page.



Plastic recycling logos

The logo tells you what type of plastic a container is made of. Each type has to be recycled separately.

Tetra pak

These are fruit juice and milk containers that look as if they are made out of plastic, but are lined with aluminium foil and plastic. Tetra pak containers are recyclable.

Batteries

Disposable batteries are not recyclable. Rechargeable batteries are recyclable.

ACTIVITY 6

The table shows what a typical household's waste consists of. Use it to answer the questions that follow:

Type of waste	Percentage of rubbish in a dustbin
garden waste	8.0
metals	8.5
paper	17.6
plastic	40.4
food scraps	7.4
glass	7.0
rubber, leather and textiles	11

1. Draw a bar graph to depict the data shown in the table.

2. Which of the above 'types of waste' can be recycled?

3. What are the advantages of recycling waste?

4. Provide the correct plastic recycling logo for each of the items given below.

ANSWERS ON PAGE 169

Window cleaner

Soft drink

Bleach

Shampoo bottles

Polystyrene containers

Plastic Shopping bags

Yogurt

Bottled water

Drinking straws

A concern that many scientists have is that some of our non-renewable resources, such as oil and coal, are running out. You will remember from the previous lesson that in some countries mielies are used to produce ethanol to run motor car engines.

However, using ethanol to run engines is problematic and some scientists think that it is not a sustainable source of energy. They feel that a more sustainable alternative is to use algae to produce oil which is converted into a biodiesel.

New energy sources

Biodiesel from algae

bioreactor:
an apparatus in which a biological reaction or process is carried out.
photo bioreactor:
a bioreactor that uses some type of light source
salinity:
salt content

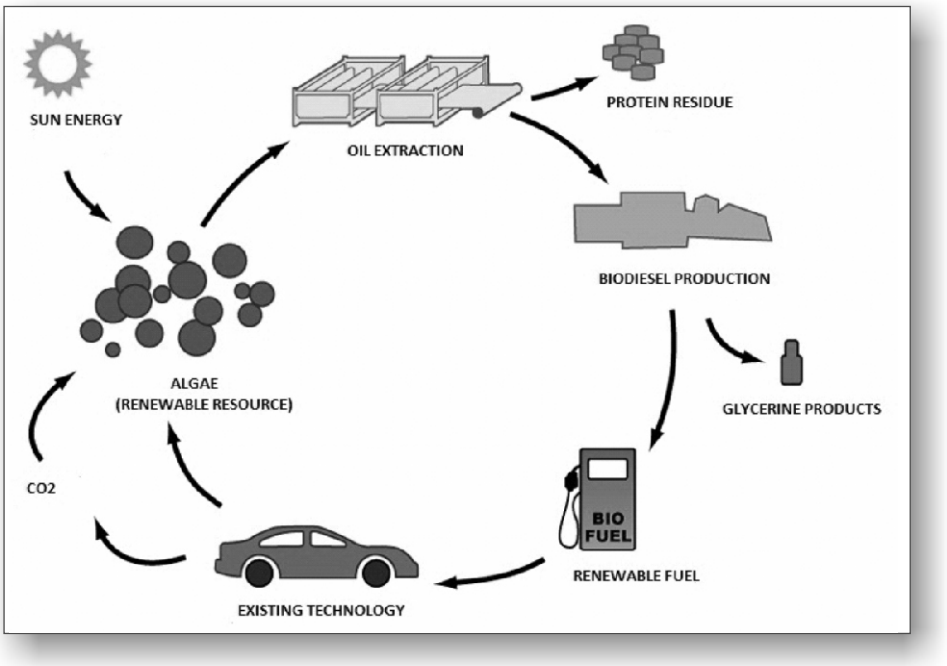
Algae range from small single-celled organisms to multicellular organisms with fairly complex forms. Algae are usually found in damp places or in bodies of water. They contain anywhere between 2% and 40% lipids/oils and it is possible to extract these oils and manufacture biodiesel.

The main equipment used to harvest algae is a **photo-bioreactor**. The purpose of a photo-bioreactor is to grow as much algae as possible. A photo-bioreactor is set up with nutrients and algal 'seed' which are allowed to grow until the batch is harvested.

Algae should be grown in shade, temperatures must be kept constant, overcrowding stops growth, and the 'waste' oxygen they produce from photosynthesis must be continually removed. Open algal ponds are subject to evaporation and rainfall which influences the salinity and pH of the water body and local species of algae often overgrow the desired strain.

Algae culture for biodiesel production

Processing algal-oil into biodiesel is easily achieved. Look at the diagram and the description to see how biodiesel is made.



Biodiesel from algae

Once the alga has grown in the photo reactor it is processed. First the oil from the algae is extracted. The rest of the algae – mainly protein – is discarded. The oil is then sent to a biodiesel production plant. Here both biodiesel and glycerine products are produced from the algal oil. The biodiesel may be used to run motor car engines.

The difficulty in producing biodiesel from algae is to find a strain of algae with a high oil content and that grows quickly. The algae must also be easy to harvest and grow well under culture conditions.

Since many algae have faster growth rates than land crops, the amount of oil harvested from them is much greater than that from any land crop. The production of algae to harvest oil for biodiesel holds much promise.

Advantages of producing biodiesel from algae oil

The advantages of deriving biodiesel from algae oil are that algae grow quickly, there is a high per-acre yield (7-31 times greater than the next best crop, palm oil). Algae biofuel contains no sulphur, is not toxic, and is bio-degradable.

Algae consume carbon dioxide as they grow, so they could be used to capture carbon dioxide from power plants and other industrial plants that would otherwise go into the atmosphere.

The production of algae to harvest oil for biodiesel has not yet been undertaken on a commercial scale. This production holds much promise, though, because of high oil yield. Further, unlike crop-based biofuels, algae do not result in a decrease in food production as it does not use farm land or freshwater supplies.

ACTIVITY 7

1. What organic chemical is used to manufacture biodiesel?

2. List 6 advantages of obtaining biodiesel from algae.

3. Why has biodiesel not been commercially produced from algae?

ANSWERS ON PAGE 170

COMMENT

There is an urgent need to use our natural resources in a sustainable way. Our inventiveness is constantly being tested as we develop new ways of countering the destructive effects of industrial contamination, soil erosion, invasive vegetation, and deforestation. Techniques such as cleaning and reusing waste water, recycling waste products, producing biodiesel from algae, reforestation, crop rotation, and companion planting are significant steps in the right direction, and point the way to a cleaner, healthier planet.

CHECKLIST

Are you able to:

- ❒ explain what is meant by crop rotation and companion planting
- ❒ discuss and list the advantages of crop rotation
- ❒ explain three types of companion planting
- ❒ state what is meant by reforestation and explain its importance in sustainable forestry
- ❒ define what an alien invasive plant is, explain how invasive alien plants are destroying natural habitats, and discuss how alien vegetation is controlled
- ❒ explain how wind and water cause soil erosion and how to reduce soil erosion
- ❒ explain the use of water in industry and mines
- ❒ list contaminants found in mine waste water
- ❒ explain the advantages of reusing both mine and industrial waste water
- ❒ explain how some mines clean their waste water for reuse
- ❒ name the categories of items which can be recycled
- ❒ state advantages of recycling various materials
- ❒ explain how biodiesel is produced from algae
- ❒ list the advantages of using algae to produce biodiesel.

LESSON 8

Land Use

About this lesson

In this lesson you will look at the various purposes we use land for its desirability, as a natural resource, for development or agriculture.

What is important is that when land is used, it is used in a sustainable way which will ensure that it remains a natural resource which will be available for future generations to use.

In this lesson you will:

- list purposes for which land is used
- consider how decisions are made regarding the use of land
- distinguish between arable and marginal land
- explain how farmers may use marginal land
- discuss how paved urban areas cause water pollution and the urban heat effect
- list advantages and disadvantages of living in multi-unit dwellings and stand-alone houses.

Debates around land use

Land is a natural resource. In modern societies land is not only needed for agricultural production but also for other purposes such as:

- housing
- sport and recreational facilities
- forestry
- highways, roads, and streets
- industrial sites
- wildlife conservation
- water storage
- mining

Land uses

Nature Conservation

Allocation of land	% **Total area**
Arable land	13.0
Forestry	1.1
Grazing	54.7
Other agriculture	2.5
Nature conservation	9.6
Urban, industrial, mining, transportation	19.1

9.6% of South Arica's land is used for conservation. Land set aside for conservation not only protects habitats, but can be used to generate income through ecotourism which attracts many tourists into an area and creates employment opportunities and new developments.

New developments

Infrastructure (e.g. roads) needs to be planned to meet the needs of future growth

Before any new land development is undertaken, developers should conduct an Environmental Impact Assessment study and need to ensure that the infrastructure (roads, water supply, electricity and sewage removal) is suitable to meet the needs of the predicted future growth. They forward their plans to the local municipality for approval and put up signs to inform the community of their proposed development so that residents can be involved and voice their concern if necessary. The municipality will listen to complaints and concerns and then make a decision on whether the proposed development can go ahead or not. If approved, the land may be developed.

Conflicts over land use may arise from competition for scarce resources such as fresh water or mineral deposits or as a result of disagreements over sustainable land use.

People are concerned that land and water are not managed properly resulting in the land and or water becoming polluted. These conflicts need to be settled to ensure that when natural resources are used they are used in a sustainable way.

Arable land should not be developed. It is essential that farmers have good quality land to produce crops and raise animals to feed the nation. However, as cities grow and other developments such as housing settlements take place, land previously used for agricultural production is increasingly being used.

arable land:
land suitable for cultivation

ACTIVITY 1

1. Use the information provided in the table on the previous page to draw a pie chart showing how land is used in South Africa.

2. Name some issues which may result in conflict concerning how a piece of land should be used.

3. Read the case study of St Lucia in the text box below and answer the questions that follow:

Case Study: St Lucia

In the past, conservation in St Lucia competed as a land use with subsistence agriculture, sugar plantations, and the defence force (which secured part of the area as a missile testing range). More recently, it competed with the mining industry. Coastal dunes on Lake St. Lucia's eastern shores contain many mineral deposits. To maintain the life of their smelter further south, Richards Bay Minerals (RBM), secured a prospecting right in the 1980s for new sources of mineral sands on the eastern shores. In attempting to exercise its option to mine, RBM came up against the Natal Parks Board, backed by environmental organisations keen to secure the eastern shores for conservation and tourism. RBM commissioned a lengthy Environmental Impact Assessment (EIA) study.

Some people felt mining would offer new job opportunities. Other people felt such jobs would not necessarily be given to local people, nor, with the mining cycle of 17 years, would they be very sustainable. People were also concerned about the impact the mine would have on the environment. However, many of the local communities were not consulted.

In mid-1995 Derek Hanekom, the then Minister for Land Affairs, visited the area. He commissioned new studies to deal with gaps in the original EIA report and to resolve the question of whether tourism could outperform mining in enhancing local development. It was conclusively shown that mining was a less viable development option, and cabinet approved dropping the plans for mining the eastern shores. The conservation group and the Natal Parks Board had won in preventing the RBM from mining. In return they said they would create jobs in the ecotourism industry.

