DEPARTMENT OF EDUCATION

GRADE 12

CHEMISTRY

MODULE 5

NATURAL RESOURCES AND CHEMICAL INDUSTRIES IN PAPUA NEW GUINEA

PUBLISHED BY FLEXIBLE OPEN AND DISTANCE EDUCATION
PRIVATE MAIL BAG, P.O. WAIGANI, NCD
FOR DEPARTMENT OF EDUCATION
PAPUA NEW GUINEA
2017

Writer
Paul Nongur

Content Editors
Science Department
Subject Review Committee

Language Editor
Dr. Steven Winduo

Course Format Editor
Joydee Mabbagu

GRADE 12

CHEMISTRY

MODULE 5

NATURAL RESOURCES AND CHEMICAL INDUSTRIES IN PAPUA NEW GUINEA

IN THIS MODULE YOU WILL LEARN ABOUT:

12.5.1: CRUDE OIL

12.5.2: METALLIC ORES

12.5.3: PRODUCTION OF ETHANOL

12.5.4: TRADITIONAL CHEMICAL PRACTICES

12.5.5: INDUSTRIAL CHEMICAL POLLUTION

Acknowledgement

We acknowledge the contributions of all secondary teachers who in one way or another have helped to develop this Course.

Our profound gratitude goes to the former Principal of FODE, Mr. Demas Tongogo for leading FODE team towards this great achievement.

Special thanks to the staff of the Science Department of FODE who played active roles in coordinating writing workshops, outsourcing lesson writing and the editing processes involving selected teachers of Central Province and NCD.

We also acknowledge the professional guidance provided by Curriculum and Development Assessment Division throughout the processes of writing and the services given by members of the Science Review and Academic Committees.

The development of this book was co-funded by the GoPNG and World Bank.

DIANA TEIT AKIS
PRINCIPAL

Flexible Open and Distance Education
Papua New Guinea

Published in 2017 by Flexible Open and Distance Education

Printed by the Flexible, Open and Distance Education
ISBN 978-9980-89-525-7
National Library Services of Papua New Guinea

TABLE OF CONTENTS

SECRETARY'S MESSAGE

Achieving a better future by individual students and their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is a part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the national curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The course promotes Papua New Guinea values and beliefs which are found in our Constitution, Government Policies and Reports. It is developed in line with the National Education Plan (2005 -2014) and addresses an increase in the number of school leavers affected by the lack of access into secondary and higher educational institutions.

Flexible, Open and Distance Education curriculum is guided by the Department of Education's Mission which is fivefold:

- To facilitate and promote the integral development of every individual
- To develop and encourage an education system that satisfies the requirements of Papua New Guinea and its people
- To establish, preserve and improve standards of education throughout Papua New Guinea
- To make the benefits of such education available as widely as possible to all of the people
- To make the education accessible to the poor and physically, mentally and socially handicapped as well as to those who are educationally disadvantaged.

The college is enhanced through this course to provide alternative and comparable pathways for students and adults to complete their education through a one system, two pathways and same outcomes.

It is our vision that Papua New Guineans' harness all appropriate and affordable technologies to pursue this program.

I commend all the teachers, curriculum writers and instructional designers who have contributed towards the development of this course.

UKE KOMBRA, PhD
Secretary for Education

Learning Outcomes

After going through this module, you are expected to:

- demonstrate and understanding of fundamental scientific principles and models.
- apply scientific thinking, motor and process skills to investigate and find solutions to problems.
- communicate findings of scientific investigations in different ways.
- analyse and evaluate past and present scientific developments and their impacts on human beings and the environment and on the ethical decisions made.
- evaluate the traditional knowledge and practices of chemistry and their relevance today.
- analyse and interpret data, graphs and other forms of information relevant to a topic of study.
- demonstrate an understanding of traditional knowledge and skills of chemistry practiced over many years and explain their relevance today.
- demonstrate an understanding of natural resources and the importance of developing them in a sustainable way.
- demonstrate an understanding of important chemical industries in PNG by discussing an overview of the processes.
- Investigate and understand traditional chemical practices in PNG.
- Investigate pollution caused by producing and using chemicals and burning fossil fuels, with special reference to global warming and climate change.

Time Frame

Suggested allotment time: 10 weeks

If you set an average of 3 hours per day, you should be able to complete the module comfortably by the end of the assigned week.

Try to do all the learning activities and compare your answers with the ones provided at the end of the module. If you do not get a particular exercise right in the first attempt, you should not get discouraged but instead, go back and attempt it again. If you still do not get it right after several attempts then you should seek help from your friend or even your tutor.

DO NOT LEAVE ANY QUESTION UN-ANSWERED.

Terminologies

Before you get into the thick of things, let us make sure you know some of the terminologies that are or will be used throughout this unit.

Biodegradable Capable of being broken down (decomposed) rapidly by the action of microorganisms; Biodegradable substances include food scraps, cotton, wool, wood, human and animal waste, manufactured products based on natural materials (such as paper, and vegetable-oil based soaps).

Biogas Typically refers to a gas produced by the breakdown of organic matter in the absence of oxygen.

Carbon Is a chemical element with the symbol C and atomic number 6 which forms a large number of compounds, more than any other element.

Carbon cycle Is the process in which carbon is exchanged between all parts of Earth and its living organisms.

Crude oil Is a mixture of hydrocarbons that exists as a liquid in natural underground reservoirs and remains a liquid when brought to the surface.

Distillation Is a purification process wherein a substance is heated to its boiling point, the vapour produced upon boiling is allowed to flow away from the boiling liquid, and the vapour is cooled to condense it back to the liquid.

Environmental pollution Is the release of chemical waste that causes detrimental effects on the environment.

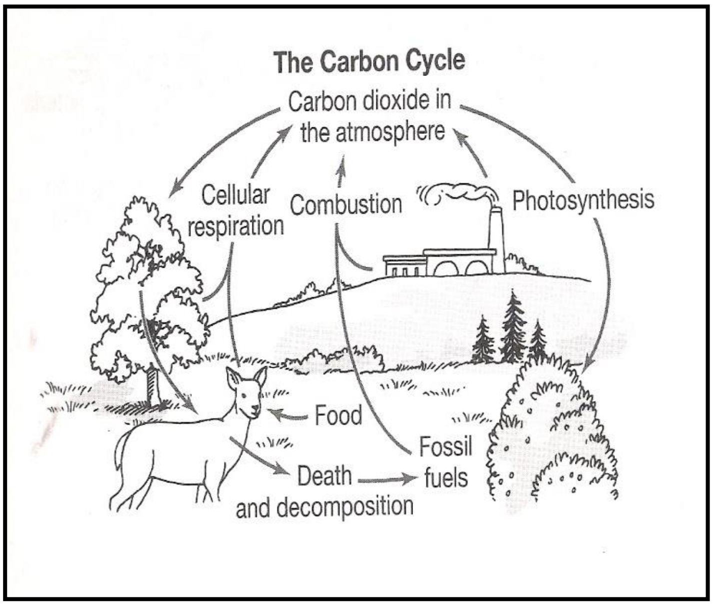
Fermentation Is the breakdown of complex molecules to simpler ones through the action of some microorganism, such as yeast.

Fossil fuels	Any class of materials of biological origin occurring within the Earth's crust that can be used as a source of energy.
Glycerine	A thick, sweet, odourless, colourless, or pale yellow liquid; Source: fats and oils as a by-product of soap manufacture. Use: solvent, antifreeze, plasticizer, manufacture of soaps, cosmetics, lubricants, and dynamite. Formula: $C_3H_8O_3$
Greenhouse Effect	Is a natural process that warms the Earth. Gases in the atmosphere, like water vapour (clouds), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) act as a natural blanket by preventing the sun's heat energy from radiating back into space, so much like a greenhouse trapping the sun's energy to warm someone's plants even in the middle of cold day.
Industrial pollution	It contaminates many sources of drinking water, releases unwanted toxins into the air and reduces the quality of soil. is mixed with a strong alkali.

12.5.1 Crude Oil

The Carbon Cycle

As you have learnt in your module 11.6, carbon is the backbone of life on Earth. All living things are made of carbon.



Living things need carbon in order to live, grow and reproduce. Carbon is a finite resource that circles through the Earth in many forms. This makes carbon available to living organisms and remains in balance with other chemical reactions in the atmosphere and in bodies of water like ponds, rivers and oceans.

The carbon cycle is the process in which carbon is exchanged between all parts of earth and its living organisms. It is of vital importance to life on Erath, allowing carbon to be continually reused and recycled. The following diagram of the carbon cycle shows the movement of carbon between land, atmosphere and oceans.

Plants use carbon dioxide and sunlight to make their own food and grow. The carbon becomes part of the plant.

While an organism is alive, it acts a **carbon sink** or as a **storage room** for carbon atoms, because so many carbon atoms are being used to build the organism's akin, bark, toenails or leaves. However, as soon as an organism dies, these valuables carbon atoms begin to be returned to the environment, where they can be used by other organisms.

Decomposers are tiny microorganisms that live in soil and water, and they consume organic waste matter and dead organisms, returning the carbon back into the atmosphere in the form of carbon dioxide.

Plants that die and are buried may turn into fossil fuels made of carbon like coal and oil over millions of years. When humans burn fossil fuels, most of the carbon quickly enters the atmosphere as carbon dioxide.

Instead of seeing the different stages of the carbon cycle, we shall try to answer this question: **Why is carbon important to life?** For a better understanding, **the question is simple and straight forward because most living things on Earth are made of carbon.**

Carbon Dioxide and Global Warming

Carbon dioxide is the form that carbon takes in our atmosphere, and it is crucial for maintaining life on Earth. However, a relatively recent source of carbon dioxide in the atmosphere – burning of fossil fuels by humans–has greatly increased the amount of carbon dioxide in the atmosphere. This increased level of carbon dioxide threatens to upset the natural carbon balance previously maintained by photosynthesis, respiration and decomposition. This extra carbon dioxide acts like a blanket in the atmosphere, perhaps causing global warming.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 1 **20 minutes**

Answer the following:

1. What is the important role of carbon dioxide to humans?

____

____

____

____

____

____

2. List and explain the processes involved in the Carbon Cycle.

____
____
____
____

Thank you for completing your learning activity 1. Check your work. Answers are at the end of this module.

Fossil fuels

Fossil fuels are any class of materials of biological origin occurring within the Earth's crust that can be used as a source of energy. They are hydrocarbons that include coal, petroleum, natural gas, oil shales, bitumen, tar, and heavy oils. All fuels contain carbon and were formed as a result of geologic processes acting on the remains of dead organic matter.

When these fuels are burnt, the energy released can be harnessed to produce electricity, power vehicles, heat homes, cook food, and much more.

Crude oil and natural gas

Today's world runs on fossil fuels. Coal, oil, and natural gas are essential to our modern lifestyle. Coal is by far the dirtiest of the three, both in its emissions and extraction m ethods. Oil and natural gas are both moderately better.

These were produced when tiny plants and animals decayed under layers of sand and mud millions of years ago. Crude oil is a mixture of hydrocarbons that exist as a liquid in natural underground reservoirs and remain liquid when brought to the surface.

These were produced when tiny plants and animals decayed under layers of sand and mud million of years ago.

Crude oil

Crude oil is useless as a mixture and must be sent to an oil refinery to be separated. Crude oils from different parts of the world, or even from different depths in the same oilfield, contain different mixtures of hydrocarbons and other compounds. This is why they vary from light coloured volatile liquids to thick, dark oils.

Petroleum products are produced from the processing of crude oil and other liquids at petroleum refineries, from the extraction of liquid hydrocarbons at natural gas processing plants, and from the production of finished petroleum products at blending facilities. One has to remember that petroleum is a broad category that includes both crude oil and petroleum products.

Description of oil and natural gas
Oil actually refers to any viscous liquid that is not soluble in either water or alcohol. It can include edible oils as well as petrochemicals. The latter will be the focus of our discussion hereon. Natural gas on the other hand is a lightweight, colourless and odourless substance that is made up of primarily methane.

Origins of oil and natural gas

Oil comes out from the ground. It was created or formed over millions of years by pressure being exerted on organic substances. Today, it is found in porous rock formations. Sometimes there will be a large open space underground that is filled with a 'sea of oil.' It can also be found in sand traps, a very difficult place from which to extract it. Natural gas comes from a variety of sources. Sometimes it is found underground, often associated with oil fields. It can also be found by itself in natural gas fields. It is also produced through natural processes in bogs, landfills, and sewage or manure dumps.

Uses of oil and natural gas
Oil when burned will produce a concentrated flame. It is therefore used for heating. It is also used for hot water heaters. When refined into petrol, it is used to power internal combustion engines in cars and trucks. A cruder refinement is used to power electricity plants. Oil can also be used as a lubricant.

Natural Gas is mainly used to power the turbines that create electricity. It is also canned or bottled (in Papua New Guinea) and or piped into home and used for gas stoves and other domestic purposes. If it is canned and compressed, it can be used to power a converted combustion engine that will power a car.

Oil and gas extraction
It is important that the source rock is not 'over-cooked' or the hydrocarbons will be destroyed. There must be suitable reservoir-rock, such as porous sandstone, into which the hydrocarbons can migrate and accumulate. This must be overlain by a preventive cap-rock, such as clay, which prevents the hydrocarbons from escaping to the surface. Finally, the geometry of the reservoir and cap-rock bodies must be such that the hydrocarbons become trapped. Usually folding will suffice.

The number of exploration licenses issued in Papua New Guinea increased from 119 in 2006 to 311 in 2010, and tenements under application, more than doubled to 143 in 2010 from the year before.

Current mines

The table shows current nine (9) mining operations in PNG.

Mine Name	Mineral	Province
Ok Tedi	Copper/Gold	Western
Porgera	Gold	Enga
Lihir	Gold	New Ireland
Tolukuma	Gold	Central
Kainantu	Gold	Eastern Highlands
Simberi	Gold	New Ireland
Sinivit	Gold	East New Britain
Edie Creek	Gold	Morobe
Hidden Valley	Gold	Morobe
Ramu Nickel	Nickel/Cobalt	Madang

There are now nine (9) mining operations in Papua New Guinea.

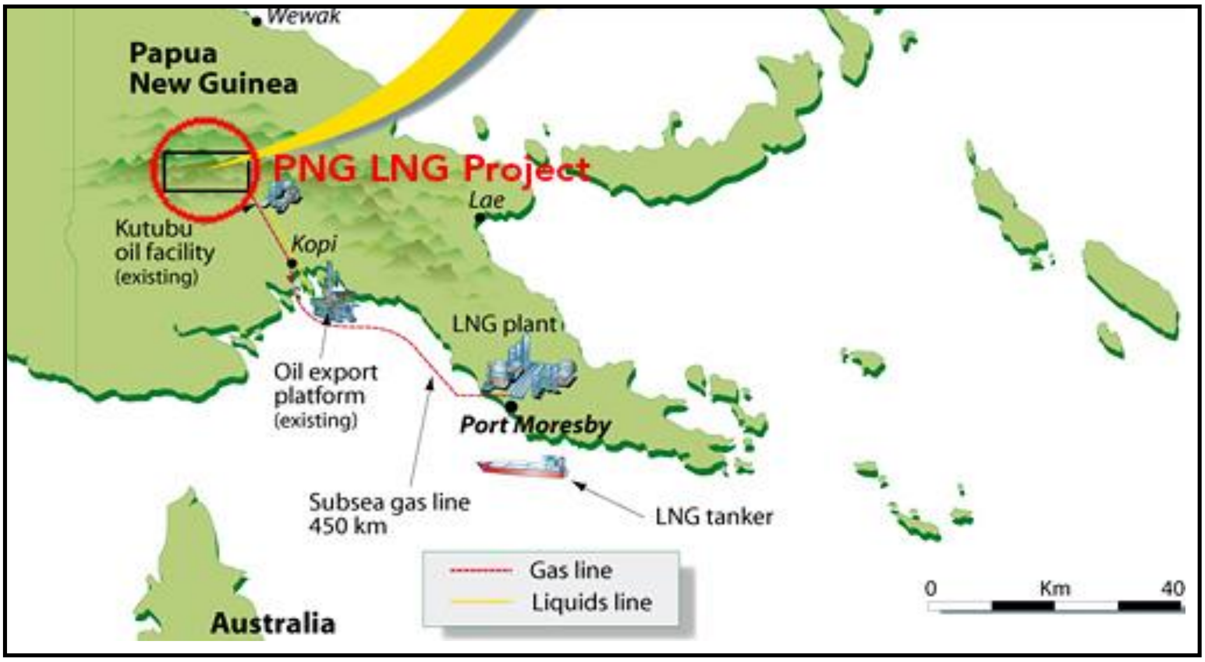
PNG LNG project

The magnitude of the PNG LNG (Liquified Natural Gas) project is remarkable. Gas will be extracted from the Hides and surrounding fields of the Southern Highlands, where it will be treated then pumped through mountainous terrain to a shore base at Kopi. Then, it will travel under sea to an LNG production and export facility near Port Moresby. The maps on the following pages show oil and gas projects and the location of PNG LNG's key infrastructure sites.

This table shows a range of oil and gas projects in Papua New Guinea.

Project Name	Petroleum Projects	Locality/Province
Moran	Oil	Southern Highlands
Kutubu	Oil	Southern Highlands
Gobe	Oil	Southern Highlands
Hides	Gas	Hela
S.E. Mamanda	Oil	Southern Highlands

Maps showing oil and gas projects in Papua New Guinea

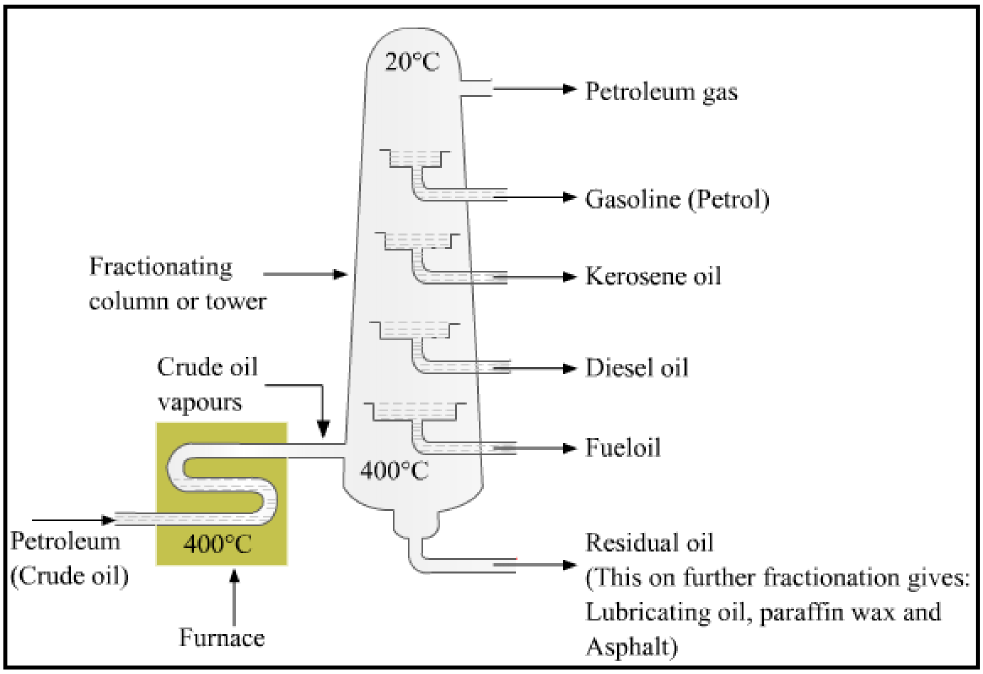


Refining Oil

Fractional distillation of crude oil

Crude oil is completely vaporised by a furnace and the vapor fractionalised in a fractionating tower made up of a number of compartments as shown in the diagram below. The lower the boiling point of a substance, the more it will rise up the tower before condensing.

The fractional distillation of crude oil does not produce pure substances. It provides a number of fractions, each containing a large number of organic compounds.



The fractional distillation of crude oil

The function of the gaps and bowls is to allow the vapour to pass freely to a higher compartment and prevent the liquid formed from running back down the fractioning tower. The vapour from the lower compartment passes into the compartment above it by the upward movement of the bubble bowls. Some of the vapour condenses forming the liquid after a while, when enough liquid is accumulated and overflows, it tickles down to the lower compartment. The liquid can turn further pass on to the compartment above it through the similar process.

The different fractions are used as follows:

Fractions	Uses
Refinery gas (1 -2% of crude oil) is similar in composition to natural gas. It contains C_1 to C_4 hydrocarbons and gases at normal temperatures. Methane (CH_4) is the major component in this category.	As fuel and starting point for the production of other petrochemicals.
Gasoline (15 -30% of crude oil) is a complex liquid mixture of C_5 to C_{10} hydrocarbons with a boiling point in the range 40 -110˚C.	As fuel, in internal combustion engine. In the manufacture of chemicals called naphtha.
Kerosene (10-15% of crude oil) consists of C_{11} and C_{12} hydrocarbons with boiling points in the range of 160-250^oC.	As a fuel in jet engines, for domestic heating purposes and can also be cracked to produce extra gasoline.
Diesel oil or gas oil (15-20% of crude oil) consists of C_{13} to C_{25} compounds with boiling points in the range of 220-350^oC.	As fuel for diesel engines and in furnaces for industrial heating purposes. It can be cracked to produce extra gasoline.
Residue (40-50% of crude oil) is a highly complex mixture of involatile C_{26} to C_{28} hydrocarbons that boil above 350^oC.	As fuel oil in large furnaces such as those in power stations or big ships. Used in the production of lubricating oils and waxes. Bitumen or asphalt is also obtained as left-over and is used for road surfaces and water-proof materials.

Catalytic cracking

Cracking is breaking of higher hydrocarbon to lower hydrocarbons. The alkanes are heated to high temperatures. As a result, the molecules vibrate strongly enough to break bonds and form smaller molecules, one of which is alkenes.

For example:

$C_{11}H_{24}$ Undecane	→	$C_9H_{20} + H_2C = CH_2$ Nonane Ethene

Below are three (3) methods of cracking depending on what is being used to facilitate the process:
Steam cracking makes use of steam to break the higher hydrocarbon to lower hydrocarbon.

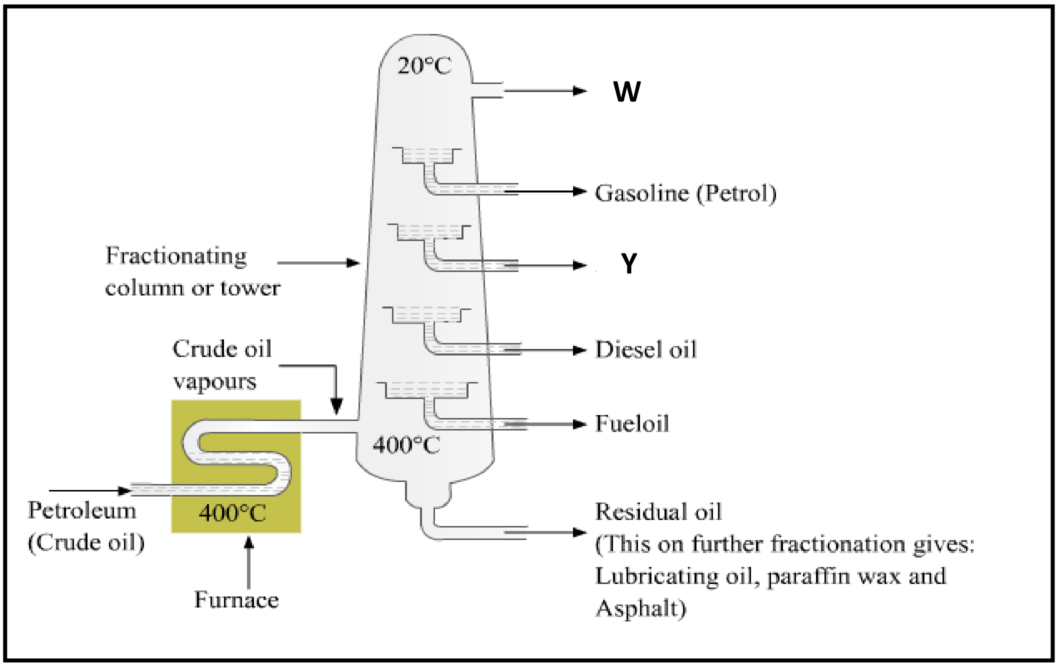
1. Thermal cracking makes use of high temperatures to break the higher hydrocarbon to lower hydrocarbon.
2. Catalytic cracking makes use of a catalyst to break the higher hydrocarbon to lower hydrocarbon. The use of catalyst allows cracking to take place at fairly low temperatures.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 2 **20 minutes**

Answer the following questions:

Refer to the diagram below to answer Question 1.



1. Name the fractions **W** and **Y** which are separated in the fractional distillation of crude oil?

(i) W __________

(ii) Y __________

2. How many Petroleum Prospecting Licenses have been issued by the PNG Government and has some interest in them?

____

3. How many of those Petroleum Prospecting Licenses issued are from the Southern Region?

____

3. When crude oil is passed through a fractionating column, the different fractions separate out according to their ____

Thank you for completing your learning activity 2. Check your work. Answers are at the end of this module.

Production of plastics (Polymerisation)

Polymerisation is any process in which relatively small molecules, called monomers, combine chemically to produce a very large chainlike or network molecule, called a polymer. The monomer molecules may be all alike, or they may represent two, three, or more different compounds.

Usually at least 100 monomer molecules must be combined to make a product that has certain unique physical properties such as elasticity, high tensile strength, or the ability to form fibres, that differentiate polymers from substances composed of smaller and simpler molecules. Many thousands of monomer units are incorporated in a single molecule of a polymer.

Products made using the polymerisation process.

Four categories in the production of plastics

1. Acquiring the raw material or monomer.
2. Synthesizing the basic polymer.
3. Compounding the polymer into a material that can be used for fabrication.
4. Molding or shaping the plastic into its final form.

Raw materials

Resins derived from vegetable matter are used to produce most plastics. These included such materials as cellulose (from cotton), furfural (from oat hulls), oils (from seeds), and various starch derivatives.

Today, most plastics are produced from petrochemicals which are widely available and cheaper than other raw materials. The global supply of oil is exhaustible, so researchers are investigating other sources of raw materials, such as coal gasification.

Synthesis of the polymer

The first step in plastic manufacturing is polymerization. There are two basic types of polymerization, chain-reaction (or addition) and step-reaction (or condensation).

1. Chain-reaction Polymerization

   One of the most common types of polymer reactions is chain-reaction (addition) polymerization. This type of polymerization is a three step process involving two chemical entities. The first, known simply as a monomer, can be regarded as one link in a polymer chain. It initially exists as simple units. In nearly all cases, the monomers have at least one carbon-carbon double bond. Ethylene is one example of a monomer used to make a common polymer.

2. Step-reaction Polymerization

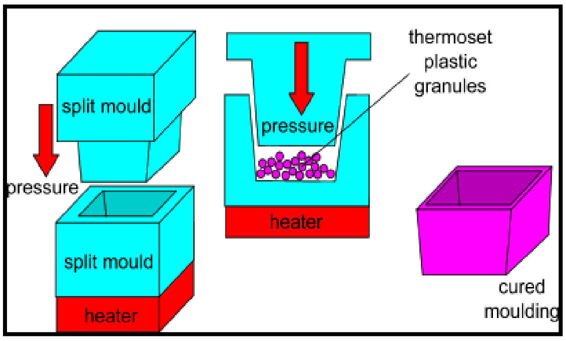
   Step-reaction (condensation) polymerization is another common type of polymerization. This polymerization method typically produces polymers of lower molecular weight than chain reactions and requires higher temperatures to occur.

   Unlike addition polymerization, step-wise reactions involve two different types of di-functional monomers or end groups that react with one another, forming a chain. Condensation polymerization also produces a small molecular by-product (water, and HCl).

Plastics are often manufactured as composites. This is achieved by adding reinforcements such as glass or carbon fibres to the plastics, increasing their strength and stability. Plastic foam is a different type of composite which combines plastic and gas. An example of this can be seen in styrofoam cups which are made of foamed polystyrene.

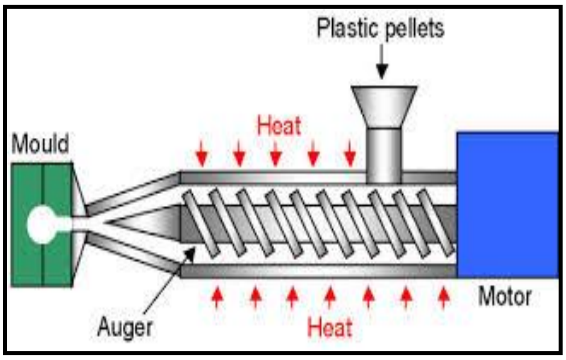
Methods in shaping and finishing of plastics

1. Compression moulding is one of the oldest methods used for converting polymers into useful materials. It uses pressure to force the plastic into a certain shape. One half of a two-piece mold is filled with plastic and then the two halves of the mold are brought together and the plastic is melted under high pressure.



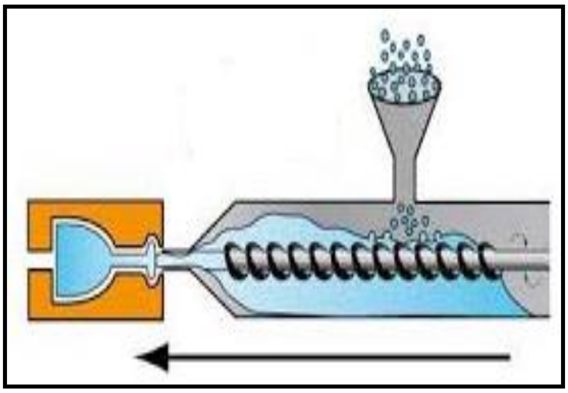
Compression moulding

2. The extrusion method uses a device called an extruder, forces softened plastic through a shaped die from which it may emerge in almost any form, including a circular rod or tube, and a wide, flat sheet. The driving force is supplied by a screw which provides constant pressure. All extrusion products have a regular cross section. A variation on this method is extrusion blow molding, in which a plastic tube produced by extrusion is sealed around a blowing tube and expanded to the shape of a mold with compressed air.



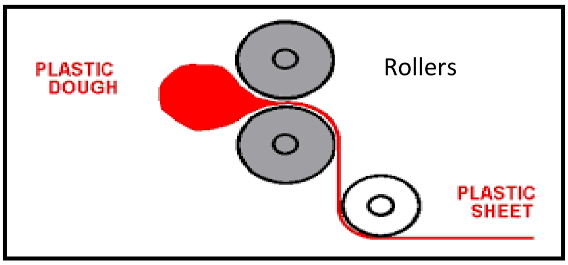
Extrusion

3. Injection moulding involves one or more extruders which force melted plastic into a cold mold where it is allowed to set to the required shape. An adaptation of this method is injection blow molding which is used to make plastic pop bottles. A thick-walled plastic tube is initially injection-molded around a blowing stick and is then transferred to a blowing mold. The tube is reheated and expanded to the shape of the mold by passing air down the blowing stick.



Injection

4. Calendaring produces plastic sheets and transfer molding, in which softened plastic is forced by a ram into a mold.



Calendaring

Two types of plastics

1. Thermoset

   It is a polymer that solidifies or "sets" irreversibly when heated or cured. In real life, an example is the relationship between a raw egg and a cooked egg. A cooked egg cannot revert back to its original form once heated, just as a thermoset polymer cannot be softened once "set".

   Thermosets are valued for their durability and strength and are used extensively in construction including applications such as adhesives, inks, and coatings. The most common thermoset is the rubber truck accessories and automobile tyres.

Some examples of thermoset plastics and their product applications are:

(i) Polyurethanes
- Mattresses
- Cushions
- Insulation

(ii) Unsaturated Polyesters
- Boat hulls
- Bath tubs and shower stalls
  - Furniture

(iii) Epoxies
- Adhesive glues
- Coating for electrical devices
  - Helicopter and jet engine

(iv) Blades Phenol Formaldehyde:
- Oriented strand board
- Plywood
- Electrical appliances
- Electrical circuit boards and switches

Sample of thermoplastic and thermoset

2. Thermoplastic

This is a polymer in which the molecules are held together by weak secondary bonding forces that soften when exposed to heat and return to its original condition when cooled back down to room temperature.

When a thermoplastic is softened by heat, it can then be shaped by extrusion, molding, or pressing. Ice cubes are common household items which exemplify the thermoplastic principle. Ice will melt when heated but readily solidifies when cooled. Like a polymer, this process may be repeated numerous times.