Though this was a victory for the conservation lobby, the expectations of job creation in ecotourism have yet to be met. It is unclear whether the Natal Parks Board has the ability to translate promises into reality.

a. Name the various uses there are for the land in St Lucia.
b. What advantages would there be to the local community if the mine was approved.
c. What disadvantages would there be if the mine was allowed to operate?
d. List the types of jobs that would be created by:
   i. the mine.
   ii. ecotourism.
e. How would the jobs mentioned in d. affect the quality of life of the community?

ANSWERS ON PAGE 171

Use of arable and marginal land

Farmland can be described as either being arable or marginal. Arable land is the most favourable for planting crops.

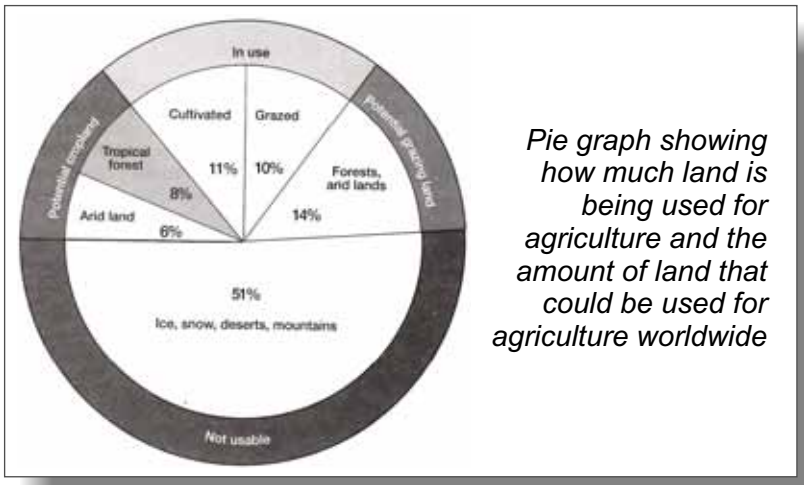
Arable land is usually flat and the soil has lots of nutrients. Land which is on a slope, has low rainfall, and is nutrient poor is said to be marginal land. Farmers use marginal land to provide grazing for animals such as cattle, sheep and goats.

Using marginal land is a risk in that the animals may overgraze the land, crush the soil with their weight and compact it. Plants find it difficult to grow on soil which has been compacted and soil which has no plant cover is vulnerable to soil erosion. When marginal land is used to farm on, care needs to be taken to protect the land. Farmers need to ensure that when they use marginal land they do so in a sustainable way.

ACTIVITY 2

1. Distinguish between arable and marginal land.

2. Name two uses of marginal land for farmers.



Pie graph showing how much land is being used for agriculture and the amount of land that could be used for agriculture worldwide

3. a. Tabulate the data provided in the pie chart on the left which shows how much land is being used for agriculture and how much land could be used for agriculture worldwide.

b. How much more land could be used to plant crops world-wide?
c. Name the problems which could result from using forests and arid lands for grazing animals.

ANSWERS ON PAGE 172

COMMENT

As can be seen from the table which shows the various ways land is used in South Africa, almost 20% of our land has been developed. Much of this developed urban land has been covered with some form of road, paving or concrete.

Let's look at how paving affects the environment.

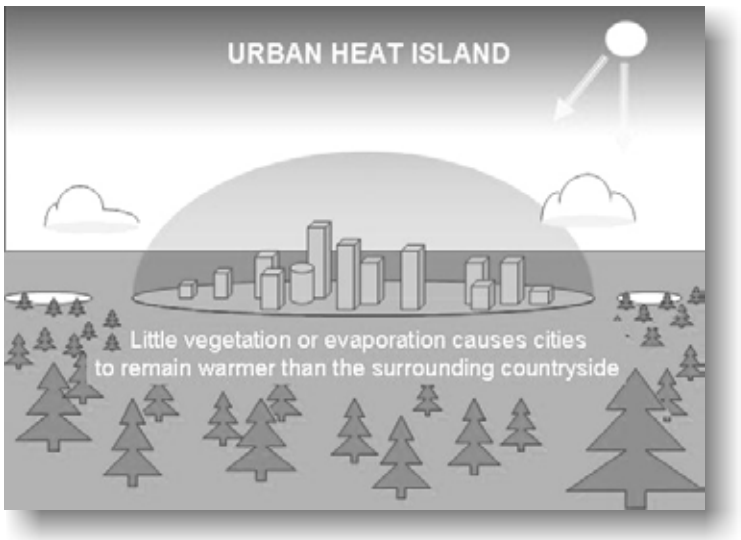
Paved urban areas

Storm water drain

Pavements, asphalt (tar road surfaces), and concrete are all bad for our planet. These surfaces are impermeable to water which means that any rain that falls onto paved surfaces does not filter through the ground. It runs over the road and pavement into storm water drains. On the way it picks up litter, pesticides, and heavy metals from tyres. These substances end up in waterways. Not only does storm water pollute rivers, dams and lakes, but it also upsets the water cycle. This is water wasted that could have been used for crops and animals.

Pavements absorb heat from the sun during the day and release this heat during the night. As a result, urban areas can be as much as 3°C hotter than the surrounding countryside. This temperature difference is called the **urban heat island effect**.

Heat islands develop as cities and towns grow, replacing plants and natural landscapes with roads, buildings, and pavement.



High temperatures in cities may cause a rise in energy use as people try to keep their houses and offices cool by using fans and air conditioners. This increases the use of electricity. As much of our electricity comes from coal-powered plants, an increase in electricity use will cause more coal to be burnt. Burning coal increases the amount of carbon dioxide in the atmosphere. You will remember that increasing the amount of carbon dioxide in the atmosphere results in global warming.

ACTIVITY 3

1. Name the various materials and chemicals that get washed into storm water drains.

2. Where does water from storm water drains go?

ANSWERS ON PAGE 172

3. Explain what is meant by the term 'urban heat effect'?

We are now going to look at two different types of housing: multi-storey buildings and stand-alone houses.

Alternative designs for communal living

The South African constitution states that housing is a basic right of all people.

The government has attempted to provide all people of South Africa with houses. More than two million houses have been built to date. These are mainly the so-called RDP stand-alone (reconstruction and development programme) 'starter' houses.

RDP stand-alone houses are single-family dwellings on large or small plots. An alternative to stand-alone houses is housing people in multi-storey buildings. Here, many people live on a small plot of land.

In this unit we consider the advantages and disadvantages of many people living in multi-unit dwellings compared to fewer people living in a stand-alone house.

Multi-unit dwellings

There are advantages and disadvantages to living in multi-storey buildings with large common areas of parkland.

A multi- unit dwelling in Hillbrow

Advantages

- These buildings are usually located close to CBDs so living near where you work will save transport costs and the time taken to get to and from work.
- The units are not too large, so the time and energy needed to clean them is less than a stand-alone house.
- No time is needed to take care of a garden because these are either communal or the complex would be located near a nearby municipal park.
- Security is usually at a higher level than stand-alone houses. There may be a 24- hour guard and CCTV to monitor the comings and goings at the entrance of the complex.
- Residents who live in multi-unit dwellings tend to form their own community and there are many more eyes and ears that will see and hear if anyone is engaging in disorderly or criminal behaviour.

Disadvantages

- There is usually a levy that is paid to the corporate body for maintenance of units in the complex. This fee pays for maintaining communal gardens, security, water and perhaps even electricity if it is not prepaid. The levy is usually calculated per square metre of unit owned.
- Each multi-unit dwelling complex has a set of rules for all residents, for example prohibition of pets, and being considerate when listening to music.
- Units are generally small, so if you are used to space, you may feel very cramped.
- The value of units for long-term investment is lower than buying a house. As stand-alone houses generally occupy more land, their value increases more than multi-unit dwellings.

Stand alone RDP houses

Stand-alone houses

RDP houses are examples of stand-alone houses which the government built in an attempt to provide people with one of their basic human rights: housing.

Advantages

- The space around the house is private.
- The owner can add on to the existing house if more room is needed.

Disadvantages

- All maintenance and repair costs are at the owner's expense.
- Amenities such as pools and playgrounds are usually absent, unless built at private expense.
- Landscaping and lawn upkeep costs are at the owner's expense.
- From an environmental point of view, single family houses are likely to require more energy to heat in cold weather than do housing units in multi-storey buildings.
- Public transport may not be as readily available as the low density of housing leads to less frequent bus and taxi services.
- Usually there are longer distances to commute as these houses are situated further away from the CBD. This makes single-family houses part of a much more energy- and carbon-intensive lifestyle.
- The low-density nature of this type of housing requires using more land which could otherwise be used for agriculture or as natural habitat

The following data was provided by Statistics South Africa regarding the types of houses people lived in, in 2010.

Type of dwelling	Number of dwellings (in thousands)
stand -alone house	14 304
traditional dwelling (made of traditional materials)	9 094
flat or apartment in a block of flats	1 385
cluster house / town house in complex	760
semi-detached house	160
flat/room/cottage in backyard	1 382
informal dwelling (shack) in backyard	736
informal dwelling (shack) not in back yard	1 123
caravan/tent	4

The city of Johannesburg released the following data concerning the housing situation in their jurisdiction:

Johannesburg's Population

- 791 000 households
- 33% households are housed in less adequate accommodation.
- 108 000 people living in backyard shacks.

Challenges faced by the city:

- The backyard shacks are unregulated.
- 6947 inner city houses need upgrading.
- 27 Hostels need upgrading.
- 89 informal settlements with 170 000 households.
- 145 073 council houses are in a bad state of repair.

To address some of the issues that not only the city of Johannesburg faces, but many urban areas in Gauteng, the Gauteng provincial department launched a housing plan in 2004 called Breaking New Ground.

This housing plan aims to provide people living in the province with well-designed houses, well-serviced houses and houses that are situated in well-located areas.

Well-designed means that people will have amenities such as schools, sports facilities, roads and clinics. **Well-serviced** areas will be serviced with access to basic sanitation, water, electricity, roads and libraries. **Well-located** human settlements must be built where people can access employment and be closer to their means of earning a livelihood.

The Gauteng provincial government is moving towards formalizing informal settlements, eradicating old hostels and replacing them with community residential units, promoting high density accommodation (where land is not available), and improving the economies of some poor townships.

ACTIVITY 4

1. Provide an example of:
   a. a stand-alone house
   b. a multi-unit dwelling.

2. Use the data from the table on page 140 showing the types of dwellings people were living in in 2010 to answer these questions:
   a. Draw a bar graph using this data.
   b. How many households were counted in this study?
   c. Which types of dwellings are stand-alone houses and which are multi-storey buildings?
   d. What percentage of dwellings were multi-storied dwellings?
   e. What are the advantages of living in a multi-storey dwelling?
   f. What are the disadvantages of staying in a multi-storey dwelling?

3. Do you think the provincial government should continue to provide people with RDP houses as part of their Breaking New Ground project? Give reasons for your answers.