Thermoplastics offer versatility and a wide range of applications. They are commonly used in food packaging because they can be rapidly and economically formed into any shape needed to fulfill the packaging function. Examples include **milk jugs** and **carbonated soft drink bottles.**

Other examples of thermoplastics are:

(i) Polyethylene
- Packaging
- Electrical insulation
- Milk and water bottles
- Packaging film
- House wrap
- Agricultural film

(ii) Polypropylene
- Carpet fibres
- Automotive bumpers
- Microwave containers
- External prostheses

(iii) Polyvinyl Chloride (PVC)
- Sheathing for electrical cables
- Floor and wall coverings
- Siding
- Automobile instrument panels

Physical and chemical properties of plastics

Physical	Chemical
Flexibility	Solubility
Elasticity	Chemical resistance
Permeability	Thermal stability
Water resistant	Reactivity with water
Electrical resistance	Flammability
Specific gravity	Heat of combustion
Soft when hot	

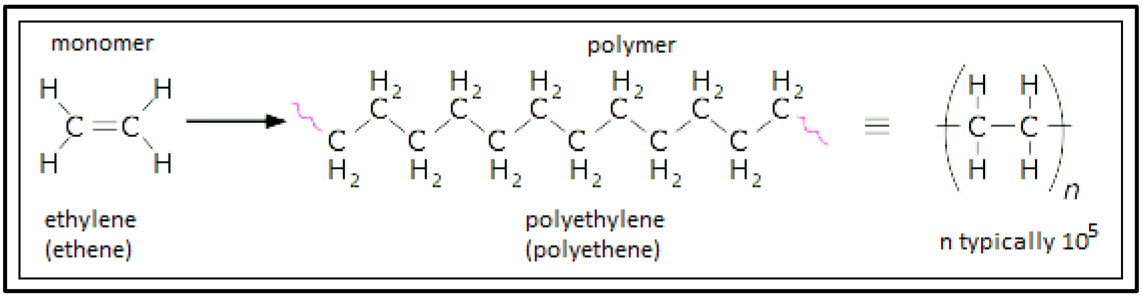
Some common plastic types and properties

Name	**Properties**	**Density Range**	**Common Use**
Polyethylene Terephthalate	Tough, rigid, shatter resistant, softens when heated	1.38-1.39 g/mL	Soft drinks, Soda, water, juice, cooking oil bottles
High Density Polyethylene	Semi-rigid, tough, and flexible	0.95-0.96 g/mL	Milk and Water jugs, Bleach bottles
Polyvinyl Chloride	Strong, semi-rigid, glossy	1.16-1.35 g/mL	Detergent bottles, shampoo bottles, shrink wrap, pipes
Low Density Polyethylene	Flexible, not crinkly, moisture	0.92-0.94 g/mL	Garbage bags, sandwich bags, 6-pack
Polypropylene	Non-glossy, semi-rigid	0.90-0.91 g/mL	Yogurt cups, margarine tubs, screw-on
Polystyrene	Often brittle, sometimes glossy, often has strong	1.05-1.07 g/mL	Styrofoam, egg cartons, packing pellets, take-out containers

Bond structures and structural formulas

Plastics and natural materials such as rubber or cellulose are composed of very large molecules called polymers. Polymers are constructed from relatively small molecular fragments known as monomers that are joined together.

Bonding structure for polyethylene



Synthetic polymers, which include the large group known as plastics, came into prominence in the early twentieth century. Chemists' ability to engineer them to yield a desired set of properties (strength, stiffness, density, heat resistance, electrical conductivity) has greatly expanded the many roles they play in modern industrial economy.

Let us look at an artificial polymer that is known to everyone in the form of flexible, transparent plastic bags: polyethylene. It is also the simplest polymer, consisting of random-length (but generally very long) chains made up of two-carbon units.

You will notice some "fuzziness" in the way that the polyethylene structures are represented above. The squiggly lines at the ends of the long structure indicate that the same pattern extends indefinitely. The more compact notation on the right shows the minimal repeating unit enclosed in brackets overprinted with a dash; this means the same thing and is the preferred way of depicting polymer structures.

Environmental effects of plastic

"Better things for better living through chemistry" is a famous commercial slogan that captured the attitude of the public around 1940 when synthetic polymers were beginning to make a major impact in people's lives.

What was not realised at the time, however, were some of the problems these materials would create as their uses multiplied and the world became more wary of "chemicals".

Products of Plastic

Some environmental effects of plastics

1. Small-molecule release

   Some or many kinds of polymers contain small molecules - either unreacted monomers, or substances specifically added (plasticizers, UV absorbers, and flame retardants) to modify their properties.

   Many of these smaller molecules are able to diffuse through the material and released into any liquid or air in contact with the plastic and eventually into the aquatic environment. Those that are used for building materials (in mobile homes, prefabricated houses, for example) can build up in closed environments and contribute to indoor air pollution.

2. Residual monomer

   Formation of long polymer chains is a complicated and a random process that is never perfectly stoichiometric. It is not common for some unreacted monomer to remain in the finished product.

   Some of these monomers, such as formaldehyde, styrene (from polystyrene, including polystyrene foam food take-out containers), vinyl chloride, and bisphenol-A (from polycarbonates) are known as carcinogens. Although there is little evidence that the small quantities that diffuse into the air or leach out into fluids pose a health risk. People are reluctant to tolerate these exposures, and public policy is gradually beginning to regulate them.

3. Plasticizers

   One of the most widely plasticized types is polyvinyl chloride polymers. The odour often associated with flexible vinyl materials such as garden hoses, waterbeds, cheap shower curtains, raincoats and upholstery are testament to their ability to migrate into the environment. Another is the well-known "new car smell" largely due to plasticizer release from upholstery and internal trim.

4. Endocrine disrupters

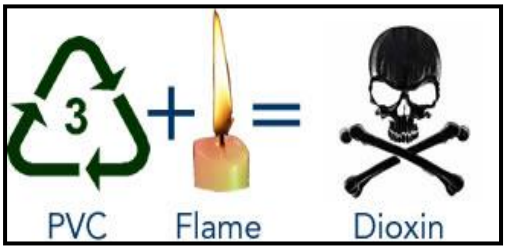
   Many of these small molecules have been found to be physiologically active owing to their ability to mimic the action of hormones or other signalling molecules, probably by fitting into and binding with the specialised receptor sites present in many tissues. The evidence that many of these chemicals are able to act in this way at the cellular level is fairly clear, but there is still some dispute whether many of these pose actual health risks to adult humans at the relatively low concentrations in which they commonly occur in the environment.

   However, there is some concern about the effects of these substances especially on foetuses, given that endocrines are intimately connected with sexual differentiation and neurological development which continue up through late teens.

5. Decomposition products
   Most commonly-used polymers are not readily biodegradable, particularly under the anaerobic conditions of most landfills. Decomposition will combine with rainwater and contaminate nearby streams and groundwater supplies.

Partial photo decomposition, initiated by exposure to sunlight is a more likely long-term fate for exposed plastics, resulting in tiny broken-up fragments. Many of these materials are less dense than seawater, and once they enter the oceans through coastal sewage outfalls or from marine vessel wastes, they tend to remain there indefinitely and pose a lot of danger to aquatic animals.

Open burning of polymeric materials containing chlorine (polyvinyl chloride, for example) is known to release compounds such as **dioxins** that persist in the environment. Incineration under the right conditions can effectively eliminate this hazard.



Disposed products containing fluorocarbons (Teflon-coated ware, some personal-care, waterproofing and anti-stick materials) break down into perfluorooctanesulphonate which has been shown to threaten aquatic animals.

6. Hazards to animals
   It has been well established that small aquatic animals such as fish and fresh water crustacean are being seriously affected by such substances in many rivers and estuarine systems, but details of the sources and identities of these molecules have not been identified. One factor is the release of sewage water containing human birth-control drugs (which have a feminising effect on sexual development) into many waterways.

Biodegradable and non-biodegradable

As we become more technologically advanced, we produce materials that can withstand extreme temperatures, are durable and easy to use. Plastic bags, synthetics, plastic bottles, tin cans, and computer hardware- these are some things that make life easy for us.

But what we forget is that these advanced products do not break down naturally. When we dispose them in a garbage pile, the air, moisture, climate, or soil cannot break them down naturally to be dissolved with the surrounding land. They are not biodegradable. However natural waste and products made from nature break down easily when they are disposed as waste. But as more and more biodegradable materials pile up, there is increased threat to the environment, plants and animals.

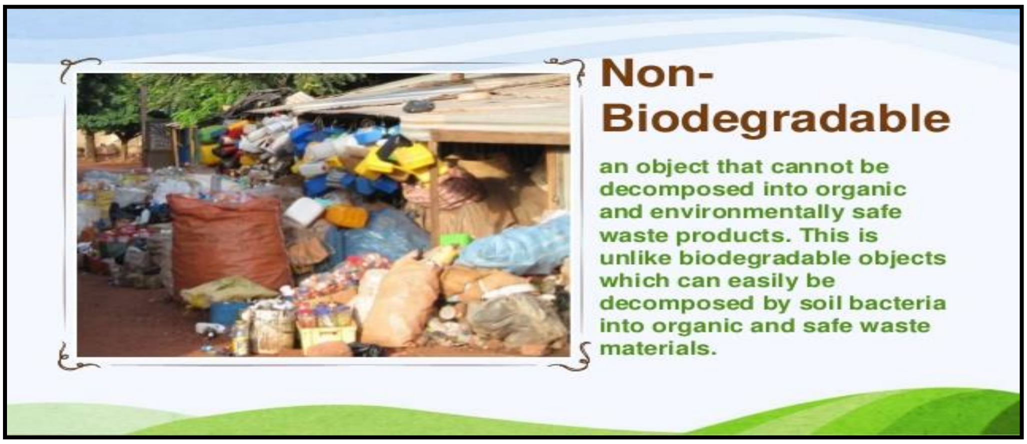
We often encounter terms like 'biodegradable' and 'non-biodegradable' in a variety of products around us. From household items to food we eat, basically everything can be labelled in either of the two categories. So, what is this all about and why is it so important to know the difference between them.

Biodegradable substances

The term **biodegradable** is used for those things that can be easily decomposed by natural agents like water, oxygen, ultraviolet rays of the sun, acid rains and micro-organisms. One can notice that when a dead leaf or a banana peel is thrown outside, it is acted upon by several micro-organisms like bacteria, fungi or small insects in a time period. The natural elements like oxygen, water, moisture and heat facilitate the decomposition process thereby breaking the complex organic forms to simpler units. The decomposed matter eventually mixes or returns back to the soil and thus the soil is once again nourished with various nutrients and minerals.

Non-biodegradable substances

Those materials which cannot be broken down or decomposed into the soil by natural agents are labelled as non-biodegradable. These substances consist of plastic materials, metal scraps, aluminum cans and bottles, hazardous chemicals and others.



These things are practically immune to the natural processes and thus cannot be fed upon or broken down even after thousands of years.

Therefore, these wastes rather than returning back to the soil, contribute to solid waste which is very hazardous for the environment. The ever increasing load of non-biodegradable trash is a growing concern all over the world and several countries are therefore, looking for eco-friendly alternatives that can minimise the threat on land and aquatic life forms.

Key Differences between Biodegradable and Non-biodegradable substances:

1. Biodegradable is referred to all those things that can be easily decomposed by natural agents. Natural agents include water, oxygen, ultra-violet rays of the sun, acid rains, microorganisms and others. On the other hand, non-biodegradable substances are never broken down or decomposed by environmental factors.
2. Biodegradable substances includes food waste like vegetable and fruit peels, dead plants and animals, chicken, egg shells, paper materials and garden waste. Non-b i o Degradable substances consist of plastics, polystyrene, metals, plastic and aluminium cans, toxic chemicals, paints and tyres.
3. Biodegradable substances on breaking up are converted into simple organic matter and are thus assimilated in to the soil and become a part of the carbon cycle of the atmosphere. On the contrary, non-biodegradable substances are resistant to environmental factors and never decompose and instead contribute to majority of solid waste.
4. Biodegradable substances may decompose within few days or months while non-biodegradable items may take thousands of years or may never ever be broken down and remain in their original form as it is.

Identifying the commodities and separating the garbage according to biodegradable and non-biodegradable label is very important in proper waste disposal and its management. Non-biodegradable items for instance can be 'recycled' and used again. Plastics, metals, bottles can be broken down with the help of chemicals and can once again be used to create new plastic and metal products. This can go a long way to effectively reducing environmental hazards caused by these non-biodegradable products and creating a better and greener planet.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 3 **30 minutes**

Answer the following questions:

1. Write the meaning of:

   (i) Polymer

   ____

   ____

   (ii) Monomer

   ____

   ____

   (iii) Polymerisation

   ____

   ____

2. List the methods of shaping and finishing plastic.

   (i) ____

   ____

   ____

   (ii) ____

   ____

   ____

   (iii) ____

   ____

   ____

   (iv) ____

   ____

   ____

Thank you for completing your learning activity 3. Check your work. Answers are at the end of this module.

12.5.2 Metallic ores

Most metals can be extracted from rock, called ore, in the Earth's crust. Ores in the rock contain the metal, or a compound of the metal, in a high enough concentration to make it worth extracting the metal.

ore copper metal Copper jar

In nature, metals occur in all kinds of rocks but usually in concentrations that are too low to be mined. Metallic ore deposits are relatively rare concentrations of metal-bearing minerals (usually sulphides) that contain enough metal to be profitably mined. Most important metals are iron, copper, aluminium, lead, zinc, silver, gold, chromium, nickel, cobalt, manganese, tin, mercury, magnesium, platinum, and titanium.

In PNG mined metallic minerals are copper, gold, nickel, cobalt and some lead and zinc. Mineral exploration is the practice of exploring for and discovering new ore deposits. Exploration is becoming progressively more challenging as the ore deposits exposed at the surface are discovered and mined. Metallic ores occur in every kind of rocks and some varieties of soil. The metallic minerals are concentrated into rich masses by igneous, hydrothermal, or weathering processes.

The process of extracting metals in a mine site.

Metals are very useful. The method used to extract a given metal from its ore depends upon the reactivity of the metal and how stable the ore is. Very reactive metals are extracted using electricity, while less reactive metals are extracted by reduction with carbon.

12.5.2.1 Methods of extracting metals (Copper, gold and silver)

The method used to extract a metal from its ore depends upon the stability of its compound in the ore, which in turn depends upon the reactivity of the metal.

- The oxides of very reactive metals, such as aluminium, form stable oxides and other compounds. A lot of energy is needed to reduce them to extract the metal.
- The oxides of less unreactive metals, such as iron, form less stable oxides and other compounds. Relatively little energy is needed to reduce them to extract the metal.

The method of extraction of a metal from its ore depends on the metal's position in the Reactivity Series. The table on the next page shows the method of extraction according to its reactivity.

Panning for gold

Reactive metals such as aluminium are extracted by electrolysis, while a less-reactive metal such as iron may be extracted by reduction with carbon. Because gold is so unreactive, it is found as a natutral metal and not as a compound and does not need to be chemically separated. Chemical reactions may be needed to remove other elements that might contaminate the metal.

The table below shows the reactivity and extraction methods of metals.

Metal	Reactivity
• potassium • sodium • calcium • magnesium • aluminium	extract by electrolysis
carbon	
• zinc • iron • tin • lead	extract by reaction with carbon or carbon monoxide
hydrogen	
• copper • silver • gold • platinum	extracted by various chemical reactions

High ↕ Low

Reactivity and Extraction Methods

Extracting gold

Excluding mechanical, smelting, and amalgamation processes, the methods of extracting gold from its ores may be conveniently grouped together under the heading of wet or chemical methods. In these, the gold is dissolved by some suitable solvent, and is then separated from the unaltered ore by washing, and recovered by precipitation. The processes owe their origin to the rapid advance in the science of chemistry which has been made during the present century. Chemistry has not done more for the gold-mining industry. At the present day, the wet methods produce little more than a tenth of the total output of gold, while mechanical improvements in the old processes, made during the last half-century, are answerable for four or five times as much.

Newcrest's Lihir mine in Papua New Guinea is one of the world's largest gold resources.

Gold extraction methods

Alluvial gold is extracted using a rocker and cradle or simple drain and various panning techniques. Reef gold is imbedded in quartz rock, which has to be crushed to release the gold caught in the seams.

Barrick Gold in PNG

Gold processing in plant on Lihir Island in PNG.

Ore treatment

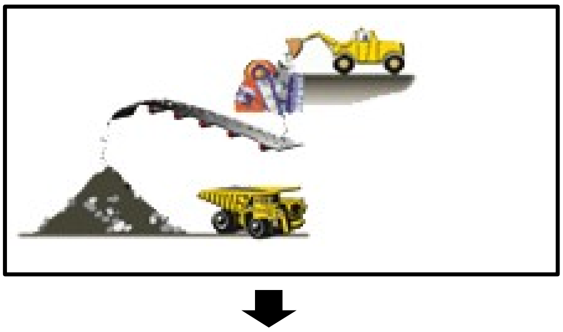
The ore after crushing goes through a screen, with the assistance of water and ran over a flat area that is treated with, firstly, copper sheet, cyanide paste and then mercury. Mercury has a chemical affinity with gold, silver and other metals. As the processed ore runs over this area, the gold attaches itself to the mercury while the rest of the ore passes through to the tailings dump.

Eventually the cyanide, mercury and gold are scraped up and placed in a retort, where the mixture is heated until the cyanide and mercury evaporate off and are recycled, leaving the gold behind. The cyanide paste acts as a buffer so that scrapings of copper do not contaminate the separated gold.

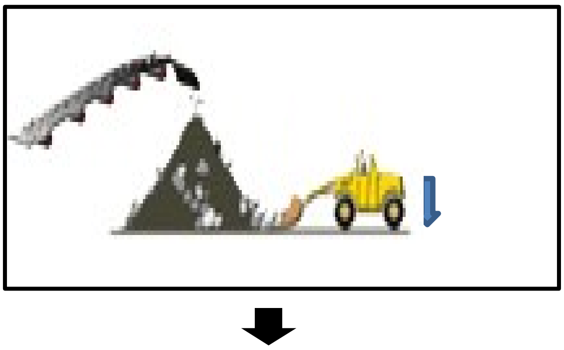
The extraction of gold is a dirty process, often doing environmental damage and causing lung damage and deafness to workers, as well as the dangers of mercury and cyanide poisoning.

1. **Mining – open pit and underground**
To define the ore from the waste rock, samples are taken and assayed. Assay results are used to mark out areas of ore and waste rock, which are mined separately. Some of the harder areas require blasting to loosen the rock prior to excavation by hydraulic diggers. Dump trucks haul the rock to primary crushers in open pit or to ore stockpiles from underground.

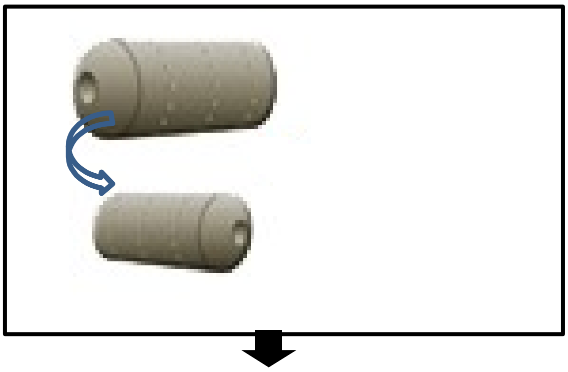
2. **Crushing**
The primary crushers located at open pit mine site, receive ore and waste at separate times. They break the larger rocks down to a size suitable for transport on conveyor belts.



3. **Transport**
A rubber belted conveyor transports the ore and waste rock from the open pit, approximately two kilometres, via a tunnel through Union Hill, to the mill and waste rock embankments. Large electromagnets remove any steel debris excavated from the old Martha Mine workings.



4. **Grinding and sizing**
Ore from both open pit and underground is stockpiled separately at the mill before being fed into a mill with lime, water and steel balls. The larger particles from this mill are returned to the mill for more grinding. The finer particles receive more grinding in a ball mill, and are size classified to give a final product of 80% <70 microns.

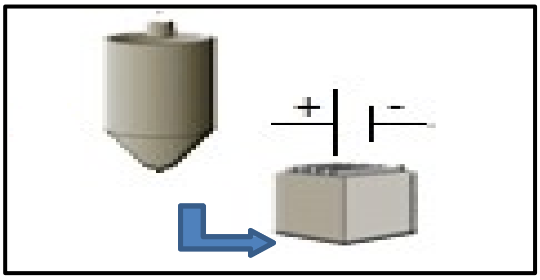


5. Leaching and adsorption

A slurry of ground ore, water and a weak cyanide solution is fed into large steel leach tanks where the gold and silver are dissolved. Following this leaching process, the slurry passes through six adsorption tanks containing carbon granules which adsorb the gold and silver. This process removes 93% of the gold and 70% of the silver.

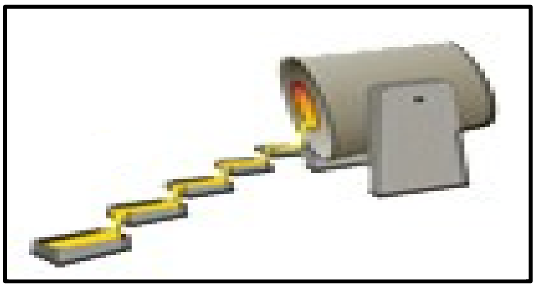
6. Elution and electrowinning

The loaded carbon is fed into an elution column where the bullion is washed off. The barren carbon is recycled. The wash solution (pregnant electrolyte) is passed through electrowinning cells where gold and silver is won onto stainless steel cathodes.



7. Bullion production

The loaded cathodes are rinsed to yield a gold and silver bearing sludge which is dried, mixed with fluxes and put into the furnace. After several hours the molten material is poured into a cascade of moulds producing bars of doré bullion.

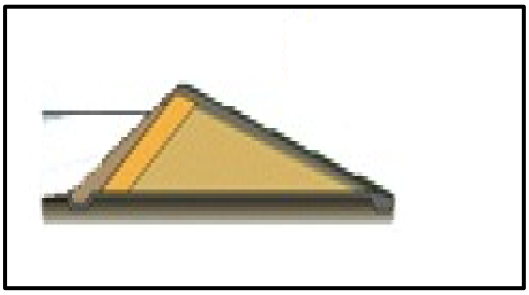


8. Water treatment

Some water from dewatering the mine, from the embankment under drains and decant water from the tailings pond is recycled for use in the grinding circuit. Excess water is pumped to the water treatment plant and treated to the required standards before discharged into the main river system.

9. Tailings disposal

Waste rock from the open pit mine is used to build the embankment structures. The embankments retain the tailings slurry in a pond where solids settle and compact. Water is decanted off and used in the process plant or treated before it is discharged into the river system.



12.5.2.2 Extraction of nickel and cobalt

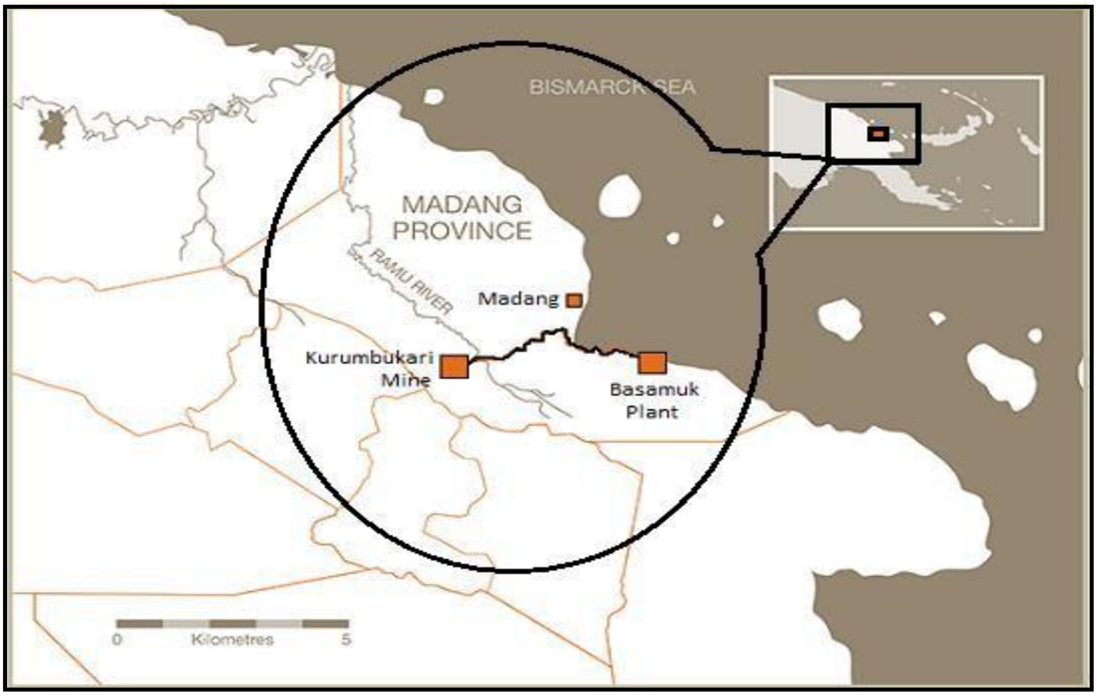
Proposed mining projects vary according to the type of minerals, metals or materials to be extracted from the earth. The majority of proposed mining projects involve the extraction of ore deposits such as copper, nickel, cobalt, gold, silver, lead, zinc, molybdenum, and platinum.

The Highlands Pacific Limited is PNG based nickel/cobalt exploration company that owns the Ramu Nickel Mine. Ramu is a large "wet tropical" laterite nickel/cobalt project located in the Madang Province of PNG.

The resource at Ramu, Madang is estimated at 143 million tonnes at 1.01% nickel and 0.10% cobalt which gives a mine life in excess of 20 years based on forecast annual production of 33,000 tonnes of contained nickel per annum.

The Ramu Nickel project is premised on mining the nickel and cobalt ore at Kurumbukari which is located in the foothills of the Bismark Ranges approximately 75km south west of Madang. The upgraded ore will be pumped, as a slurry, through a 134km pipeline to a refinery located at Basamuk Bay on the Rai Coast.

At the refinery, the slurried ore will be processed to produce high-grade nickel and cobalt metal or alternatively a high-grade nickel intermediate product for the world market. The project is fully permitted, having received all the permits and approvals required from the government of PNG. The map below shows the Ramu Nickel Project.



The Kurumbukari nickel and cobalt laterite mine is connected by a 135km pipeline from the Kurumbukari plateau, to the Basamuk process plant which is 75km east of the provincial capital of Madang, along the Rai Coast of the Vitiaz Basin.

Slurry Pipeline

A 135km slurry pipeline runs from the Kurumbukari mine plant to the Basamuk refinery, with a drop in elevation of about 680m. Most of the pipeline is buried and has road access for ease of checking and maintenance.

Basamuk Process Plant

The Basamuk process plant incorporates three High Pressure Acid Leach (HPAL) trains (autoclaves) and is designed to produce 78,000 tonnes (dry) of mixed hydroxide product containing 31,150 tonnes of nickel and 3,300 tonnes of cobalt per annum. The plant has a two train acid making facility as well as a limestone processing plant for making the key reagents used in the making of mixed hydroxide product.

Environment and deep sea tailings

Based on advice from international sources during the study and permitting stages, it was decided to dispose the tailings from the operation into the 1500 metre deep sea canyons as this is the most appropriate and safe method of disposal. The reasons for this decision include the fact that the area has the highest rainfall in the region and land based tailing storage could be disturbed a highly active volcanic and high-rainfall region while impinging on agriculture and landholder customary land.

The table shows the production figure from 2102 to 2014.

Description	2012	2013	2014	Nameplate
Ore Mined (wet tonnes)	1,547,000	3,481,800	6,009,450	8,500,000
Ore Processed (dry tonnes)	647,000	1,252,998	2,273,276	3,400,000
MHP Produced (dry tonnes)	13,777	29,736	57,360	78,000
Contained Nickel (tonnes)	5,283	11,369	20,987	31,150
Contained Cobalt (tonnes)	469	1,013	2,134	3,300
MHP Shipped (dry tonnes)	576	39,472	57,216	78,000
Contained Nickel (tonnes)	217	15,123	21,100	31,150
Contained Cobalt (tonnes)	19	1,338	2,164	3,300

Production figures 2012-2014

Cobalt

Humans have been using compounds of cobalt since 1400 B.C. The compounds were used to colour glass and glaze blue. In 1735, Swedish Chemist Georg Brandt (1694-1768) analysed a dark blue pigment found in copper ore. Brandt demonstrated that the pigment contained a new element, later named cobalt.

Cobalt is a transition metal, one of several elements found in Rows 4 through 7 between Groups 2 and 13 in the Periodic Table. The Periodic Table is a chart that shows how chemical elements are related to each other. Cobalt is located between iron and nickel and shares many chemical and physical properties with these two elements.

The most important application is in the production of super-alloys. Super-alloys primarily consist of iron, cobalt, or nickel, with small amounts of other metals, such as chromium, tungsten, aluminium, and titanium. Super-alloys are resistant to corrosion (rusting) and retain their properties at high temperatures. Super-alloys are used in jet engine parts and gas turbines.

Extraction of cobalt

Cobalt is obtained by heating its ores to produce cobalt oxide (Co_2O_3). That compound is then heated with aluminium to free the pure metal**. C**obalt oxide can be converted to cobalt chloride ($CoCl_3$). An electric current is then passed through molten (melted) cobalt chloride to obtain the free element.

Nickel

Nickel is the only element named after the devil. The name comes from the German word Kupfernickel, meaning "Old Nick's Copper," a term used by German miners. They tried to remove copper from an ore that looked like copper ore, but they were unsuccessful. Instead of copper, they got slag, a useless mass of earthy material. The miners believed the devil (Old Nick) was playing a trick on them. So, they called the fake copper ore as Old Nick's Copper.

Since then, nickel has become a very valuable metal. The most common use is in the production of stainless steel, a strong material that does not rust easily. It is used in hundreds of industrial and consumer applications. Nickel is also used in the manufacture of many other alloys.

Nickel is classified as a transition metal and closely related to iron, cobalt, copper, and zinc. in the Periodic Table.

Copper miners were confused about nickel and copper because they both occurred in ores with a green tint. But copper ores reacted differently to heat than did nickel ores. This confusion led to the choice for nickel's name.

But cobalt miners were confused too. Some ores of nickel also look like cobalt ores. But these ores did not react chemically in the same way either. Cobalt mine owners called the "misbehaving" ores of nickel "cobalt which had lost its soul."

Extraction of nickel

Nickel is the earth's 22nd most abundant element and the 7th most abundant transition metal. It is a silver white crystalline metal that occurs in meteors or combined with other elements in ores.

The method used for making pure nickel metal is a common one in metallurgy. Most nickel ores contain nickel sulfide (NiS). These ores are "roasted" (heated in air). Roasting converts the nickel sulfide to nickel oxide. The nickel oxide is then treated with a chemical that will remove the oxygen from the nickel.

For example, a large amount of nickel is now recycled from the scrap metal. Scrap metal comes from old cars, shed buildings, appliances like washing machines and stoves, and landfills. This separation of nickel from other metals in the scrap is done by taking advantage of special properties of nickel. For example, a magnet will remove nickel from scrap, leaving copper behind.

Another process is called the "Mond Process". It involves the conversion of nickel oxides to pure nickel metal. The oxide is obtained from nickel ores by a series of treatments including concentration, roasting and smelting of the minerals.

In the first step of the process, nickel oxide is reacted with water gas, a mixture of H_2 and CO, at atmospheric pressure and a temperature of 50°C. The oxide is reduced to impure nickel. Reaction of this impure material with residual carbon monoxide gives a toxic and volatile compound, nickel tetracarbonyl, $Ni(CO)_4$. This compound decomposes on heating to about 230°C to give pure nickel metal and CO, which can then be recycled. The actual temperatures and pressures used in this process may vary slightly from one processing plant to the next. However the basic process as outlined is common.The process can be summarized as follows:

$$Ni + 4CO \xrightarrow{50°C} Ni(CO)_4 \xrightarrow{230°C} Ni + 4CO$$

Environmental consequences of mining

The environmental impact of mining includes erosion, formation of sinkholes, loss of biodiversity, and contamination of soil, groundwater and surface water by chemicals from mining processes.

In some cases, additional forest logging is done in the vicinity of mines to increase the available space for the storage of the created debris and soil. Besides creating environmental damage, contamination resulting from leakage of chemicals also affects the health of local population.

Mining companies in some countries are required to follow environmental laws and rehabilitation codes, ensuring the area mined is returned to its original state. Some mining methods have significant environmental and public health effects.

Erosion of exposed hillsides, mine dumps, tailings dams and resultant siltation of drainages, creeks and rivers can significantly impact the surrounding areas, a prime example being the giant Ok Tedi Mine in PNG.

In wilderness areas, mining may cause destruction and disturbance of ecosystems and habitats. In areas of farming**,** it disturbs or destroys productive grazing and croplands. In urbanised environments, mining produces noise, dust, and visual pollution.

Mining Location	**Type of Dumping**	**Tailings dumped each year**
Grasberg, West Papua	River	80 million
BatuHijau, Indonesia	Marine	40 million
Ok Tedi, Papua New Guinea	River	22 million
Wabush Scully, Labrador, Canada	Lake	13 million
Lihir, Papua New Guinea	Marine	5 million
Porgera, Papua New Guinea	River	5 million

Tailings dams and resultant siltation of drainages

The table above highlights the world's waters that are suffering the greatest harm or are at greatest risk from dumping of mine waste – three (3) out of six (6) are PNG. The offending mines are Ok Tedi, Porgera, Ramu nickel, Lihir, Simberi and Tolukuma. Just as shocking is the fact that three of PNG's mines are among the six worst water polluting mines in the world.

Mine processing wastes, also known as tailings, can contain many dangerous chemicals including arsenic, lead, mercury and processing chemicals such as petroleum by-products, acids and cyanide. Waste rock, the extra rock that does not contain significant amounts of ore, can also generate acid and toxic contamination. The dumping of mine tailings and waste rock pollutes waters around the world, threatening drinking water, food supply and health of communities as well as aquatic life and ecosystems.

Water Pollution

All kinds of mining can have bad effects on surrounding surface and ground water if protective measures are not taken. The result can be unnaturally high concentrations of some chemicals, such as arsenic, sulphuric acid, and mercury over a significant area of surface or subsurface. Runoff of mere soil or rock debris (although non-toxic) also devastates the surrounding vegetation.

The dumping of the runoff in surface waters or in forests is the worst option here. Submarine tailings disposal is regarded as a better option (if the soil is pumped to a great depth). Mere land storage and refilling of the mine after it has been depleted is even better, if no forests need to be cleared for the storage of the debris. There is potential for massive contamination of the area surrounding mines due to the various chemicals used in the mining process as well as the potentially damaging compounds and metals removed from the ground with the ore. Large amounts of water produced from mine drainage, mine cooling, aqueous extraction and other mining processes increase the potential for these chemicals to contaminate ground and surface water.

In well-regulated mines, hydrologists and geologists take careful measurements of water and soil to exclude any type of water contamination that could be caused by the mine's operations.

Effects of mining activity on biodiversity

The implantation of a mine is a major habitat modification, and smaller changes in quality, behaviour and movement occur on a larger scale than exploitation site, mine-waste residuals contamination of the environment. Adverse effects can be observed long after the end of the mine activity.