ANSWERS ON PAGE 172

COMMENT

We have looked at natural resources and how we use them to meet our basic needs of food, drink, and housing. We have seen how we use natural resources, such as the burning of coal to make electricity, to make our lives easier.

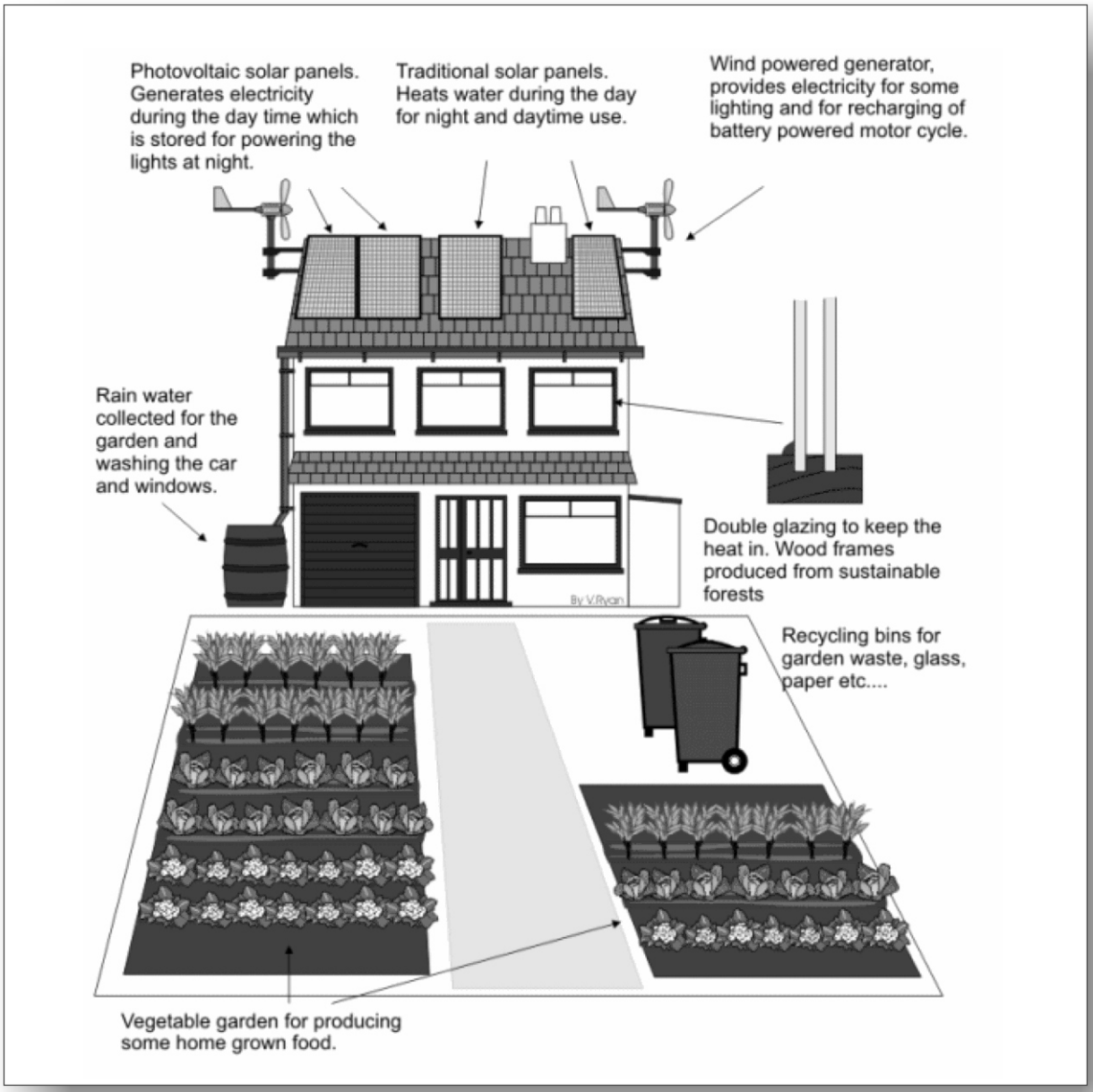
We have also looked at how we use natural resources to produce food efficiently and considered how resources are extracted and processed and how this causes pollution.

We have seen how we need to ensure that when we extract and process natural resources, the damage we do to the environment is limited.

New developments need to cause as little damage to the environment as possible and the use of natural resources such as land and water needs to be sustainable.

ACTIVITY 5

Use the diagram of a home designed to reduce the homeowner's impact on the environment to answer the questions that follow:



1. Name the natural resources used at this house.

2. Which of these resources are renewable?

3. Name the various ways the homeowner is trying to be energy efficient.

4. Explain how the methods the homeowner is using to grow vegetables could be considered as being beneficial to the environment.

ANSWERS ON PAGE 174

COMMENT

Land use is a sensitive and complex issue. Many competing interests and purposes need to be considered when land is developed and distributed, particularly in relation to town planning, housing, agriculture, employment, personal security, and the needs of communities. Decisions about the use of land have a decisive impact on the quality of life and the future of our natural resources. It is vitally important that we protect and preserve our heritage by ensuring that land remains a sustainable ecological resource.

CHECKLIST

Are you able to:

- ❒ list purposes land is used for in South Africa
- ❒ consider various points of view when deciding for which purpose a piece of land should be used
- ❒ define the terms 'arable' and 'marginal' land
- ❒ explain how marginal land may be used in agriculture
- ❒ discuss the harm that paved urban areas do to the environment
- ❒ list the advantages and disadvantages of living in a multi-unit dwelling
- ❒ discuss why RDP stand-alone houses have not been successful in housing South Africans.

Answer section

Lesson 1

Activity 1

1. An increasing world population is going to put a strain on the Earth's resources.

2. The richer, more developed countries may have fewer people; however, they are using most of the world's resources.

3. 80%

4. Renewable resources can be replaced at a rate faster than they are used; they are lasting. Non-renewable resources have taken a long time (often millions of years) to produce and man is using them at a rate faster than they can be replaced, i.e. they are going to run out.

5. It really doesn't matter what stand you take as both an increase in world population and overuse of resources by developed countries are placing a strain on the Earth's resources.

   An increasing world population is going to place a bigger strain on resources as there will be a greater demand for food, water and electricity.

   However, developed countries can afford to pay for excess of resources and they need to be made aware that there is not an endless supply of some resources, for example, coal used to generate electricity, and that everyone needs to be cautious about the amount of resources they use.

6. Everyone needs to use these resources sparingly. For example, turn off lights when not in a room, and don't waste electricity. Viable alternative ways of generating electricity using renewable resources need to be explored and developed.

Activity 2

1. Table comparing the various types of energy supply in South Africa.

Type of energy supply	2003	2004
coal	3 250 000	3 550 000
crude oil	600 000	1 000 000
renewables	450 000	450 000
nuclear	100 000	100 000
gas	20 000	50 000
hydro	0	0

2 a. The amount of energy used increased. More coal was used, and the amount of crude oil used nearly doubled from about 600 000 TJ to 1 000 000 TJ.
b. Crude oil.
c. South Africa has a large coal supply. Coal-fired power stations are cheaper to operate than using a power station which uses a scarce resource. The technology may not be developed sufficiently to compete with the amount of energy generated from coal-powered plants.

Activity 3

1. Answer will vary depending on where you stay. For example if you stay in Ellisras, the closest power station is coal powered.

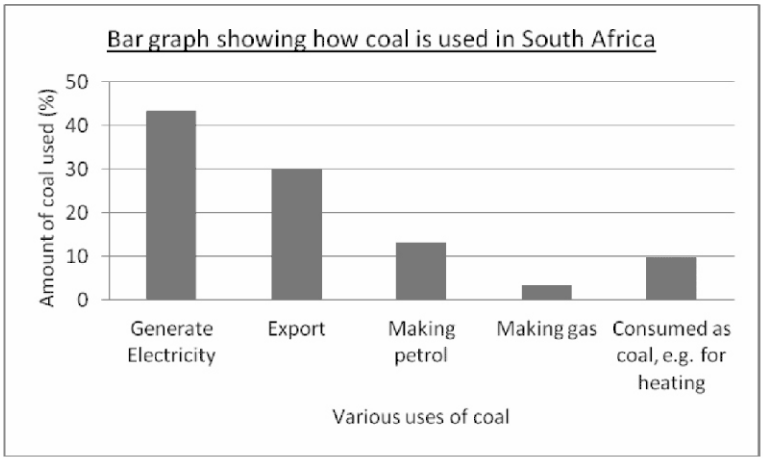
2. Cape Town.

3. 13

4. They are close to coal mines.

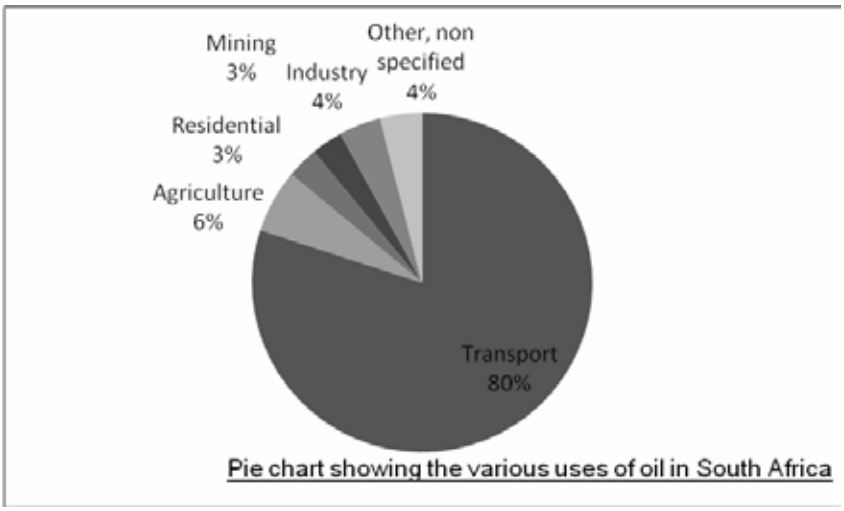
5. They are renewable sources of energy and do not produce as much air pollution (carbon dioxide and sulphur dioxide) as coal plants.

6. a.



b. Coal is used to generate electricity.
c. 30% of the coal is exported.

Activity 4



Pie chart showing the various uses of oil in South Africa

Activity 5

a. They have been produced from plants and animals that died millions of years ago.

b. They are going to run out: coal is expected to last for the next 200-400 years, oil for about 50 years, and natural gas for about 120 years. Coal and oil, when burnt, release carbon dioxide which contributes significantly to climate change. Burning coal results in the release of sulphur dioxide which contributes to acid rain.

c. Oil: petrol, diesel and jet fuel.
Natural gas: heat buildings, water, cooking, drying clothes, lighting, in paper and cement industries. Used in paint, glues, fertilizers, plastics and medicine. May be used to generate electricity or run cars, trucks and busses.

Activity 6

Clues Across

1. Platinum
3. Silica
4. Phosphate
7. Gold
8. Zinc
9. Copper
10. Magnesium

Clues Down

2. Nickel
5. Silver
6. Aluminium

Activity 7

1. There are rich mineral deposits and it is relatively cheap to mine them.

2. Mining forms an important part of our economy, contributing significantly to exports and creating employment for many South Africans.

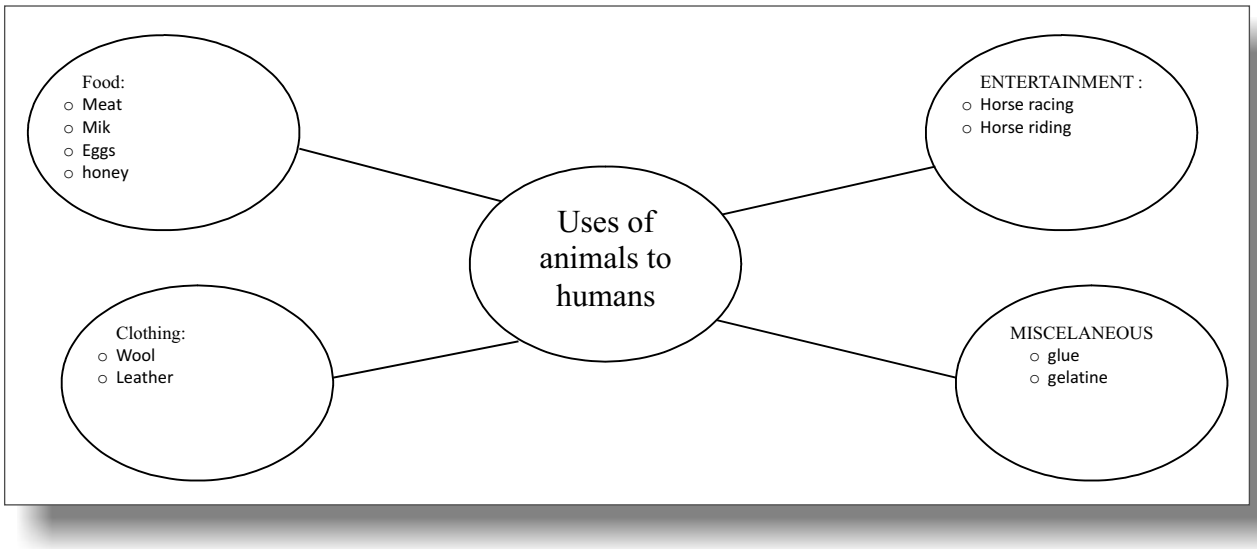
3. Miners feel that they are being exploited in that they are earning low wages and the local communities are not receiving benefits from local mining operations.

4. Mineral deposits are non-renewable and once they have been completely mined out of the ground, how will the country sustain its economy?

Activity 8

1. i. Used as a source of fuel e.g. wood.
   ii. Food, e.g. maize, wheat, rice/
   iii. Used to make clothes e.g. cotton.
   iv. Used to make shelters either directly e.g. wooden houses or indirectly e.g. floors
   v. Livestock are dependent on plants for fodder
   vi. Medicinal purposes.
   vii. In some countries ethanol is obtained from plants, e.g. sugar cane, and used to power motorcars.
   viii. Used to make paper.
   ix. Used to make rope.

2.



3. By managing forests in a sustainable way we will ensure that forests remain a resource which can be used in the future. Trees are a resource we use extensively (e.g. paper, construction) and so it is important to ensure that they are available for years to come.

Activity 9

1. The increase in population sizes places a greater demand on water supplies and an increase in agriculture, leading to an increase in the amount of water needed for irrigation.

2. i. Drinking
   ii. Washing, and personal hygiene
   iii. To extinguish fires.
   iv. Recreation: swimming, skiing
   v. Cooking

3. Advantages: generating electricity using a renewable resource which is relatively environmentally friendly compared to coal power plants; building the dam created employment; increase in the amount of electricity on China's electricity grid.

   Disadvantages: damming up water has displaced 2 million people; silting behind the dam wall; reduction in soil fertility downstream; threat of flooding.

Lesson 2

Activity 1

1 a. A substance used to make soil fertile.
   b. Fertilizer made from rock salt, animal or plant products.
   c. An agent used to kill pests.

2. a. Fertilizers contain elements that are needed for plant growth, e.g. nitrogen, potassium and phosphorus, and so this will improve plant quality and crop yield. Pesticides are used to control pests and parasites. Use of pesticides improves the yield and quality of crops.
   b. Farmer B is allowing his field to lie fallow, i.e. he is giving the soil a chance to recover from his farming activities.

3. There is an algal bloom. Hydrophytes (water plants) die. Fish die owing to lack of oxygen.

4. Eutrophication takes place. Algae die off and decompose. As a result there is no oxygen in the water.

Activity 2

1. pigs.

2. No, the waste from the pigs is being collected by a truck and will probably be taken away.

3. Vehicles: trucks bringing in food and taking away waste.
   Food and water is taken to the pigs.
   The shed appears to be air-conditioned.

4. Probably, the pigs would not be fed; nor would they be watered.
   The temperature in the shed would increase.

5. Animals living so close to each other create a breeding ground for parasites (bacteria and fungi). A pig could get sick rather quickly. Secondly, having the pigs live so close to each other could result in diseases spreading quickly. Antibiotics would prevent this from happening.

Activity 3

1. Mechanized farm.

2. Mechanized farm.

3. Mechanized farm.

4. Free range farm.

5. Mechanized farm.

6. Free range farm.

7. Free range farm.

8. Free-range farm: animals are treated humanely and there is less environmental pollution. However, produce would be expensive. Mechanized farms: produce is cheaper yet many consider that animals are inhumanly treated and this type of farming causes much pollution. Combination farms may be the solution, where animals are treated humanely, there is not too much pollution, and produce is not too expensive.

Activity 4

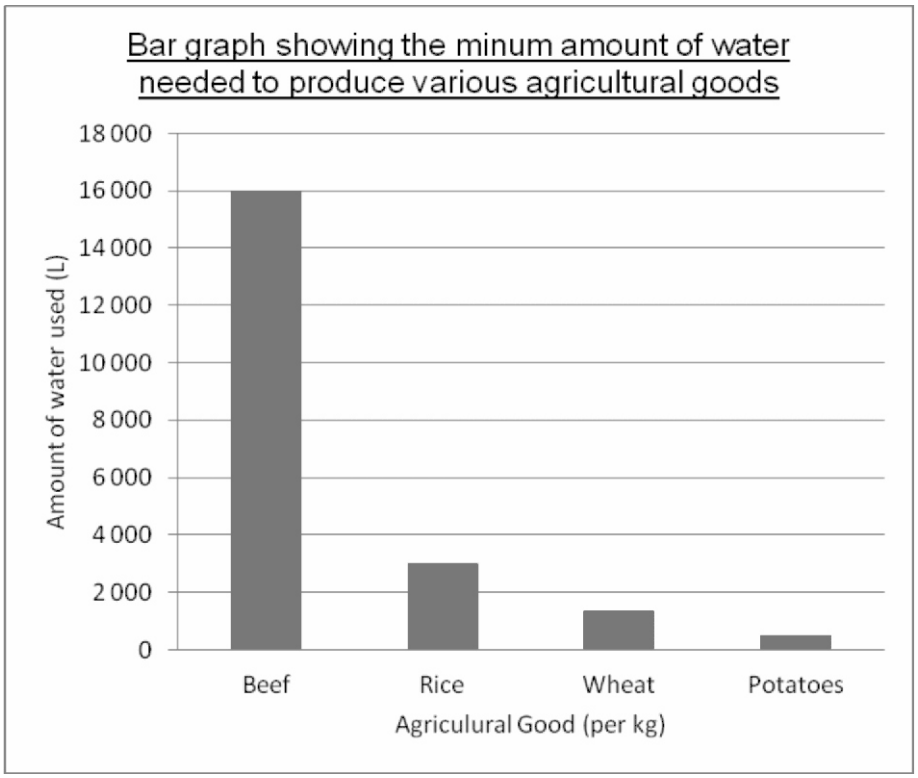
1. Primary resources for grain production:
   air (CO_2 and O_2), water, sunlight, people.

   Secondary resources for grain production:
   technology, fuel, seed stock, fertilizers, pesticides, people.

2. Primary resources for beef production:
   air (O_2), water, natural vegetation, people

   Secondary resources for beef production:
   technology, fuel, breeding stock, people.

Activity 5



Activity 6

1. Crops are pest resistant, herbicide resistant, disease resistant and are tolerant to cold and drought conditions. However, GM crops do not always have good yields, are expensive and there is still some concern about the safety of using GM crops as there may be gene transfer to non-target species during pollination.

2. Crops have not been sprayed with pesticides and herbicides. Some food types have had nutrient genes added to them. For example, golden rice produces beta carotene. GM crops may be more expensive. There are potential health risks.

Activity 7

1. Labour intensive, the chickens are free-roaming, making use of machinery difficult.

2. Primary resources: air, water, natural vegetation, people.
   Secondary resources: breeding stock.

3. Answers will vary:
   Fast-growing animals, large and meaty, less fat.

4. Arguments for GM: it may be possible to improve the nutritional value of chicken by decreasing the fat. If chickens were larger and meatier, fewer chickens would be needed. Fast-growing chickens would mean that the price of meat would be less.

   Arguments against GM: the chickens may be too expensive to develop. GMOs are not always as successful as people thought they would be. Do we really know the long term effects such an organism would have on human health and the environment?

Lesson 3

Activity 1

1. Yes, the diagram shows that trees are being planted in combination with crops.

2. The roots of the trees are preventing the soil from being eroded. The fallen leaves are decomposing and nutrients are being returned to the soil.

3. The trees could also provide a wind-break for the crops.
   or
   The trees increase the biodiversity of the area.

4. Trees could use most of the water leaving little for the plants.

Activity 2

1. South America

2. a. Logging, where the wood is used for paper, flooring, construction, furniture.
   b. Forests land is cleared for agriculture, providing more grazing land and space for crops to grow.
   c. Forests are cleared for mining of minerals

3. Habitat loss and possible loss of biodiversity in those areas. More CO_2 in the atmosphere, influencing climate change. Decline in rainfall and possible drought. Soil erosion, leading to infertile land and silting up of rivers and dams. Loss of potential undiscovered medicinal plants and food. Indigenous people living in the forest lose their way of life and are forced to move and change their lifestyles.

Activity 3

Arguments for removing Jacaranda trees:

- They are exotic and threaten indigenous vegetation. They spread quickly. From 2 trees, there are now reported to be 55 000 in Pretoria, which took only 125 years.
- They take up a lot of water. This may have an effect on nearby rivers and streams as well as affecting the level of the water table.

Arguments for keeping Jacaranda trees

- Evidence is not conclusive about the amount of water they absorb. Since they are deciduous trees, they do not absorb as much water as evergreen trees,
- The trees are very popular ornamental trees in Pretoria, providing shade.
- Their wood is used in the making of furniture.