Destruction or drastic modification of the original site and substances resulting from the influence of human beings on nature released can have major impact on biodiversity in the area. Destruction of the habitat is the main component of biodiversity losses, but direct poisoning caused by mine extracted material, and indirect poisoning through food and water can also affect animals, vegetation and microorganisms. Habitat modification such as pH and temperature modification disturbs communities in the area.

Endemic species are especially sensitive, since they need really specific environmental conditions. Destruction or slight modification of their habitat put them at the risk of extinction. Habitats can be damaged as well by non-chemical products, such as large rocks from the mines that are discarded in the surrounding landscape with no concern for damage on natural habitat.The picture illustrates the damage done to the environment, vegetation, land and animals.

Destruction or slight modification of habitat.

Aquatic organisms

Mining industry can have an impact aquatic biodiversity through different ways. Direct poisoning is the first one, and risks are higher when contaminants are mobile in the sediment or available in the water.

Contaminants can also affect aquatic organisms through physical effects: streams with high concentrations of suspended sediment limit light, thus diminishing algae biomass. Metal oxide deposition can limit biomass by coating algae or their substrate, thereby preventing colonization.

Factors that impact communities in acid mine drainage sites are temperature, rainfall, pH, salinity and metal quantity all display variations on the long-term, and can heavily affect communities. Changes in pH or temperature can affect metal solubility, and directly affect living organisms.

Contamination persists over time. Ninety years after a pyrite mine closure, water pH was still really low and microorganism populations consisted mainly of acidophil bacteria.

Affected deep sea reefs and marine life

Micro-organisms

Algae communities are less diverse in acidic water containing high zinc concentration, and mine drainage stress decreases their primary production. Diatoms community is greatly modified by any chemical change.

The phytoplankton assemblage and high metal concentration diminishes the abundance of plankton species. In sediments close to the surface, cysts suffer from corrosion and heavy coating. In really polluted conditions, total algae biomass is really low, and the plankton diatom community missing.

Macro organisms

Water insect and crustacean communities are modified around a mine, resulting in a low trophic completeness and the community being dominated by predators. Biodiversity of macro invertebrates can remain high, if sensitive species are replaced with tolerant ones.

When diversity is reduced, there is no effect of stream contamination on abundance or biomass, suggesting that tolerant species fulfilling the same function take the place of sensible species in polluted sites. Different species of fish are also affected by pH, temperature variations and chemical concentrations.

Vegetation
Soil texture and water content can be greatly modified in disturbed sites, leading to changes in plant communities in the area. Most plants have a low concentration tolerance for metals in the soil, but sensitivity differs among species. Grass diversity and total cover is less affected by high contaminant concentration than forbs and shrubs.

Mine waste-material rejects or traces can be found in the vicinity of the mine, sometimes away from the source. Some species are more resistant and will survive these levels, and some non-native species that can tolerate these concentrations in the soil will migrate in the mine surrounding lands to occupy the ecological niche.

Destruction or modification of habitat

Mine waste-material rejects or traces can be found in the vicinity of the mine, sometimes pretty far away from the source. Some species are more resistant and will survive these levels, and some non-native species that can tolerate these concentrations in the soil will migrate in the mine surrounding lands to occupy the ecological niche.

Animals can be poisoned directly by mine products and residuals. Bio-accumulation in plants or the smaller organisms they eat can also lead to poisoning. Cows, horses, goats and sheep are exposed in certain areas to potentially toxic concentration of copper and lead in the grass.

There are fewer number of ant species in soil containing high copper levels, in the vicinity of a copper mine. If fewer ants are found, the chances are great that other organisms leaving in the surrounding landscape are strongly affected as well by these high copper levels. Since ants are in good control of the environment: they live directly in the soil and are thus sensible to environmental disruptions.

Effects of mine pollution on humans

Humans are also affected by mining. There are many diseases that come from the pollutants released into the air and water during the mining process.

Children suffer from disease imposed by mining pollution. The International Labour Organization (ILO) estimates that 250 million children are involved in child labour and that over 70 percent of them face hazardous conditions.

According to the United Nations Environment Program (UNEP), small-scale gold processing operations in developing countries like PNG employ one million children. Children, who are to exposed to heavy metals such as mercury and lead will die or contact diseases associated with mass poisoning incidents from mining operations.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 4 **20 minutes**

Answer the following questions:

Circle the correct letter.

QUESTION 1

Rocks rich in metals are known as __________

A. metalloids B. allotropes

C. slags D. ores

QUESTION 2

Which metal is obtained from haematite ore?

A. Gold B. Iron

C. Aluminium D. Copper

QUESTION 3

What is a metal ore?

____

____

QUESTION 4

How is a metal extracted from its ore?

____

____

Thank you for completing your learning activity 4. Check your work. Answers are at the end of this module.

12.5.3 Production of ethanol

In the production of ethanol, there are two processes involved: fermentation and distillation. Fermentation is the process of converting carbohydrates to alcohols and carbon dioxide using yeasts. Simple fermentation is the conversion of sugar into ethanol which has been practiced since the 6^{th} millennium and historians have found evidence of it starting in ancient Egypt.

On the other hand, distillation involves separating mixtures through the process of vaporisation of boiling mixtures. Distillation is a unit operation which involves bringing a physical change such as separation evaporation, filtration or crystallization.

The difference in the boiling points of alcohol and water is utilised in distillation to separate these liquids from each other. The basic distillation apparatus consists of three parts and they are the:

- still or retort for heating the liquid.
- condenser, for cooling the vapours.
- receiver, for collecting the distillate.

12.5.3.1 Fermentation and distillation

In the process of fermentation, simple sugars, including dextrose and maltose, are converted to ethyl alcohol by the action of yeast enzymes. Several intermediate compounds are formed during this complex chemical process before the final ethyl alcohol is obtained. Yeast functions best in a slightly acid medium, and prepared grain mash, fruit juice, molasses, or other mixture must be checked for adequate acidity (pH value). If acidity is insufficient, acid or acid-bearing material is added to achieve the necessary adjustment. The previously prepared yeast is then added, and final dilution of the mixture is made. The final concentration of sugars is adjusted so that the yeast fermentation will produce a finished fermented mixture between 7 to 9 percent alcohol.

Commercial fermentation is carried on in large vats. In the past these were open and made of wood, usually cypress. Most commercial plants now use closed stainless steel vats for easier cleaning, and many are equipped with jackets or cooling coils for better temperature control. The time required for completion of fermentation is mainly dependent upon the temperature of the fermenting mash. Normal yeast is most effective in breaking down all of the fermentable sugars at temperatures ranging from 24°C to 29°C, and, in this range, completion of fermentation requires from 48 to 96 hours. Fermentation at lower temperatures requires longer periods. The mash is ready for distillation upon completion of fermentation. If fermentation is allowed to continue past this period, it will be adversely affected by bacterial action. The ethyl alcohol content will be reduced, and the flavour and aroma of the finished product will be tainted.

Fermentation

Fermentation is the breakdown of complex molecules to simpler ones through the action of some microorganism, such as yeast. We normally think of fermentation in the context of beer or wine, but the term also includes the conversion of milk to yogurt or cheese and the making of bread.

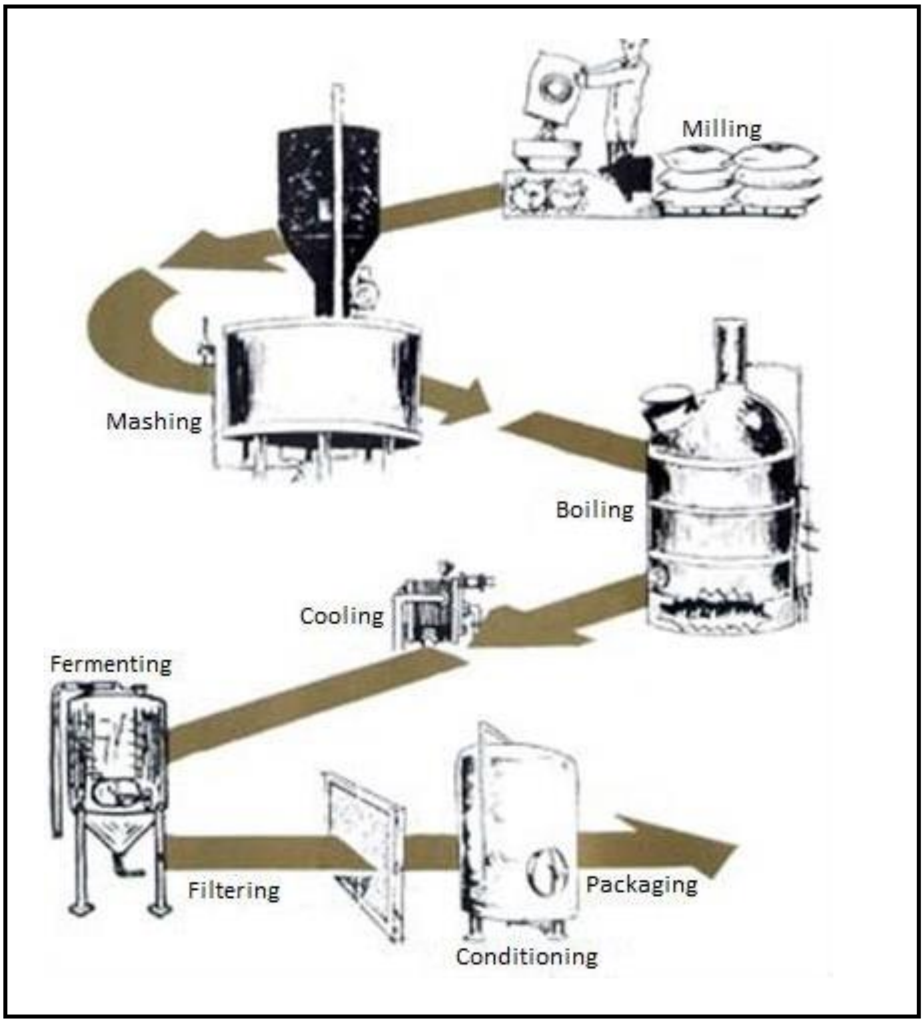


Diagram of industrial brewing process

In all of these examples, carbohydrates are being fermented by yeast. In the case of bread, yeast converts carbohydrates into carbon dioxide gas (CO_2). The little pockets of CO_2 make the bread rise and produce the fluffy consistency of the bread. This formation of gas pockets distinguishes bread from crackers.

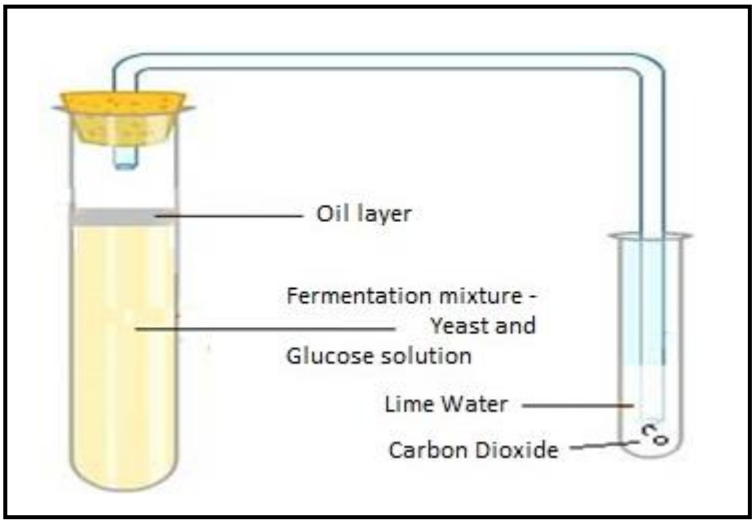
For fermentations that produce alcohol, such as wine, carbohydrate is converted to ethanol and carbon dioxide as shown in the equation below.

$C_6H_{12}O_6$	yeast	$2C_2H_5OH$	+	$2CO_2$
glucose	$\longrightarrow$	ethanol		carbon dioxide

Yeast is naturally present on the skin of grapes, which is why the making of wine dates back before recorded history. Current professional wine makers kill the natural yeast and replace it with commercial yeast so as to better control the fermentation process. This process needs to be done in the absence of air (specifically oxygen), lest the ethanol be oxidised to acetic acid, which is the chemical we associate with vinegar:

$C_2H_5\,OH$	air oxidation	$HC_2O_2H_3$
Ethanol	$\longrightarrow$	acetic acid

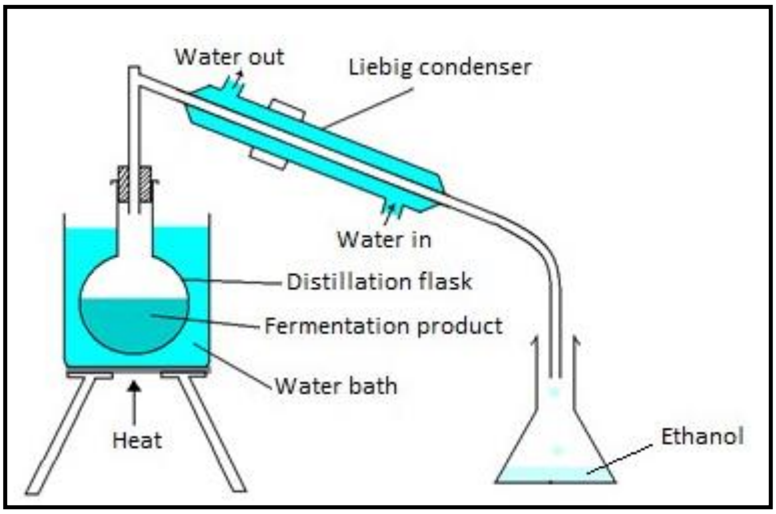
Fermentation continues until the ethanol concentration is high enough to inhibit yeast growth. This usually happens when the alcohol content is between 10 - 14 %. If you want to produce a beverage that has greater alcohol content, you must either distil it or fortify it with alcohol that resulted from the distillation of another product of fermentation. Whiskey, vodka, and gin are examples of distilled spirits. Port wine and liqueurs are examples of fortified wines.



Simple fermentation apparatus

Distillation

Distillation is a purification process where a substance is heated to its boiling point. The vapour produced upon boiling is allowed to flow away from the boiling liquid, and the vapour is cooled to condense it back to the liquid. Suppose you have a liquid that contains contaminants, like sea water. You cannot use sea water as a source of drinking because of its high salt content



A distillation apparatus

Distillation is a common way of separation and purification of crude oil into its usable components (gasoline, kerosene, asphalt and others). As mentioned above, distillation also enables one to produce a beverage or a fuel from a fermentation process that has higher alcohol content.

The maximum concentration of alcohol that can be obtained through distillation from a water-based fermentation is 95%. This is because ethanol and water form a mixture (called an azeotrope) that boils at a constant composition. Thus the vapour that forms upon the boiling of any water or alcohol mixture is 95% ethanol and 5% water.

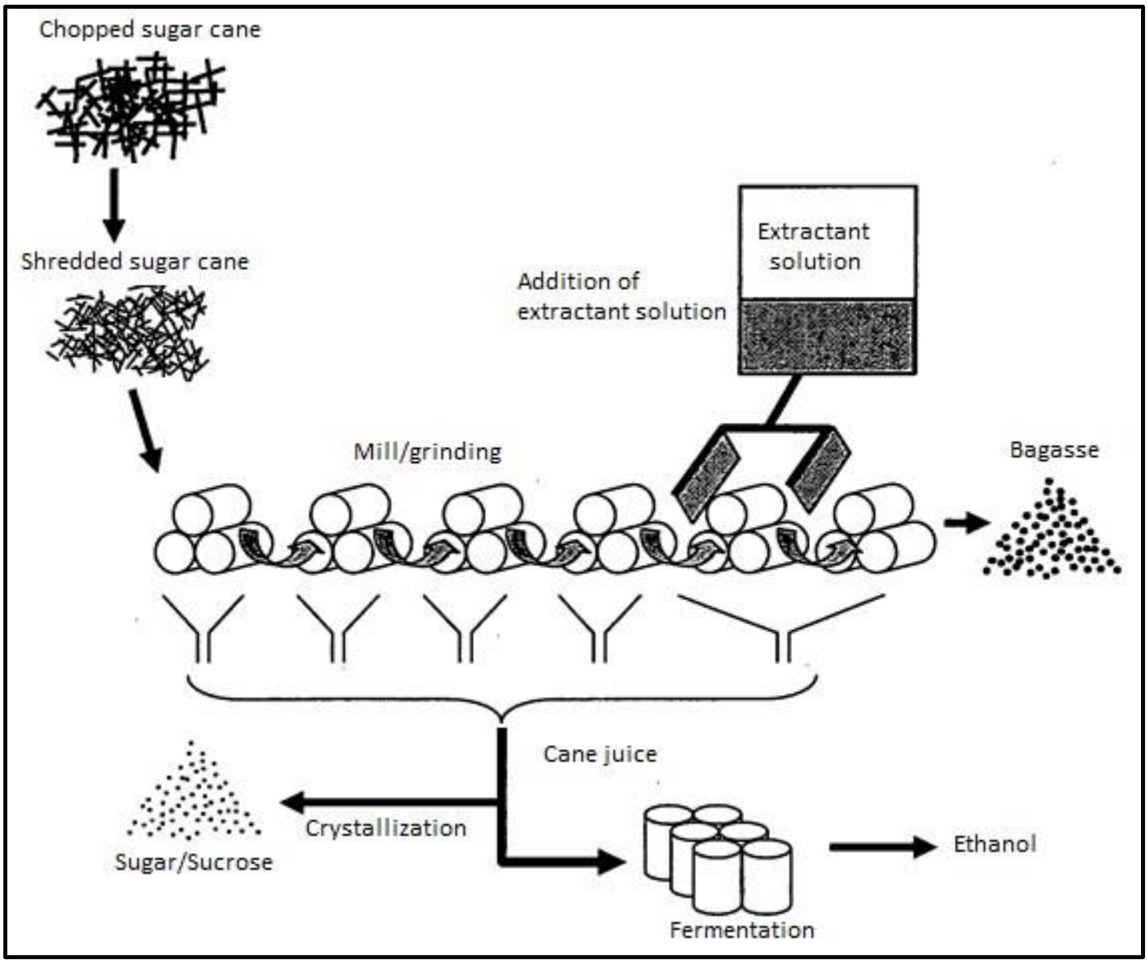
12.5.3.2 Effects of ethanol and methanol

The production of ethanol from sugar cane, molasses and juice is well known. Customarily in the production of ethanol from sugar cane, the juice is first extracted from the cane by crushing or milling and then subjected to fermentation, with or without prior concentration of the juice by evaporation and/or crystallisation of sucrose. Substantial quantities of industrial alcohol are produced using molasses obtained as a residue in conventional sugar manufacturing processes.