Language
Write in the present tense and in the third person.
Use vocabulary associated with time such as first, then, after, later, finally.
Include link words such as because, if, then, so, as a result, therefore.

Structure
Give a general statement that gives background information about the topic; logically sequenced paragraphs; a concluding statement that draws everything together; use diagrams to support the text.

Lesson 4

Activity 1

1. Answers will vary depending on the province which you live in.

2. Uses of minerals:

Name of mineral	Use
Gold	Dentistry and medicine, jewellery and arts, medallions and coins, scientific and electronic instruments, computer circuitry, and applications in space travel.
Coal	Generate electricity, heating.
Platinum	Used as an agent to control emissions in automobile and industrial plants, jewellery. Used in pharmaceutical industry to produce acids and in dentistry to make crowns and bridges.
Diamonds	Machinery, mineral services, stone and ceramic products, abrasives, construction and drilling, jewellery.
Iron	Used to manufacture steels of various types. Used in magnets and automotive parts.
Copper	Electrical cables and wires, building construction, switches, plumbing, heating, electrical and electronic components, transportation, coins and jewellery

3. You should mention employment, improved infrastructure and better services in your paragraph.

4. Mention land degradation and pollution of water and air.

Activity 2

2. a. The yolk. It is in the centre of the egg, 'deep underground'.
   b. The unwanted material the mineral is embedded in.
   c. This will vary. As long as you have made a list, and each step is one instruction. Look at this example.

      1. Make a small hole in the eggshell with the knife.
      2. 'Dig' through the egg white with a toothpick until you reach the yolk.
      3. Use the straw to suck out the soft yolk.
      4. Place the yolk in a cup.
      5. Remove any unwanted parts of the egg such as the eggshell or egg white with the straw.

   d. How much of the egg was destroyed?
      What did I do with the 'waste' that was mined?
      How much of the egg yolk was removed?
   e. It illustrated the problems that mining creates, e.g land degradation, what to do with the waste that is generated, how to get the mineral to the surface and then purify the mineral.
   f. It was on a much smaller scale. The egg yolk was extracted in a relatively pure state and so there was little waste generated.
   g. The impact of the mine on the environment.

Activity 3

1. Ventilation: is there enough oxygen for the miners? Are poisonous gases and dust removed? Rock falls, trapping the miners.

2. Ventilation shafts.

3. It is too large and heavy to move up to the surface.

4. Surface mines are much safer to work on than underground mines. Surface mines usually cost less to run than underground mines. The disadvantages of surface mines are that they destroy habitats and pollute water bodies.

Activity 4

7. a. The water is clear.
   b. In the filter paper.
   c. The clear liquid obtained after filtration.
   d. The solid substance which remains on a filter paper after filtration.
   e. (i) bigger.
      (ii) smaller, bigger

10. a. salt.
    b. salty.
    c. The water puts the sand and salt in solution. This makes filtration possible. By evaporating the water from the salt, it is possible to recover the salt.
    d. dissolves, dissolve.
    e. salt, water.

Activity 5

1. Coal is placed in large ovens to remove the coal's gases, and convert the coal to coke. Coke is used because it burns with intense heat and little smoke.

2. The coke, iron ore and limestone, are sent to the blast furnace.

3. The coke, iron and limestone are hoisted to the top of the furnace.

4. Hot blasts of air rising melt the falling ore.

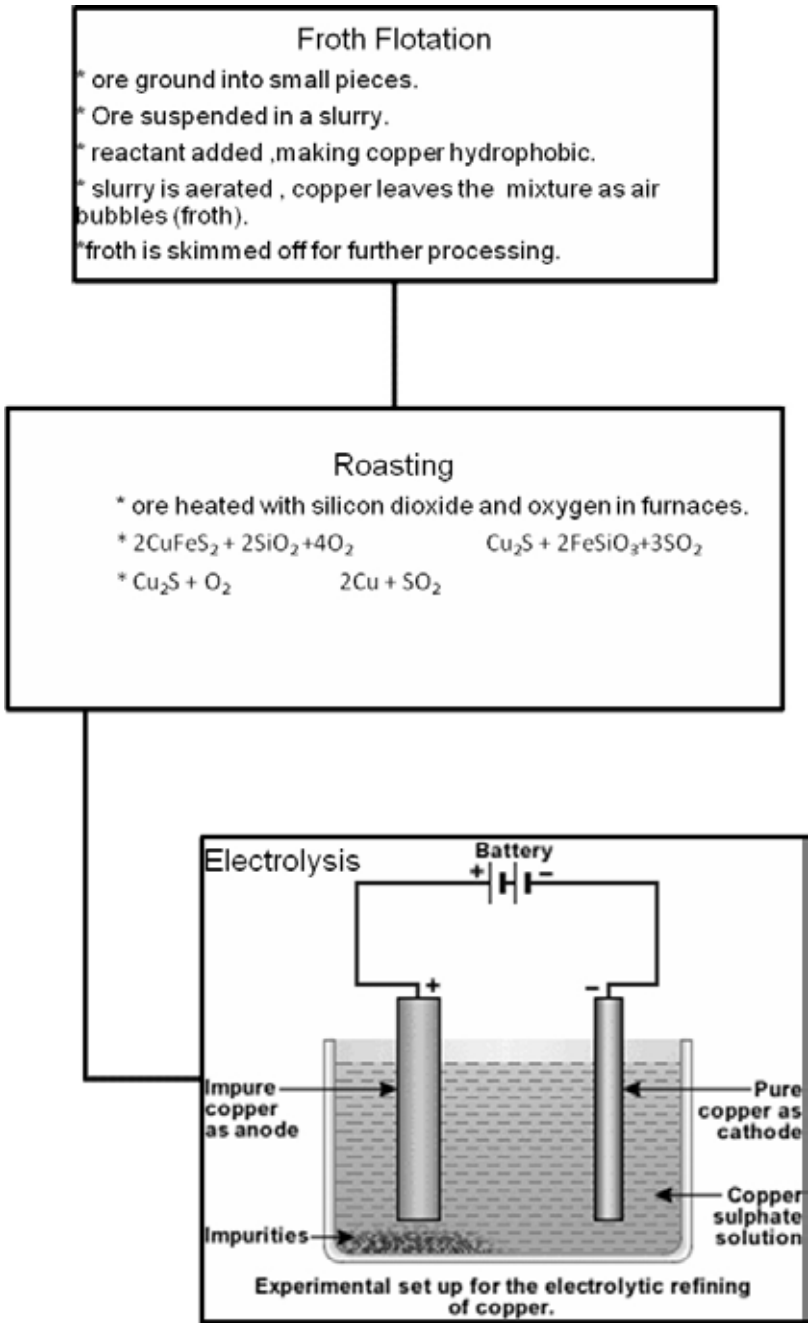
5. The molten iron collects at the bottom of the furnace and is drained.

6. Impurities rise to the top of the ore and are skimmed off.

Activity 6

On next page.

Activity 6



Activity 7

a. The gold ore needs to be crushed into smaller particles. Only fine pieces of ore can be processed. To sort out the larger pieces from the ones small enough the crushed, ore is sent through a hydrocyclone (heavier particles sink). To remove the gold from the fine powder, the powder is treated with potassiumcyanide, which dissolves the gold. Zinc is added to the aurocyande complex, resulting in the formation of gold and a potassium zinc cyanide compound, $K_2ZN(CN)_4$

b. Potassium hydroxide and $K_2ZN(CN)_4$

c. In your plan:
specify wastes by type and volume and say what you can reuse and recycle
Say where you can store the waste
Say how and where waste can be disposed of
Explain arrangements for storage and collection of wastes

Activity 8

1. The Bayer Process

$Al_2O_3 + 2NaOH + 3H_2O \longrightarrow 2NaAl(OH)_4$

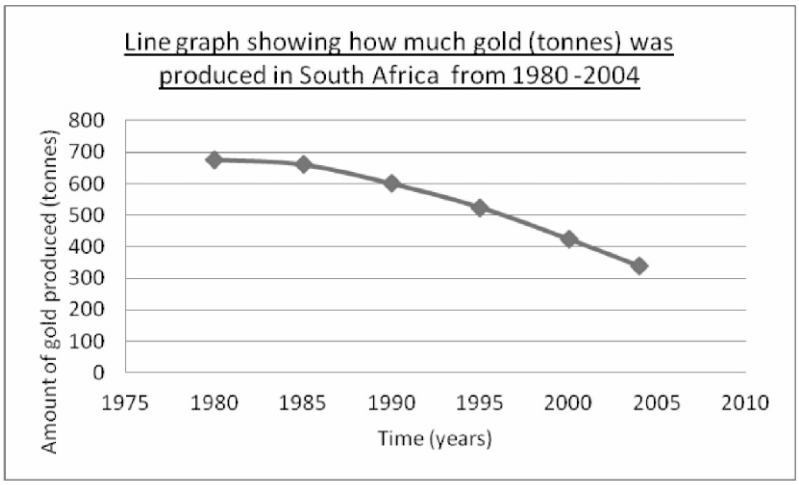
$NaAl(OH)_4 \longrightarrow Al(OH)_3 + NaOH$

$2Al(OH)_3 \longrightarrow Al_2O_3 + 3H_2O$

2. The aluminium oxide is dissolved in reduction pots which are filled with the electrolyte cryolite. Current passes from a carbon graphite anode to carbon cathodes lining the bottom the cell. An aluminium crust forms on the surface of the carbon cathode at the bottom of the cell. This pure aluminium is released from time to time. Alumina is added to the cell continually. Because of the high temperature in the cell, the alumina dissolves in the cryolite. Carbon dioxide is released at the carbon anodes.

Activity 9

1.



2. a. 70%
b. 14%

3. The fall in the rand gold price owing to a strong rand. Increasing costs in production.

4. Increasing costs means that it is less profitable to mine gold, i.e. money that could be profit is now spent on costs, e.g. water.

5. Steel is used extensively on the mine, e.g. in supports in the underground shafts.

6. a. Gold mining employs many people. Much gold is exported, and this brings foreign currency into South Africa.
   b. Many people are dependent on the gold mines for employment. However, from time to time miners go on strike when there is a dispute over wages, working conditions or safety. This is both detrimental to the miners and mines, as there is loss of income while the strike is on.

7. Gold is so expensive because it is a precious metal whose demand outweighs the supply. Gold does not react easily and therefore stays as it is.
   The price of gold varies. In December 2012 it was selling at R475 per gram.

Activity 10

1. a. Air pollution from the procession plant.
      Waste from the crushed ore.
      Waste generated from processing the crushed ore: tailings.
   b. Sent into the atmosphere via chimneys where there should be filters.
      Sent to slag or waste dumps above the ground.
      Sent to a tailings dam.

2. a. A tailings dam is where chemical waste from the mine processing plant is stored. It usually has chemicals which are toxic to both the environment and humans.
   b. Water bodies can be contaminated, leaching into the soil. Towns and villages will be covered with mud if the dam wall breaks.

Activity 11

a.

Person	Point of view regarding mining
Mining CEO	Will create employment Bring money to the town Once mine closed the area will be rehabilitated.
Sangoma	Loss of plants to make medicine
Mayor	Will bring in lots of money
Thabo	Employment
Joe	Environmental degradation, loss of biodiversity

b. The mining CEO will be making a huge profit, which probably will not go back to the community.
Improvement in infrastructure, roads, schools hospitals.
More pollution: air, land and water.
What will be done with the waste material from the mine?
Will rehabilitation really happen?
When the mine is closed, what about mine acid damage?

c. Your answer will vary here depending on the stand to take. When you make a claim, remember to back it up. You also need to ensure that in your argument you make a case for the 'other side', but say that your reasons for the position you take outweigh those of the 'other side' of the story.

Lesson 5

Activity 1

Answers will vary depending on list of items selected.

Activity 2

1. A mixture of H_2, CO and CO_2

2. coal (C) and water $\longrightarrow$

3. Coal from the coal mines in Secunda.
Water from a nearby river.

4. $C(s) + H_2O$ $\qquad$ $CO(g) + H_2(g)$
$CO(g) + H_2O(g)$ $\qquad$ $CO_2(g) + H_2(g)$

5. Washing with methanol at low temperatures.

6. ammonia, tars and pitch, xylenols, phenols. Propylene, ethylene, fertilizers, explosives, acrylic acid, butanol

7. SASOL advanced synthol reactor

Activity 3

1. X SO_2 $\qquad$ Y H_2SO_4

2. Step 1 $\quad S(s) + O_2(g) \longrightarrow SO_2(g)$;
Step 2 $\quad SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$;
Step 3 $\quad SO_3(g) + H_2SO_4(g) \longrightarrow H_2S2O_7(l)$
$H_2S_2O2_7(l) + H_2O(l) \longrightarrow 2H_2SO_4(aq)$

3. Vanadium(V) oxide

4. The sulphurtrioxide is dissolved in concentrated sulphuric acid to produce oleum which is diluted with water to produce about 98% sulphuric acid.

Activity 4

1. Step 1 $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$
   Step 2 $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$
   Step 3 $3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$

Activity 5

1. Nitrogen: atmosphere Hydrogen: coal gasification

2. High temperatures 450°C, high pressure 200-300 atmospheres, a catalyst (iron oxide), removal of ammonia as well as unreacted gas.

3. $N_2 + 3H_2 \longrightarrow 2NH_3$

4. This temperature favours a forward reaction without lowering the rate of reaction too much.

5. As ammonia has a higher boiling point than both hydrogen and nitrogen it is separated by liquefaction.

Activity 6

1. A solution containing NaCl. Usually water acts the solvent.

2. Oxidation: $2Cl^- \longrightarrow Cl_2 + 2e^-$

3. Reduction: $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

4. $2H_2O + 2Cl^- \longrightarrow H_2 + 2OH^- + 2Cl_2$

5. Na^+

Activity 7

No answers: observation activity.

Activity 8

1. Animal fat (e.g. tallow) or plant oil (e.g. palm oil) and a strong base e.g. NaOH.

2. Saponification

3. Soaps are made using animal fat or detergents, whereas detergents are made using the by-products of oil refining or coal gasification.

4. Surfactants act as wetting agents by lowering the surface tension of water.

5. Detergents are made of two parts: hydrophilic head (water loving) and hydrophobic tails (water fearing). The long hydrophobic tails attach to the grease and the head dissolves in water. As the dirty clothes are swirled around during washing, the grease becomes surrounded by the soap and is dislodged from the fabric, to float off into the water.

Activity 9

1. Monomers are small units which are repeated to form large polymers.

2. a. carbon and hydrogen
   b. oxygen, fluorine, chlorine, nitrogen, silicon, phosphorus and sulphur.

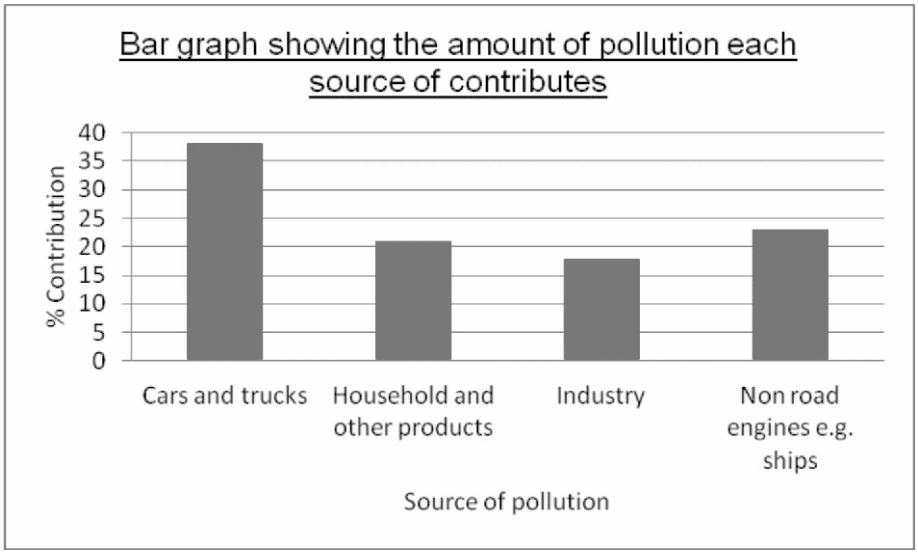
3. Amorphous plastics have no form in their polymer chains, they are transparent. Plastics with a crystalline arrangement have the molecules in a distinct arrangement. The higher the degree of crystallinity the less light can pass through the polymer, influencing the translucence or opaqueness of the polymer.

4. Thermoplastics: keep plastic properties even when they are heated. Thermosetting plastics can only be formed once.

5. a. A biodegradable substance can be broken down by decomposers. Nutrients are returned to the soil. The substance will not lie as litter on the surface of the soil.
   b. The decomposers need to have enzymes which can break down the bonds between monomers, for a substance to be biodegradable. It is unlikely that these microorganisms have the enzymes needed to break down synthetic monomers, and so they do not degrade. However, they have enzymes, for example amylase, which can break down bonds between monomers in naturally occurring polymers, for example starch.
   c. Yes: environmentally friendly.
      No: too expensive.
   d. Make synthetic plastic bags expensive to buy. Do not charge for biodegradable bags. Educate people about the advantages of using biodegradable plastic.

Lesson 6

Activity 1



2. A pollutant is a substance which, added to the air, water or soil, causes harm to the environment. We cause pollution when we harm the environment. Most pollution is caused by the waste products of mining, industrial, and household activities.

Activity 2

1. Burning of fossil fuels from the power plant, emissions from the factory and exhaust fumes from motor cars.

2. Nitrous oxide and sulphur dioxide combine with water vapour, forming nitric acid and sulphuric acid.

3. The trees would be affected, foliage would be harmed, soil would become acidic, and the pH of the water in the dam and river would drop, affecting the aquatic life in the dam. Acid rain would also cause corrosion of buildings.

4. The wind is blowing the nitrogen dioxide and sulphur dioxide towards the city.

5. The foliage of the trees would be affected. The pH of the dam and river would drop.

6. Reduce the amount of electricity they use. Reduce the amount of petrol they burn through using lift clubs or walking when they can.

Activity 3

a.

SITE 2	
Creatures	**SASS score**
1. Minnow and May flies	5
2. Leeches	2
3. Caddis flies	9
TOTAL SCORE	**16**
Number of groups of creatures	3
Average score	16/3= 5.3

SITE 3	
Creatures	**SASS score**
1. Damsel flies	4
2. Snails	5
3. Flat worm	3
TOTAL SCORE	**12**
Number of groups of creatures	3
Average score	12/3 = 4

b.

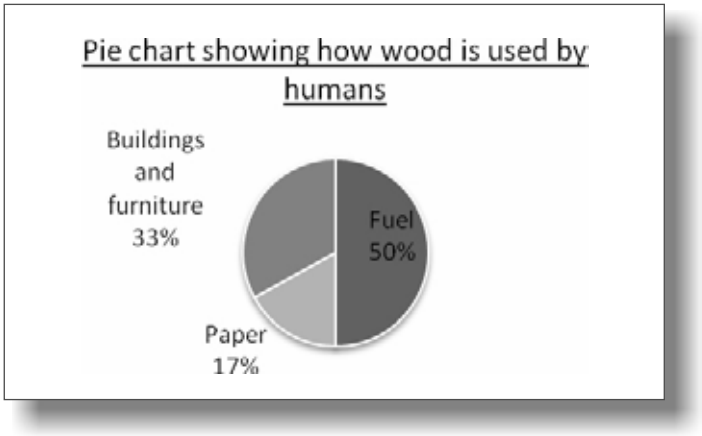
- Water at site 1 was of good quality.
- Water at site 2 score was 5.3, which means that the river was slightly polluted.
- Water at site 3 score was 4, which means the river was slightly polluted.

The water flowing from the mountains had a good quality. As it continued on its course it became more polluted. The first source of pollution was probably the industries. The river was also very close to farms. They could have added fertilizers and pesticides to the river, also polluting the water body.

Finally, at site 3 the river passed through an urban area. This could also be the source of much pollution, affecting the quality of the water. The sewage treatment plant could also have been the source of pollutants.

Activity 4

1.



2. One of the main causes of climate change is an increase in the amount of carbon dioxide in the atmosphere. Forests absorb large amounts of carbon dioxide to use during the process of photosynthesis. Thus forests play an important role in reducing atmospheric carbon dioxide levels. Deforestation therefore results in an increase in the amount of carbon dioxide in the atmosphere, adding further to concerns about climate change.

3. Deforestation is occurring on such a large scale for many reasons, including having the machinery to remove many trees quickly. The trees are removed to either make money from them (paper, construction, furniture) or to clear the land for agriculture or urban development. Either way, the faster the trees are removed, the more money is made.

Activity 5

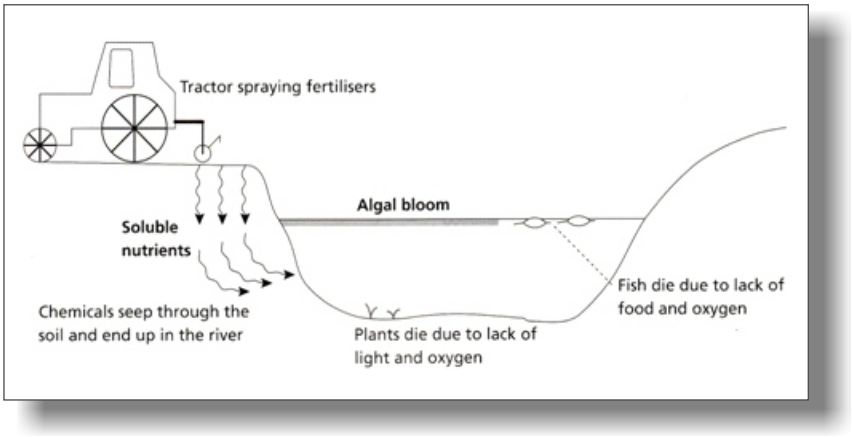
1. a. crop rotation: farming practices where two or more crops are planted alternatively from year to year.
   b. monocropping: agricultural practice of growing the same crop year after year on the same land. There is no rotation of crops.
   c. monoculture: the cultivation or growth of a single crop.