Sugarcane ethanol is an alcohol-based fuel produced by the fermentation of sugarcane juice and molasses as shown in the diagram. Because it is a clean, affordable and low-carbon bio-fuel, sugarcane ethanol has emerged as a leading renewable fuel for the transportation sector.

Ethanol can be used in two ways:

- Blended with gasoline at levels ranging from 5 to 25 percent to reduce petroleum use, boost octane ratings and cut tailpipe emissions.
- Pure ethanol is a fuel made up of 85 to 100 percent ethanol depending on country specifications which can be used in specially designed engines.

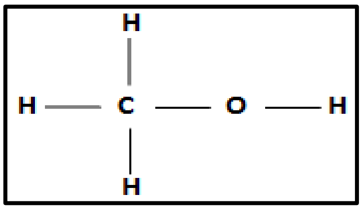


Steps to ethanol production

Properties of methanol

Physical	Chemical
Also known as methyl alcohol, wood alcohol, wood naphtha or wood spirits.	Chemical is formula CH_3OH.
It is the simplest alcohol. Methanol flame is almost colourless in bright sunlight. At room temperature it is a polar liquid.	Produced naturally in the anaerobic metabolism of many varieties of bacteria. There is a small fraction of methanol vapour in the atmosphere.
Methanol is a colourless liquid that boils at 64.96°C and solidifies at -93.9°C.	Atmospheric methanol is oxidized with the help of sunlight to carbon dioxide and water.
Light, volatile, flammable liquid with a distinctive odour similar to ethanol (drinking alcohol.	Burns in air forming carbon dioxide and water.

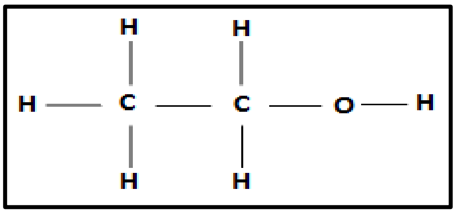
Methanol (CH_3OH) is commonly represented by the structural formula:



Properties of ethanol

Physical	Chemical
A primary alcohol which melts at - 117.3°C and boils at 78.5°C.	Burns in air with a blue flame, forming carbon dioxide and water.
Forms a constant-boiling mixture, or azeotrope, with water that contains 95% ethanol and 5% water.	Reacts with active metals to form the metal ethoxide and hydrogen.
Miscible, it mixes without separation with water.	Reacts with certain acids to form esters, with acetic acid it forms ethyl acetate.
Absolute ethanol is completely free of water.	Can be oxidized to form acetic acid and acetaldehyde.
Benzene added to 95% ethanol forms a ternary azeotrope of benzene, ethanol, and water.	Can be dehydrated to form diethyl ether or, at higher temperatures, ethylene.

Ethanol with the chemical formula C_2H_5OH, is commonly represented by the structural formula as follows. The single lines between the atoms represent single covalent bonds.



Note that each carbon atom has four bonds (valency 4), each oxygen atom has two bonds (valency 2) and each hydrogen atom has one bond (valency 1). Valency is the combining power of an atom.

Ethanol is the alcohol of beer, wines, and liquors. It can be prepared by the fermentation of sugar (e.g. from molasses), which requires an enzyme catalyst that is present in yeast; or it can be prepared by the fermentation of starch (example from corn, rice, rye, or potatoes), which requires, in addition to the yeast enzyme, an enzyme present in an extract of malt.

The concentration of ethanol obtained by fermentation is limited to about 10% (20 proof) since at higher concentrations ethanol inhibits the catalytic effect of the yeast enzyme. (The proof concentration of an alcoholic beverage is numerically double the percentage concentration.)

For non-beverage uses, ethanol is more commonly prepared by passing ethylene gas at high pressure into concentrated sulphuric or phosphoric acid to form the corresponding ester. The acid-ester mixture is diluted with water and heated, forming ethanol by hydrolysis, and the alcohol is then removed from the mixture by distillation, usually with steam.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 5 **20 minutes**

Answer the following questions.

QUESTION 1

Give at least two physical properties of methanol.

(i)____

(ii)____

QUESTION 2

Write the formula for

(i) ethanol ___________

(ii) methanol ___________

QUESTION 3

Write two harmful effects of drinking methanol.

(i) ____

(ii)____

QUESTION 4

Give at least two chemical properties of ethanol.

(i) ____

(ii) ____

QUESTION 5

Alcohols (like hydrocarbons) are named according to the number of carbon atoms in the molecule. How many carbon atoms does ethanol have? ___________

Thank you for completing your learning activity 5. Check your work. Answers are at the end of this module.

12.5.4 Production and uses of vegetable oils

The production and use of vegetable oil involves the extraction and processing of oils and fats from vegetable sources. Vegetable oil processing industry also includes fats and is principally used for human consumption, animal feed, medicinal purposes, and other uses. These oils and fats are extracted from a variety of fruits, seeds, and nuts.

The preparation of raw materials includes **husking, cleaning, crushing,** and **conditioning**. Their extraction processes are generally mechanical (boiling of fruits and pressing of seeds and nuts). The liquid oil is skimmed after boiling. After pressing, the oil is filtered and after solvent extraction, the crude oil is separated and the solvent is evaporated and recovered. Residues are conditioned (for example, dried) and are reprocessed to yield by-products such as animal feed.

12.5.4.1 Oil extraction from seeds and nuts

Oil is extracted from a number of fruits, nuts and seeds for use in cooking and soap making or as an ingredient in other foods such as baked or fried goods. Oil is a valuable product with high demand, and the possible income from oil extraction is therefore often enough to cater for the relatively high cost of setting up and running a small scale oil milling business.

Vegetable oil is extracted from a plant. Such vegetable oils have been part of human culture for years. The term vegetable oil can be simply defined as referring only to oils extracted from plants in a liquid state at room temperature. Although many plant parts may yield oil, primarily oil is extracted from seeds. Vegetable oils that are in solid state at room temperature are called **vegetable fats**.

Many vegetable oils are consumed directly, or indirectly as ingredients in food – a role that they share with animal fats, including butter. The oils serve a number of purposes in this role. For example:

- Shortening is to give pastry a crumbly texture.
- Texture oils can serve to make other ingredients stick together less.
- Flavour while less-flavourful oils command premium prices, some oils, such as olive, sesame, or almond oil, may be chosen specifically for the flavour they impart.
- Flavour base oils can also "carry" flavours of other ingredients, since many flavours are present in chemicals that are soluble in oil.

Traditional method of oil extraction

Traditional methods often require various preliminary operations, such as **cracking, shelling,** and **dehulling** after which the crop is ground to a paste. The paste, or the whole fruit, is then boiled with water and stirred until the oil separates and is collected. Such traditional methods have a low rate of efficiency, particularly when performed manually. Oil extracted by pressing without heating is the purest method and often produces an edible product without refining.

Modern method of oil extraction

Modern methods of oil recovery include crushing and pressing, as well as dissolving the crop in a solvent, most commonly hexane. Extracting oil with a solvent is a more efficient method than pressing. The residue left after the removal of oil (oilcake or meal) is used as feedstuff. Vegetable oils are obtained without further processing other than degumming or filtering. To make them suitable for human consumption, most edible vegetable oils are refined to remove impurities and harmful substances.

In comparison to animal fats, vegetable oils contain mainly unsaturated (light, liquid) fatty acids of two kinds: monounsaturated (oleic acid - mainly in extra virgin olive oil) and polyunsaturated (linoleic acid and linolenic acid - in oils extracted from oilseeds).

Uses of vegetable oils

As food	As non-food
Salad and cooking oil	Production of soaps and detergents
Production of margarine, shortening and compound fat	Production of paint, varnish and resin
Processed food products such as mustard, mayonnaise, potato chips, French fries, salad dressing, sandwich spread and canned fish	Production of plastic and lubricants

Coconut Oils

Below is a traditional method of extracting oil from coconut:

1. Grating coconut meat traditionally.
    - This grater has a metal blade. Traditionally sea shells were used to scrap coconut.
2. The grated coconut meat is mixed with warm water and coconut milk is squeezed out.
3. Grated coconut meat is squeezed for the release of milk.
4. Boil to remove the water. It takes several hours. Keep stirring to keep it from burning.
5. Finally, extracted oils are poured into bottles for safe keeping.

The pictures on the next page show coconut oil being extracted traditionally.

Coconut being grated

Extracting coconut milk from the grated coconut meat

Squashing to extract coconut milk from the grated coconut meat

Coconut milk brought to boil before extracting the oil

Bottling of extracted oil

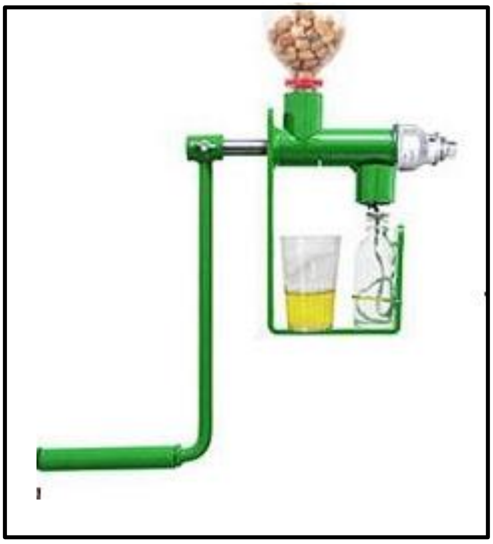
In general, there are three main types of coconut oil:

1. **Virgin coconut oil** which is difficult to find in the local market, is extracted either through a wet or dry process. The wet process involves coconut milk being heated and then the temperature being decreased to about 10^0C to obtain a solid piece of coconut oil which is then separated and warmed up. The dry process is when the white kernel is obtained and pressed, several different techniques could be applied but is similar to copra oil production.
2. **Coconut oil from copra** is extracted by crushing and pressing the copra. Done in big mills, this is the oil which is freely available in the market. The temperature in coconut oil may reach up to about 70^0C in this process.
3. **Traditional coconut oil** is produced in homes mostly in rural areas where dry coconuts are scraped and then the milk is extracted. Thereafter, the milk is heated over a high temperature going up to 120^0C, allowing the oil to collect at the top of the pan.

Coconut oil has two main fractions. They are the **lipid fraction** which contains the saturated fatty acids and the **non-lipid fraction**. The lipid fraction consists of **93% saturated fatty acids**, **5% mono-unsaturated fatty acids**, and **2% poly-unsaturated fatty acids**.

Peanut oils

Peanut oil is obtained by one of three methods, including **hydraulic, expeller** and **solvent extraction** methods.


Hand crank peanut oil press

The hydraulic method of extraction consists of pressing the shelled peanuts under 14,000psi while adding steam and heat.

Expeller pressing is the most popular method of peanut oil extraction. Expeller pressing resembles a modern day meat grinder. Peanuts are fed into a grinder, and pressure is added as the screw turns. This forces the mass out through a perforated screen. The screen separates the oil from the grinded peanuts.

The solvent method is the most expensive of the three methods. It involves using hexane to extract oil from peanut seeds. This method is frequently combined with the expeller methods.

12.5.4.2 Saponification

Saponification is the process of making soap molecules from chemical reactions in which fatty esters (fats and oils) are reacted in basic conditions. This process converts fats and oils, from a basic reaction medium, to salts of these fatty acids.

General Form

$$(CH)_2CH(CH_3(CH_2)_{16})_3 + 3NaOH \longrightarrow H(HCOH)_3H + 3CH_3(CH_2)_{16}COO^{-}Na^{+}$$

glyceryltristearate + sodium hydroxide → glycerol + sodium stearate

These oils when combined will produce soaps with desirable qualities.

Saponification Table						
Acid	**SAP**	**Hard/Soft**	**Cleansing**	**Fluffy Lather**	**Stable Lather**	**Skin Care**
Avocado Oil	133.7	Soft	Fair	Yes	No	Very good
Coconut Oil	191.1	Hard	Very good	Yes	No	Fair
Castor Oil	128.6	Soft	Fair	Yes	Yes	Good
Olive Oil	125.3	Soft	Good	No	No	Good
Palm Oil	142	Hard	Very good	No	Yes	Fair
Peanut Oil	137	Soft	Fair	No	Yes	Good
Soybean Oil	135.9	Soft	Good	No	Yes	Fair
Sweet almond Oil	137.3	Soft	Good	No	Yes	Very good
Jojoba Oil	69.5	Soft	Fair	No	Yes	Good
Kukui Nut Oil	135.5	Soft	Good	No	Yes	Good
Lard	138.7	Hard	Good	No	Yes	Fair
Tallow	140.5	Hard	Good	No	Yes	Fair

Explaining the terms:

1. SAP – How many milligrams of baser is required to completely saponify 1 gram of an acid. This is normally given in terms of how much potassium hydroxide is needed.
2. Hard/Soft – How hard or soft the bar of soap will be. If a bar of soap is too soft, it will dissolve too quickly and become too mushy. The desired outcome is achieved by combining hard and soft oils.
3. Cleansing – This is how well the acid cleans. Any soap will clean relatively well however, some soaps will be better than others.
4. Fluffy Lather – This is how fluffy the lather created by the soap is. A fluffy lather is thick and bubbly but will wash away easily so is not desirable.
5. Stable Lather – A bar of soap with a stable lather has very little substance but is harder to wash away. A balanced lather with be both fluffy and stable.
6. Skin Care – How beneficial the soap is to the skin. This is judged in terms of nourishing vitamins, mildness and moisturising abilities.

General processes of soap making

The term saponification refers to the chemical reaction that occurs when a vegetable oil or animal fat is mixed with a strong alkali. The two products formed of this reaction are soap and glycerin. Water is also present, but it does not enter into the chemical reaction. The water is only a solvent for the alkali, which is otherwise a dry powder.

Have you ever actually wondered what soap is?

The name saponification literally means **soap making**. The root word, **sapo**, is Latin for soap. The Italian word for soap is **sapone**. The oils used in modern handmade soap are carefully chosen by the soap maker for the character they impart to the final soap. Coconut oil creates lots of glycerin, makes big bubbly lather, and is very stable. Olive oil has natural antioxidants and its soap makes a creamier lather. Tallow, or rendered beef fat, makes a white, stately bar that is firm and creates abundant lather. Many other oils can be used, each one for a specific reason.

The alkali used in modern soap is either potassium hydroxide, which is used to make soft soap or liquid soap because of its greater solubility, or sodium hydroxide, which is used to make bar soap. The common term for the alkali is simply **lye**.

The true fact is that modern handcrafted soap, though necessarily made with lye to get true soap, has no lye in the final product. It has all been reacted with the oils to form soap and glycerin.

A curious fact about modern soap is that most common soap found in the grocery store made in mass-produced factories does have a small amount of excess alkali in it. Also, it has had all of its naturally-occurring glycerin removed so it can be sold as a separate commodity. The most important difference between most commercial soap and our real handmade soap is that the glycerin is left in real handmade soap and thus it retains its natural moisturising property.

We have been using soap since birth, yet most of us never even thought about this before.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 6 **20 minutes**

Answer the following:

Circle the correct answer.

QUESTION 1

Where are vegetable oils found?

A. In fruit trees

B. In seeds and nuts only

C. In seeds and fruit only

D. In seeds, nuts and some fruit

QUESTION 2

What do unsaturated oils tend to be

A. solid at room temperature.

B. liquid and gas at room temperature.

C. to remain neither solid nor liquid.

QUESTION 3

Vegetable oils have higher boiling points than water. This means that

A. food cooking in oil is faster than in water

B. food cooks more slowly in oil than it does in water

C. fried food releases more energy when eaten than boiled food does

D. food can be cooked at higher temperatures in oil than it can in water

Thank you for completing your learning activity 6. Check your work. Answers are at the end of this module.

12.5.4.3 Biodiesel production

Biodiesel is produced from vegetable oils, yellow grease, used cooking oils, and animal fats. The process to make biodiesel involves a chemical reaction. This means that the biodiesel industry is a **chemical industry**. Those involved in making biodiesel must have a good understanding of the underlying chemistry to ensure they are making quality fuel in a safe manner.

The chemical reaction that converts a vegetable oil or animal fat to biodiesel is called **transesterification**. This is a long name for a simple process of combining a chemical compound called an **ester** and an alcohol to make another ester and another alcohol. Oils and fats are included in the ester family. When they react with methanol or ethanol, they make methyl or ethyl esters and a new alcohol called glycerol or, more commonly, glycerin.

During transesterification which converts oils and fats into chemicals called long-chain mono alkyl esters. This is called biodiesel when used as a fuel. These chemicals are also referred to as fatty acid methyl esters or sometimes FAME.

For example, 100 kilograms of oil or fat are reacted with 10 kilograms of a short-chain alcohol (usually methanol) in the presence of a catalyst (usually sodium hydroxide [NaOH] or rarely, potassium hydroxide [KOH]) to form 100 kilograms of biodiesel and 10 kilograms of glycerin.

Glycerin, which is used in pharmaceuticals and cosmetics, among other markets, is a co-product. Although the process is relatively simple, homemade biodiesel is not recommended because of its composition and impurities.

Biodiesel is an alternative fuel for diesel engines that is produced by chemically reacting a vegetable oil or animal fat with alcohol such as methanol or ethanol.

The picture shows a bottle of biodiesel and glycerin (also called glycerol). The biodiesel is the lighter-coloured layer at the top. The darker-coloured crude glycerin has settled to the bottom.

Bottle of biodiesel (top layer) and glycerol (bottom layer)

It is important to realize here that **unmodified vegetable oil**, sometimes called straight vegetable oil (SVO) or waste vegetable oil (WVO), is not biodiesel. These SVO or WVO may be used in diesel engines but the primary problem is the flow rates of the unmodified vegetable oils.

Biodiesel is usually preferred over SVO and WVO because the chemical reaction converts the oil or fat into compounds that are closer to the hydrocarbons found in regular diesel fuel.

What is biodiesel?

Biodiesel is a renewable, clean-burning diesel replacement that can reduce dependence on foreign petroleum, creating jobs and improving the environment.

Biodiesel is made from a diverse mixture of feed stocks including recycled cooking oil, soybean oil, and animal fats or recycled restaurant grease for use in diesel vehicles. Before being used commercially it must meet strict technical fuel quality and engine performance specifications. It can be used in existing diesel engines without modification and is covered by all major engine manufacturers' warranties, most often in blends of up to 5 percent or 20 percent biodiesel.

Why should we use biodiesel?

Biodiesel is better for the environment because it is made from renewable resources and has lower emissions compared to petroleum diesel. It is less toxic than table salt and biodegrades as fast as sugar.

Produced domestically with natural resources, its use decreases our dependence on imported fuel and contributes to our own economy.

Biodiesel has helped several countries in reducing their dependence on foreign oil reserves. It is domestically produced and can be used in any diesel engine with little or no modification to the engine or the system.

What is biogas?

Biogas typically refers to a gas produced by the breakdown of organic matter in the absence of oxygen. It is a renewable energy source, like solar and wind energy. Furthermore, biogas can be produced from locally available raw materials and recycled waste. It is environmentally friendly and CO_2 neutral.

Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as manure, sewage, municipal waste, green waste, plant material, and crops. Biogas comprises primarily of methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), and moisture. The gases methane, hydrogen, and carbon monoxide (CO) can be burnt or oxidized with oxygen. This energy release allows biogas to be used as a fuel.

Biogas can be used as a fuel in any country for any heating purpose, such as cooking. It can also be used in anaerobic digesters where it is typically used in a gas engine to convert gas energy into electricity and heat. Biogas can be compressed, much like natural gas, and used to power motor vehicles.

Typical composition of biogas		
Compound	**Formula**	**%**
Methane	CH_4	50-75
Carbon Dioxide	CO_2	25-50
Nitrogen	N_2	0-10
Hydrogen	H_2	0-1
Hydrogen Sulphide	H_2S	0-3
Oxygen	O_2	0-0.5

12.5.5.1 Traditional chemical practices

PNG is characterised by geological, ethnic and biological diversity. It contains approximately 6% of the world's biodiversity in just under 1% of the worlds' land area. This allows people of this country to use its flora and other resources to produce what they want and need.

Although not widely documented and appreciated by many Westerners, medicine and chemistry have been associated with Papua New Guineans for thousands of years. They also have been using indigenous plants for treatment of diseases for thousands of years. The first medicinal plants recorded in PNG were shown to the Russian botanist and explorer Miklouho-Maclay (1886) who lived on the Rai Coast of now Madang from 1871 to 1876. Many other traditional plants used as medicines have been since recorded by missionaries, visiting botanists and anthropologists.

12.5.5.2 Traditional lime and salt production

Betelnut chewing is a custom or ritual that dates back thousands of years from Asia to the Pacific, a tradition very much a part of modern life in many parts of the Coral Triangle. This custom is very much alive in both coastal and highlands societies that it is hard to ignore. The first thing you notice while talking to a local men and women is their bright red-stained teeth and lips. The chewing involves three items: betelnut, mustard stick and lime powder acting as a mild stimulant which helps locals suppress their hunger, reduce stress and heighten their senses.

A jar of traditionally processed lime powder (kambang), a bean-like green stick called mustard (daka) and green betel nuts (buai)

When visiting public markets, lime powder and betelnut dominates the market scene especially the coastal markets and designated areas in the Highlands and the nation's Capital.

As almost every family in rural Papua New Guinean cultivates its own food gardens, the betelnut and mustard stick (a pepper plant) are grown in people's backyards. For the Highlanders, all the three products are to be bought since the betel nut and mustard are not grown locally and the lime is processed from corals (seashells).

Below are the traditional methods of lime production.

Step 1:

Harvesting of coral, men and women go to designated locations and harvest coral. Freshly harvested corals are left outdoors to dry for a couple of weeks until it turns white and dry.

Freshly harvested

Sorting dried

Step 2:

With corrugated iron sheet as the base, these women make a fire out of very dry drift hard wood for the dry corals to burn for as long as three hours.

Preparing to fire up the dried corals

Step 3:

After long hours of burning, the coral turns into ashes with no black coal like particles remaining, leaving the burned corals white.

The dried coral being burnt using dry hard wood

Step 4:

After the fire has burnt out or extinguished, it is time to pick out the cooked corals. When cooled down, the corals are stored in a leaf lined basket for two weeks. It is left alone to crumble into powder.

Women picking out baked corals

Step 5:

The women have a basket of lime ready for sieving. Residue pieces of burned corals are thrown away, leaving the whitest powder ready for use. For their own consumption or to sell in faraway lands, lime powder will be sold from 50t to K1 per plastic bag. You can easily buy lime power in any designated public market in PNG.

After sieving the residue of burnt coral are separated from the powder

The final product of lime on the market

Traditional salt production

Sodium chloride (NaCl) commonly known as salt is a chemical compound made of sodium and chloride which has been exceptionally important to humans for thousands of years. Salt's ability to preserve food is a foundation of civilization. It helped to eliminate the dependence on the seasonal availability of food and it traveled over long distances.

However, salt was difficult to obtain, and so it was a highly valued trade item to the point of being considered a form of currency by certain people.

Salt making in the Highlands

In pre-contact times in many areas of PNG, there was a traditional trade in locally produced salt. In the Highlands, villagers' vegetable-based diets were lacking in salt. Protein intake was limited to an occasional glut of pig meat during and after ceremonial occasions. In some areas, salt was extracted from mineral springs, others derived from specific plants.

There are many different ways of producing salt, ranging from salt ponds to burning plants and washing ashes. Described below is one method of making solid salt. The salt produced using this process is very likely high in potassium salts and other substances and relatively low in sodium chloride which is what we call salt.

Process of salt making

1. First they gathered a reed-like plant growing in swamps near their village. After drying it in the sun for several days, they burnt the leaves and stalks in a compact fire. The ash was carefully collected into a banana leaf supported on a simple frame in a slopping position. Water was dribbled onto the ash which flowed through it dissolving the soluble parts of the ash.

2. As the solution came through, it trickled down the spine of the banana leaf and dripped into another banana leaf bent into a cup shaped vessel.

3. The vessel was carefully tied to a stick which was then suspended over a slow fire to evaporate the water. Because the heat of the fire was carefully kept low, the liquid only got warm and the banana leaf retained its strength.

4. After some hours, the liquid solidifies into a greyish mass which was further dried out in the sun for a few more days. In this form, the lump could be stored or traded to neighbouring villages. To add flavour to boiled vegetables, a piece was broken off the lump and added to the cooking pot.

However, those who lived inland used rock salts in the following ways:

1. They cut hollow bamboo tubes and collect droplets of salt water coming out of porous rock bed under 15 metres beneath the Earth surface.
2. The saltwater filled bamboos are then laid out in the sun from morning till sunset.
3. The bamboos are split into halves and the salt crystals are removed and spread onto soft banana leaves. These are then collected and stored into hollow tough skinned gourd.
4. The salts in the gourd are kept high above the fire place. After two to three days the salt is ready to be used.

12.5.5.3 Traditional Dyes and Medicines

Long before supermarkets were forced to give or sell non-plastic bags for customers to carry groceries, the women of PNG were using a **bilum.** A **fibre bilum** is perfectly suited to today's environmentally conscious world, being reusable and biodegradable.

A woman carrying a bilum

Uses of traditional dyes

Originally made from traditional materials, they are now usually made from commercially manufactured materials such as nylon and wool. The original fibre was manufactured from the inner bark of the wild tulip tree and other readily available natural materials.

First**,** the bark is soaked in a stream or the sea for up to 8 months until the material that binds the bark twine together rots. Then the bark is dried and the strands of bark are separated before the woman will rub the bark with her hand on her thigh to produce the strands of twine.

Inner bark of a wild tulip

There were many methods used to traditionally change the colour of the twine fibre. Sometimes the twine was rubbed on a white stone and the result was pure white. Another method was to soak the twine in mud before weaving. Slate stone, orchid bark, roots and jungle grasses were some of the other materials used to produce dye.

Burnt shell was often used to make the dye fast. Some special seashells were also crushed to produce a dark red dye. The end result was often striking especially the bright colours.

A modern day **bilum,** often taking weeks to make, is fashioned from commercially manufactured wool and often brightly coloured nylon strings but nothing beats the feel and pride of owning a **real bilum** made from traditional fibre.

Natural dye

Steps in making natural dye

Step 1:

Collect flowers and seeds as per requirement.

Step 2:

Squeeze flowers on palm of hand to extract dye (lighter colour). Open seed from casing, crash into powder form. Mix into flower (to obtain darker pigment).

Step 3:

Rub mixture into twine (tree bark) with extracted dye.

Step 4:

Dry out the twine for colouring to show out.

Four-o'clock (Mirabilis jalapa) – Pink/yellow/creamy in colour

Another but very simple and popular dye is the Coleus Canina (pictured below) one of the most colourful tropical plants with almost every colour you can think of. The Coleus plant grows in back yard gardens, along main roads, in food gardens or in the cemeteries. Everybody grows some kind of Coleus plant. The Coleus plant dye is also used for decoration during traditional dancing.

The Coleus plant is not only used for extraction of dye but was planted to repel animals such as cats and dogs from gardens. Certain Coleus plant types have strong colour. Women use the leaves to rub into flax fibres as they twist the fibres into ropes for making (b*ilum*) bags as pictured. As they twisted the ropes and rubbed with Coleus leaf, the rope would instantly turn from its natural colour into deep purple, blue and even black. Dark blue, almost black dye from Coleus plant is rubbed into the fibre on this billum.

Coleus Canina

Another strong dye plant is the Blackberry Waffle, pictured below which gives the strongest colour dye.

The Blackberry Waffle Coleus, the

Traditional medicine

In other parts of Papua New Guinea, foreigners have documented medicinal plants which are of importance to the present day discovery of medicinal properties contained in plants. Anthropologist **Hornets Powdermaker** lived with the people of Lesu on the east coast of New Ireland in the early 1930's.

A famous scientist who worked extremely hard to document as many medicinal plants was a chemistry lecturer,Dr. David Holdsworth (1970-1986) of the University of Papua New Guinea. Dr.Holdsworth had conducted studies into the medicinal plants of Papua New Guinea and had found that the plants used in treating the disease in one part of the country are also used in other parts of the country and the same plants are also used in other parts of the world. He collected plants from the New Guinea Island, Papuan Coast and the New Guinea mainlands for his research.

In 2009, World Health Organization published a book written by Dr. Prem Rai of the University of PNG. The book gives information on 126 commonly used medicinal plants in PNG. Mr. David Timi of Wau Ecology Institute in Morobe Province in Papua New Guinea also carries out microbiological screening and chemical investigation of traditional medicinal plants.

Some commonly used medicinal plants found in Papua New Guinea

1. Local Names:
   kokoai (Kokopo, East New Britain)
   lep, eseue (Mendi, Southern Highlands)
   wamala (Aroma, Central Province)
   neng (Mt. Hagen, Western Highlands)
   kuligou (Rigo,Central Province).

   English Names:
   copper leaf; beef steak plant; Joseph's coat

Copper leaf

Common in house yard gardens, often as a hedge or living fence, occasional in rural garden areas. It prefers partial shade or partial sun, with dry to moist soil.

Traditional Uses

Leaves are squeezed into water and the resulting solution drunk to treat diarrhoea and dysentery, while the fresh leaf juice is drunk for laryngitis. Leaves are boiled in water and used to massage the body of a patient with fever.

Fresh young leaves of Copper leaf, Acalypha wilkesiana, Ocimumbasilicum, Hibiscus rosasinensis, and Euodiahortensis are mixed together and placed in a bowl of hot water. Patient is exposed to hot vapour for relief from pneumonia, malaria, pain and fever. Leaves are chewed as first aid for ruptured appendicitis. As abortifacient, fresh shoots are squeezed into water and the solution is drunk.

2. Local Name: **aloe**
   English Names: **aloe, aloe vera**

Traditional Uses

The plant is primarily used as purgative. The sap from the fresh leaves is used to treat cuts, grazes sores and wounds, fungal infections of the skin, and to promote hair growth.

Aloe vera

3. Local Name:
goragora or gorgor (Kuanua, East New Britain), **audu** (Ubili, West New Britain Province).


Goragora

Traditional Uses
Fresh leaves are chewed for sore tongue in children and adults. Leaves are also used for covering wounds and also as a wrapping of other plant materials for heating over a fire. Leaves and roots are used in sorcery preparations.

4. Local Names:
tutu (Boku, Central Province),
tutua (Rigo, Central Province),
foro (Brown River, Central Province),
tutuwana (Darubia, Normanby Island,
nhopu (Awaiama, Milne Bay).

English Name:
Hard milkwood


Hard milkwood

Traditional Uses
Decoction of the leaf is drunk to cure bad cough and provide relief from asthma. Sap squeezed from the fresh stem and mixed with water is also used for bad cough. The stem sap is used externally on tropical ulcers.

A hot water extract of the leaf is used as an abortifacient. Decoction from bark is taken orally for malaria. Fresh young leaves are boiled in water, solution cooled and drunk to treat cold, cough, fever and malaria. Plant is also reportedly used as an anti-fertility agent.

5. Local Names:
sow sop (Kebuguili, MilneBay)
kahiloko (Tawala, Milne Bay)

English Names:
Soursop, prickly custard apple


Soursop

Traditional Uses
Leaves are heated over a fire and inhaled to give some relief to an upset stomach. The heated leaves are pressed against the stomach and stroked downwards to provide relief from stomach ache.

6. Local Names:
kapiak (Pidgin)
metkul (Manus Island)
uda (Goodenough Island, MilneBay)
dacwa (Dobu Island, Milne Bay)
gunu (Rigo, Central Province)
nahua (Vanapa, Central Province)

English Name: **Bread fruit**

Bread fruit

Traditional Uses
Crushed leaves are applied on to boils and swollen groins. The sap is diluted and drunk to treat diarrhoea and dysentery. The sap is also used on sores, boils and abscesses. Leaves of A. altillis and Carica papaya are crushed with lime until yellow and the mixture rubbed on to a swollen groin.

A paste made from the young leaves is applied to sore eyes or eyes filled with dust. Decoction made from the bark is used to treat chest pains. Root decoction is used in shortness of breath, pneumonia, and breathing disorder. The dried rod-like flowerings are used as mosquito coils; they are burnt and the resulting smoke wards off the mosquitoes.