2. Allows the farmer to specialize in a particular crop, using specialized equipment for maximum yield.

3. - Monocropping depletes the soil of nutrients. This results in farmers using fertilizers which disturb the soil and may result in water pollution.
   - Monocropping results in an increase in the number of pests and diseases in an area.

Activity 6

1. Diagram showing how eutrophication takes place in a dam:



2. Through the process of nitrification, soil organisms convert ammonium to nitrate. The hydrogen atoms released lower the pH of the soil.

3. Fertilizers are added when the soil the farmer wants to grow crops on is nutrient poor. Chemical fertilizers are used since they add plant nutrients which may increase the yield of the crop.

Activity 7

Table comparing various diseases miners are exposed to:

Name of disease	Mineral mined	Symptoms	Treatment
Pneumoconiosis	Coal	Breathlessness, cough, respiratory difficulty	No treatment
Silicosis	High grade coal	Coughing, chronic bronchitis, difficulty breathing. Persons are at risk of contracting: tuberculosis , emphysema and pneumonia.	No treatment.
Asbestiosis	Asbestos	Shortness of breath, dry cough. Hardened lungs. Death	No treatment.

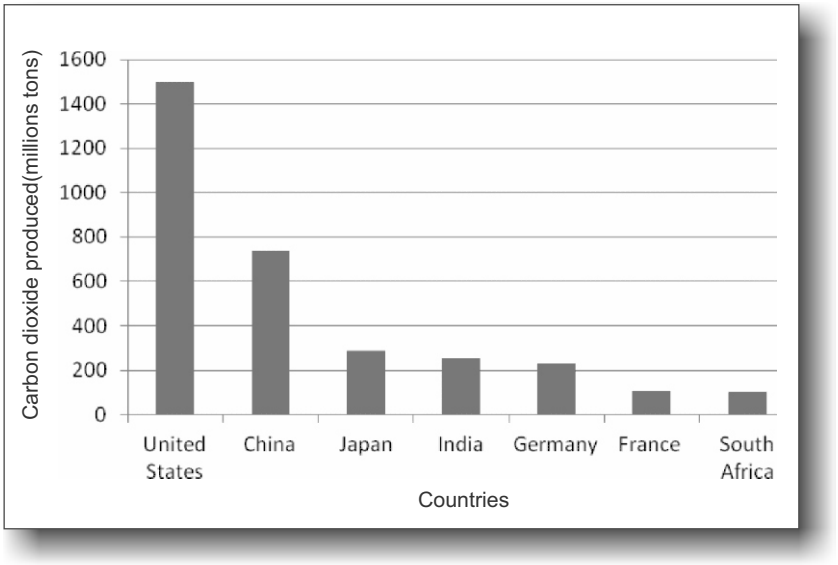
Activity 8

1. Food is seen as economic goods and is sold for a profit. That food is seen as a basic human need is disregarded. In some instances people are too poor to buy food and are hungry and in other instances too much food is produced and eaten resulting in much waste and obesity.

2. A grocery store is in the business of making money and creating jobs. It is not the grocery store's responsibility to ensure that people are fed. Perhaps the government needs to manage or set guidelines on food production and distribution of healthy nutritious food, ensuring that all people are well fed.

Activity 9

1. Bar graph showing carbon emissions from burning fossil fuels in the United States, China, Japan, India, Germany, France and South Africa.



2. After deciding whether you think mielies should be used to produce biofuel, you need to consider both the advantages and disadvantages of using maize to produce the biofuel.

   Advantages of using biofuels:
   - A reduction in greenhouse gas emission.
   - Increasing energy security by providing an alternative to fossil fuels.

   Disadvantages of using biofuels:
   - A food crop is being used (e.g. maize to produce fuel) which could result in an increase in food prices.
   - It takes more energy to produce biofuel than the biofuel produces.

Lesson 7

Activity 1

1. Deforestation results in loss of topsoil, extinction of species, increased flooding, and increasing levels of carbon dioxide.

2. Reforestation is necessary to ensure sustainable management of forests, thereby alleviating the negative effects of deforestation and ensuring a continuous timber supply.

Activity 2

1. a. Crop rotation: when plants are planted in a field following a defined order, for example maize followed by soyabeans.
   b. Companion planting: Planting plants together such that they benefit one another.

2. Advantages of companion planting:
   i. Trap cropping: companion plants attract insect away from the crop that is to be harvested.
   ii. Nurse cropping: tall plants protect more vulnerable plants.
   iii. Refugia: companion plants provide a habitat for predators and parasites of pests that occur on the crop to be harvested.

3. Plants need to be rotated with plants which are different with respect to growth strategies (deep root vs shallow rooting), nutrient accumulating and depletion, water accumulating vs. water consuming, types of pests and diseases that harm the plant.

4. i. Plants may have positive effects on succeeding plants.
   ii. Reduced pests and disease.
   iii. Improved soil quality.
   iv. Harvest times are different; therefore labour is distributed throughout the year.

5. The following is given as a sample answer. As long as the crops are 'companions', there are a variety of answers.

Beans	**Mielies**
Carrots	**Cabbage**

Activity 3

1. Soil erosion is the process by which soil is removed, especially when vegetation is removed.

2. Where there is no soil erosion, crop yields improve, nutrients are retained in the soil, water quality improves, and drainage of the soil improves.

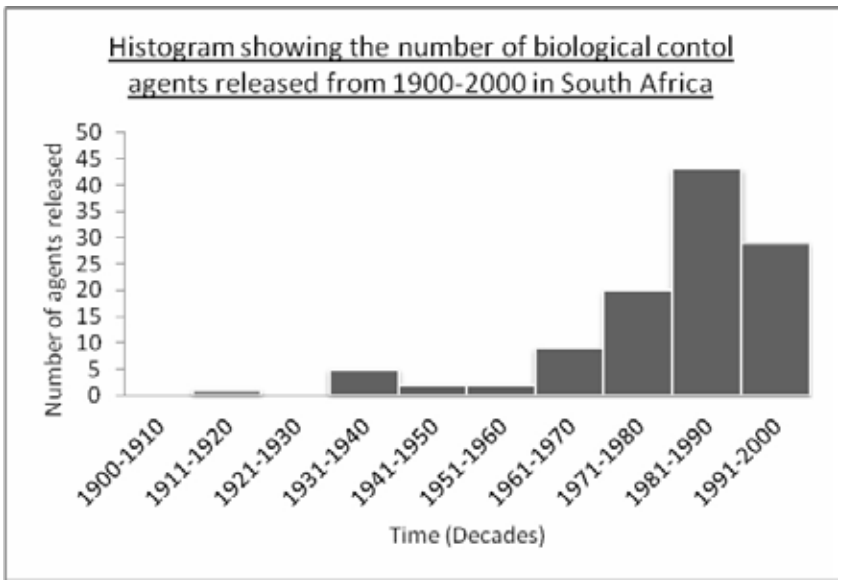
3.
   - Mulching. Placing a layer of plant material on top of the soil.
   - Silt fencing which traps soil but allows water to flow.
   - Cover crops. Planting vegetation on top of soil:
   - By constructing roads and buildings on the contours of slopes.
   - Crop rotation.
   - Contour farming: Planting crops along the contours of slopes.
   - Planting grass strips between ploughed fields.

Activity 4

1. a. cactus plants/ prickly pear plants
   b. cochineal insects, mealy bugs and cactus moths

2. They were alien plants, i.e. they were brought into a new area and did not have natural enemies and so they were able to grow very fast. They started to overgrow in certain areas.

3. They fed only on the cactus species. This meant the insects started to reduce the numbers of the cactus plants. The insects fed only on the cactus and so they did not become a pest themselves, by feeding on natural vegetation.

4. 

Activity 5

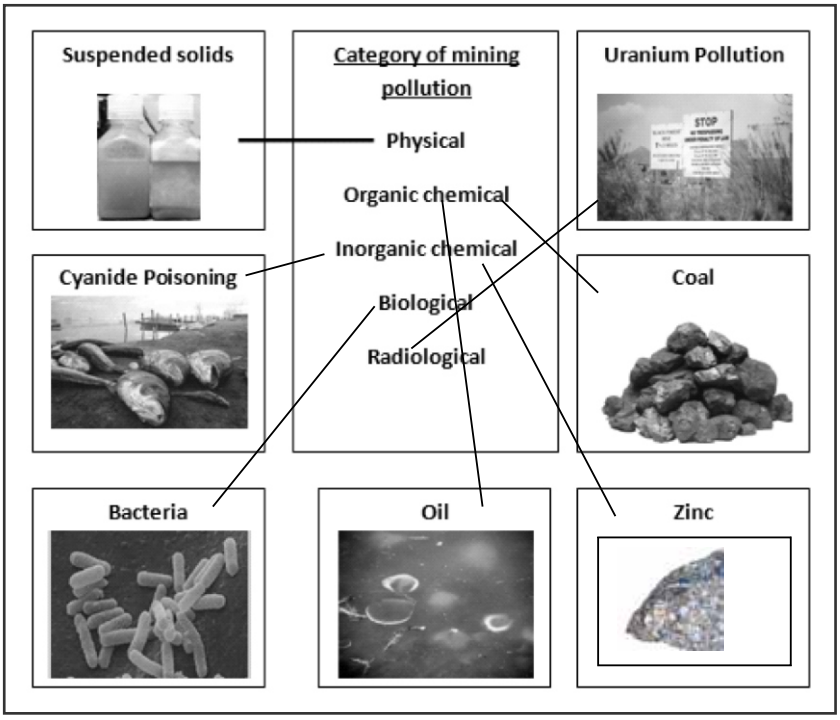
1. To reduce the amount of clean water being used for industrial and mining purposes which do not necessarily require such clean water.

2.

Main categories	Sub categories
Pathogenic organisms	Virus and bacteria
Nutrients	Nitrogen and phosphorus
Biodegradable organics	Protein, carbohydrate, fat
Dissolved inorganics	Calcium and sodium
Metals	Arsenic, cadmium, lead, mercury and silver

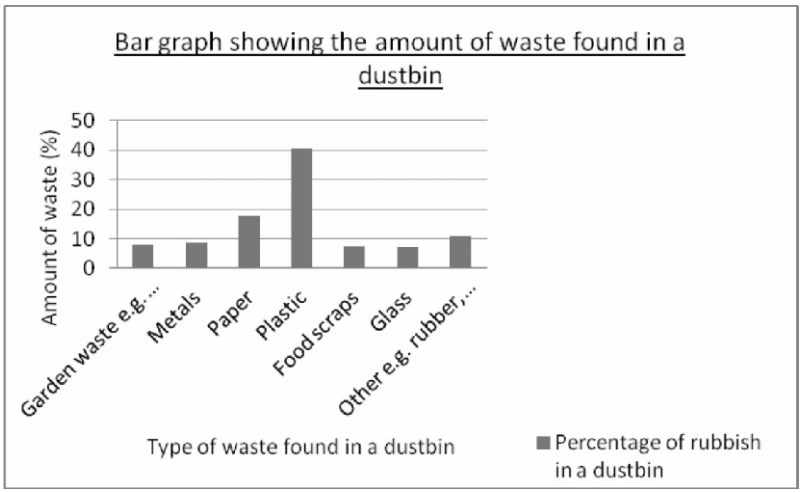
3. Uses of reused industrial waste water include: cooling, material washing, irrigation, and toilet flushing.

4.



Activity 6

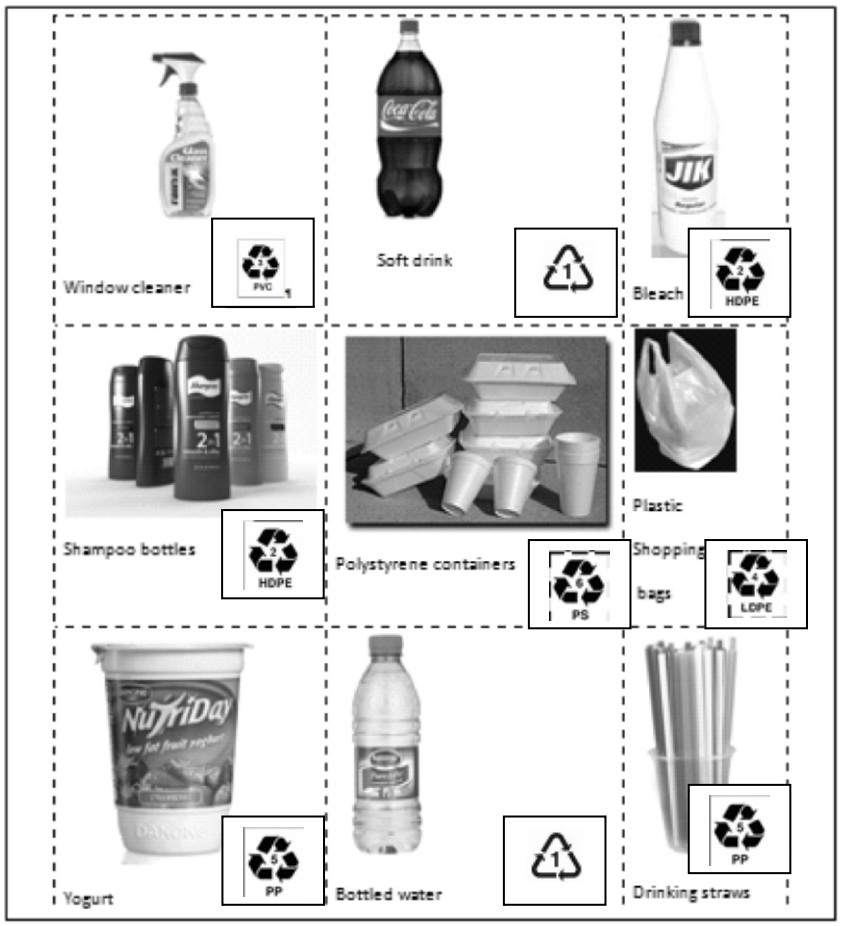
1.



2. Metals, plastic, paper, and glass.

3. Reduces the amount of waste that ends up on landfill sites. It is cheaper to use materials from already made goods than to produce them from raw material, i.e. reduces production costs

4.



Activity 7

1. Oil from algae.

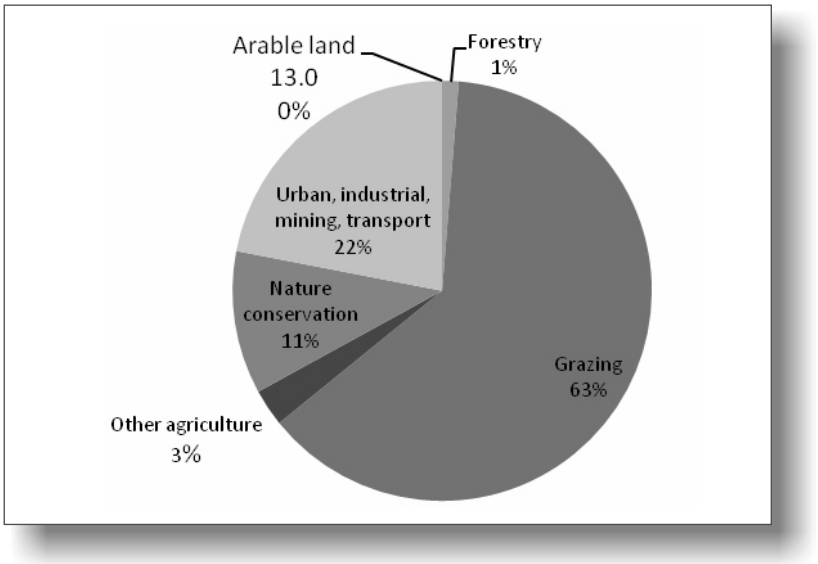
2.
   - Algae have fast growth rates.
   - There is a high per-acre yield compared with land crops.
   - Algae biofuel contains no sulphur.
   - Algae biofuel is not toxic.
   - Algae biofuel is bio-degradable.
   - Algae consume carbon dioxide, removing it from the atmosphere.

3. The technology is in its early stages and scientists are looking for an algal species which has a high oil content and fast growth, making the process of producing biodiesel cost effective.

Lesson 8

Activity 1

1.



Pie chart showing how land is utilised in South Africa

2. Environmental impact, competition for scarce resources, e.g. water, management of polluting and hazardous materials.

3. a. subsistence agriculture, sugar plantations, defence force, potential mine, conservation, tourism.
   b. The mine would provide jobs.
   c. Land degradation, tourism drops, questions around the sustainability of the mine.
   d. i. engineers, miners, truck drivers, office administrative staff, people to process the ore
      ii. game rangers, office administrative staff, people to work in the hotel and hospitality industry, local crafters could sell their goods to tourists.
   e. Both the mining and ecotourism industry would provide both skilled and unskilled employment for the local community. However, the mine has a predicted lifespan of only 17 years, so employment in this sector is less sustainable, whereas employment in the ecotourism sector is more sustainable. The local community would also be involved in conserving their ecosystem, and generate income from it. Earning income from whichever venture alleviates poverty, and so the quality of life improves with employment.

Activity 2

1. Arable land: land that is suitable for cultivation of crops.
   Marginal land: farmland which is not suitable for farming.

2. Grazing and agroforestry.

3. a.

Type of land	Can it be used for farming?	How much is being used / not used (%)
Ice, snow, deserts, mountains	No	51
Arid land	Potential crop farming	6
Tropical forest	Potential crop farming	8
Cultivated	Farmland	11
Grazing land	Farm land	10
Forests and arid lands	Potential grazing land	14

   b. 6% + 8% = 14%

   c. Forests would need to be cleared if they are used for grazing. The problems which were discussed in the unit on deforestation would result in soil erosion, increase in the concentration of carbon dioxide in the atmosphere, destroy the habitat and there would be loss of biodiversity. If arid land is used for grazing, the farmer needs to ensure that the land is not overgrazed as this could lead to soil erosion.

Activity 3

1. Water, litter, pesticides, heavy metals.

2. Rivers, lakes and dams.

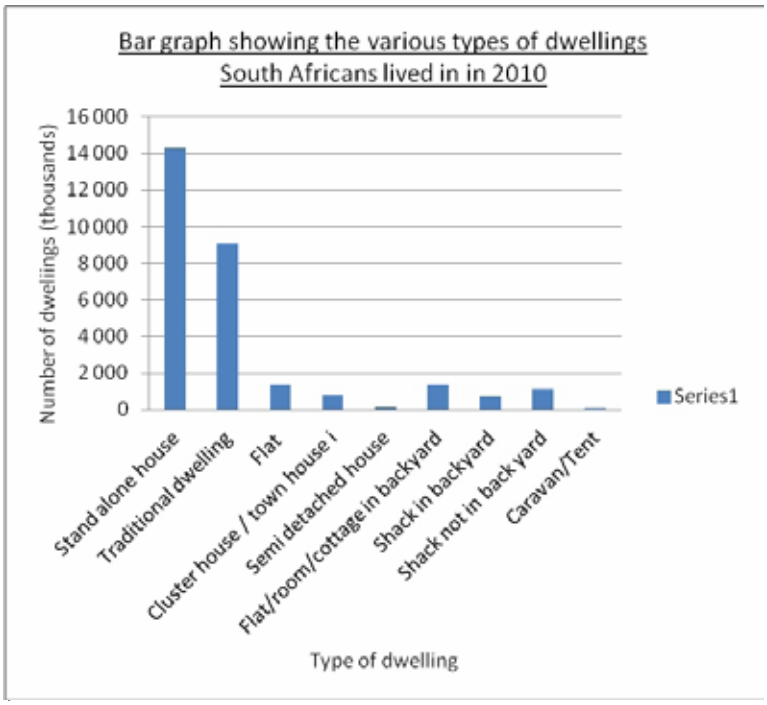
3. During the day, pavements absorb heat, which they release at night, making urban areas up to 3°C warmer than rural areas.

Activity 4

1. a. RDP house.

   b. Flats/ hostel accommodation/ town house complex.

2. a.



b. 28 948 000 dwellings

c. Stand-alone houses:
Stand alone house, traditional dwelling, room in back yard, shack in back yard, shack not in back yard, caravan/tent.

Multi-unit dwellings:
Flat or apartment in block of flats, cluster house/town house complex, semi-detached house.

d. 1385 000 + 760 000 + 160 000+ = 2 305 000
2 305 000/ 28 948 000 X 100/1 = 8.0% of dwellings in South Africa surveyed in 2010 were multi-unit dwellings.

e. i. Located close to CBDs.
ii. Small units require little cleaning.
iii. Communal gardens, which do not require the owners to maintain.
iv. Good security.
v. Form part of a community, safety in numbers.

f. i. A levy needs to be paid for maintenance and gardens.
ii. Each complex will have its own set of rules.
iii. Units are small; residents may feel cramped.
iv. Value of stand-alone houses generally improves over time, compared with multi-unit dwellings.

3. Although housing is a basic human right and government should attempt to house everyone in properly built, well-serviced houses. However, perhaps one could consider alternatives such as renting houses to people. Another problem the government would need to monitor is that in low income areas where there are multi-unit dwellings, gangs and crime often increase.

Activity 5

1. Land, water, sun, wind.

2. Water, sun, wind.

3. Electricity is generated using the sun and wind. Recycling waste saves energy as it is cheaper to recycle items such as cans than producing them from raw materials.

4. The homeowner produces only a small amount of crops. The crops are watered using collected rain water. Garden waste is collected and could be used to return nutrients to the soil.