7. Local Names:
Lombo (Pidgin)
ule hekini (Vanapa, Central Province)
kodukarava (Rigo, Central Province).

English Names:
chilli pepper, red pepper, paprika, cayenne pepper

Chilli pepper

Traditional Uses

The ripe, red fruit is squeezed and rubbed onto body pains, especially chest pain, to act as an analgesic. The fruit and leaves are made into poultices and used to treat ulcer and aching heads. The juice from pounded fruit is cooked and added to food to treat pneumonia, which develops following an attack of malaria. Mature fruits are soaked into cold water and solution drunk to treat asthma.

8. Local Names:
ki'ikata (Siwai, Bougainville, North Solomons Province) **kerowai** (Buin, North Solomons Province) **maa** (Wapenamanda, Enga)
ina (Yabiufa, Eastern Highlands)

English Names:
taro, wild taro, elephant yams, coco-yam

Taro

Traditional Uses

Leaves are heated over a fire and applied directly to boils. Tuber is used for sores and burns. The tuber of a short-leafed variety of taro is heated over a fire, peeled and taken internally to relieve diarrhoea. The green stem of the wild taro is used to kill intestinal worms in the body. The leaves of wild taro are heated over a fire and massaged on swollen breasts.

9. Local Names:
kaukaul (Kokopo, East New Britain)
tea (Vanapa, Central Province)
gigi (Kokopo, East New Britain Province)

English Names**:**
lemon grass, ginger grass, citronella grass

Lemon grass

Traditional Uses

Crushed leaves are boiled and steam inhaled for cold and cough. Leaves are boiled in water and solution drunk to treat sore throats and upper respiratory tract infections. Patients with high fever, usually due to malaria, are bathed with the decoction prepared from the leaf. Whole plant is washed, mashed and wrapped in a banana leaf and heated over a fire. The oily juice is squeezed out and administered orally for treatment against constipation, flu, headache and stomach ache. To improve eyesight, leaves are boiled in water, cooled and eyes bathed with the solution.

10. Local Names:
kumumosong (pidgin)
kagua (Raluana, East New Britain)
surosai (Siwai, Bougainville)

English Name:
plentiful fig

Plentiful fig

Traditional Uses

Unripe fresh fruits or fresh leaf mixed with root are chewed to relieve stomach ache. Sometimes stomach is massaged with fresh leaves to relieve pain. Leaf is eaten as a poison antidote to excrete toxins. The scrapings from the bark are chewed together with lime, and the mixture is applied on a boil. Fresh fruit latex is used to treat a boil.

11. Local Names:
salat (Pidgin)
nik (Mendi, Southern Highlands)

nondi (Ialibu,Southern Highlands)

English Name:
stinging nettle

Stinging nettle

Traditional Uses

The nettle-like leaves are used externally on the body to alleviate body pains, fatigue, headache, stomach ache, joint and muscle pains, and bruises. A leaf, with its lower surface held towards the body, is gently stroked over the site of pain. As leaves are rubbed on aching area, a stinging sensation is felt at first, but numbness and anaesthesia eventually develops. For treatment of asthma, leaves are rubbed on the chest.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 7 **40 minutes**

Answer the following questions:

QUESTION 1

What is the chemical name of lime that is produced locally?

QUESTION 2

Generally how many steps are there in the lime production?

QUESTION 3

What was one of the purposes for traditional salt?

QUESTION 4

How many days does the drying process take before the salt was ready for consumption?

QUESTION 5

What chemical compound is found in common table salt?

Thank you for completing your learning activity 7. Check your work. Answers are at the end of this module.

12.5.6 Industrial chemical pollution

Industrial pollution happens in many ways. It contaminates many sources of drinking water, releases unwanted toxins into the air and reduces the quality of soil all over the world. Major environmental disasters have been caused due to industrial pollutions, which have yet to be brought under control.

What is theirs is mine ... the open cut mine and process plant that makes up Porgera mine in Papua New Guinea.

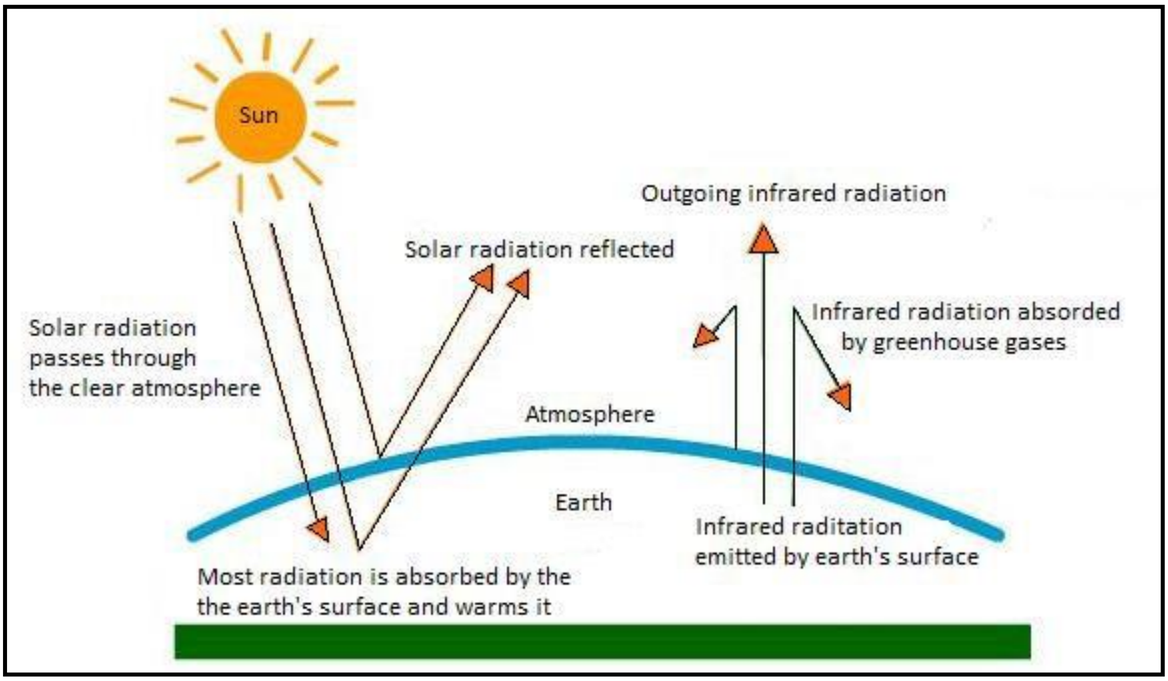
Environmental pollution is the release of chemical waste that causes harmful effects on the environment. Environmental pollution is often divided into pollution of water supplies, the atmosphere, and soil.

While much pollution is produced by the chemical industry, domestic sources include human waste and automobile exhaust. Physical sources, such as noise and light pollution are important; people most often notice the damage of chemical pollution on animals and plant life. These chemicals can react with tissues in the body and change the structure and function of the organ, cause abnormal growth and development of the individual, or bind with genetic material of cells and cause cancer.

On the other hand, individuals and chemical and petroleum companies contribute to the pollution of the atmosphere by releasing inorganic and organic gases and particulates into the air. The atmosphere is a paper-thin layer of gas (representing 1 percent of the mass of Earth) that protects the planet from damaging cosmic and ultraviolet radiation, contains life-giving oxygen, and allows the efficient cooling of the planet.

12.5.6.1 Greenhouse effect

Greenhouse Effect is a natural process that warms the Earth. In fact, it is quite necessary for our survival. Gases in the atmosphere, like water vapour (clouds), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) act as a natural blanket by preventing the sun's heat energy from radiating back into space, so much like a greenhouse trapping the sun's energy to warm someone's plants even in the middle of a cold day. The natural greenhouse effect helps warm the Earth's surface by as much as 33°C. Without it, our planet would be too cold for humans to survive on.



The concept of green house effect

The diagram illustrates the basic processes behind the greenhouse effect. As the sun's energy hits the Earth, some of that energy is absorbed by the earth's crust and oceans, warming the planet. The rest of the energy is radiated back toward space as infrared energy. While some of this infrared energy does radiate back into space, some portion is absorbed and re-emitted by water vapour and other greenhouse gases in the atmosphere. This absorbed energy helps to warm the planet's surface and atmosphere just like a greenhouse.

Factors affecting the greenhouse effect

There are three main factors that directly influence the greenhouse effect:

(1) total energy from the sun, which depends on the earth's distance from the sun and on solar activity,

(2) chemical composition of the atmosphere (what gases are present and in what concentrations), and

(3) albedo, the ability of the earth's surface to reflect light back into space.

The only factor that has changed significantly in the last 100 years is the chemical composition of the atmosphere resulting from human activity.
Human activity has changed the concentration of certain greenhouse gases in the atmosphere since the beginning of the Industrial Revolution, around 1750.

Although the greenhouse effect is a naturally-occurring process, humans have recently amplified the natural effect by increasing the concentration of CO_2 and other greenhouse gases in the atmosphere (primarily through fossil fuel use in the energy and transportation sectors).

The following percentage contributing to the greenhouse effect on Earth are four major gases:

- water vapour (H_2O) 36–70%
- carbon dioxide (CO_2) 9–26%
- methane (CH_4) 4–9%
- ozone (O_3) 3–7%

There are several other gases that contribute to the greenhouse effect. Most prominent among these mentioned above are nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). Each gas is present in the atmosphere at a different concentration. In addition to knowing the concentration of the greenhouse gas, it is important to understand that each gas has different relative greenhouse efficiency. In other words, some gases are better at absorbing solar radiation than others, and therefore have a greater overall impact on the greenhouse effect.

It is not physically realistic to assign a specific percentage to each gas because the absorption and emission bands of the gases overlap (hence the ranges given). The major non-gas contributor to the Earth's greenhouse effect, clouds, also absorbs and emits infrared radiation and thus has an effect on radioactive properties of the atmosphere.

The Earth gets energy from the sun in the form of sunlight. The Earth's surface absorbs some of this energy and heats up. The Earth cools down by giving off a different form of energy, called **infrared radiation**. But before all this radiation can escape to outer space, the greenhouse gases in the atmosphere absorb some of it, which makes the atmosphere warmer.

As the atmosphere gets warmer, it makes the Earth's surface warmer, too. If it were not for greenhouse gases trapping heat in the atmosphere, the Earth would be a very cold place. Because of the simple fact that, greenhouse gases keep the Earth warm through a process called the greenhouse effect.

12.5.6.2 Environmental effects of persistent organic pollutants (DDT and CFC)

Persistent Organic Pollutants (POP) are a set of toxic chemicals that are persistent in the environment and able to last for several years before breaking down. These POPs are circulated globally and chemicals released in one part of the world can be deposited at far distances from their original source through a repeated process of evaporation and deposition. Therefore, this makes it very hard to trace the original source of the chemical. POPs are **lipophilic**, meaning that they accumulate in the fatty tissue of living animals and human beings. In fatty tissue, the concentrations can become magnified by up to 70,000 times higher than the background levels. As you move up the food chain, concentrations of POPs tend to increase so that animals at the top of the food chain such as fish, predatory birds, mammals, including humans tend to have the greatest concentrations of these chemicals, and therefore are at the highest risk from acute and chronic toxic effects.

Effects

We now know that POPs are poisonous and exposure can take place through diet, environmental exposure, or accidents. They negatively affect humans, plant and animal species and natural ecosystems both in close ranges and at significant distances away from the original source of discharge.

Exposure to POPs in humans can cause several negative health effects including:

- Death
- Cancers
- Allergies
- Hypersensitivity
- Developmental changes
- Damage to the central and peripheral nervous systems
- Disruption of the endocrine, reproductive, and immune systems

The negative effects of pesticides in the marine and coastal environments include changes in reef community structure, such as decreases in live coral cover and increases in algae and sponges and damage to seagrass beds and other aquatic vegetation from herbicides.

General facts about Persistent Organic Pollutants (POPs)

- Persistent organic pollutants (POPs) are organic compounds that resist environmental breakdown via biological, chemical, and photolythic processes, some taking as long as a century to degrade.
- POPs exposed to the environment are proven to travel long distances from their origin via wind and ocean currents. Precipitation has been found to carry PCBs (polychlorinated biphenyls).
- POPs therefore can be found globally, even in areas such as the Arctic and Antarctica, far from their source. Human exposures in certain Arctic areas are among the highest worldwide.
- POPs bio-concentrate as they move up through the marine food chain and accumulate in the fatty tissues of living organisms at higher trophic levels.
- Although many countries have banned these chemicals, they remain stockpiled, are produced or used illegally, or, because of lengthy half-lives, they continue to exist in soil, or other environmental media.
- The United Nations is currently considering the elimination or reduction of twelve of some of the most damaging POPs through the formulation of an international treaty. Nine of the POPs chemicals under consideration are pesticides that have been extensively used in both developed and developing countries.

General health effects of Persistent Organic Pollutants (POPs)

- POPs can disrupt the endocrine, reproductive, and immune systems. The developing brain and nervous system may be most vulnerable.
- POPs are capable of causing behavioural problems, cancer, diabetes and thyroid problems.
- The health of marine mammals has deteriorated significantly over the past two or so decades. Many of the newly emerging and resurgent diseases are associated with immune system dysfunction and suggest a broad environmental distress syndrome.

- Marine mammals present a metabolic imbalance, so they are the most vulnerable organisms with respect to long-term toxicity of man-made chemicals such as organochlorines. Cetaceans (whales and dolphins) are known to have a poor ability to detoxify organic pollutants because they lack isozymes that are required to detoxify DDT and PCBs.

DDT – a synthetic pesticide

- DDT is a toxicant.
- It has a half life of 2-15 years, and is immobile in most soils.
- Breakdown products in the soil environment are DDE and DDD, which are also highly persistent and have similar chemical and physical properties.
- Banned in the US for most uses in 1972.
- Subsequently banned for agricultural use worldwide, but is still used to a limited extent in mosquito control in certain parts of the world.
- DDT and its metabolic products DDE and DDD magnify through the food chain.
- DDT bio-concentrates significantly in fish and other aquatic species, leading to long-term exposure to high concentrations.
- The EPA, in 1987, classified DDT as a probable human carcinogen.

DDT (dichlorodiphenyltrichloroethane) is a colourless, crystalline, tasteless and almost odourless organochloride known for its insecticidal properties. DDT has been formulated in almost every conceivable form, including solutions in xylene or petroleum distillates, emulsifiable concentrates, water-wettable powders, granules, aerosols, smoke candles and charges for vaporizers and lotions.

DDT's insecticidal actions were discovered by a Swiss chemist, Paul Hermann Müller in 1939. It was then used in the second half of World War II to control malaria and typhus among civilians and troops. After the war, DDT was made available for use as an agricultural insecticide and its production and use duly increased.

The book Silent Spring by American biologist Rachel Carson questioned the logic of releasing large amounts of potentially dangerous chemicals into the environment without a sufficient understanding of their effects on ecology or human health including DDT and other pesticides had been shown to cause cancer and that their agricultural use was a threat to wildlife, particularly birds. A worldwide ban on its agricultural use was formalised under the Stockholm Convention, but its limited use in disease vector control continues to this day and remains controversial, because of its effectiveness in reducing deaths due to malaria, which is countered by environmental and health concerns.

Properties and chemistry

DDT is highly **hydrophobic**, it is nearly insoluble in water but has good solubility in most organic solvents, fats and oils. DDT does not occur naturally, but is produced by the reaction of chloral (CCl_3CHO) with chlorobenzene (C_6H_5Cl) in the presence of sulphuric acid as a catalyst.

Chlorofluorocarbons (CFC)

Chlorofluorocarbons or CFCs (also known as Freon) are non-toxic, non-flammable and non-carcinogenic. They contain fluorine, carbon and chlorine atoms. The 5 main CFCs are:

- CFC-11 (trichlorofluoromethane - $CFCl_3$),
- CFC-12 (dichloro-difluoromethane - CF_2Cl_2),
- CFC-113 (trichloro-trifluoroethane - $C_2F_3Cl_3$),
- CFC-114 (dichloro-tetrfluoroethane - $C_2F_4Cl_2$), and
- CFC-115 (chloropentafluoroethane - C_2F_5Cl).

CFCs are widely used as coolants in refrigeration and air conditioners, as solvents in cleaners, particularly for electronic circuit boards, as a blowing agents in the production of foam (for example fire extinguishers), and as propellants in aerosols. Indeed, CFCs have made possible much of the modern lifestyle of the second half of 20^{th} century. Man-made CFCs however, are the main cause of stratospheric ozone depletion. CFCs have a lifetime in the atmosphere of about 20 to 100 years, and consequently one free chlorine atom from a CFC molecule can do a lot of damage, destroying ozone molecules for a long time. Although emissions of CFCs around the developed world have largely ceased due to international control agreements, the damage to the stratospheric ozone layer will continue well into 21^{st} century.

What are CRC's used for?

The properties of CFCs make them useful for a variety of commercial and industrial purposes:

1) as a propellant in aerosol sprays (now banned in the US and Europe).
2) in refrigeration and air conditioning systems.
3) in foams.
4) in cleaning solvents.
5) in electrical components.

Where does CFC's come from?

Most CFCs are released into the atmosphere through the use of aerosols containing them and as leakages from refrigeration equipment. Other releases may occur from industry producing and using them and other products containing them. There are not thought to be any natural sources of CFCs to the environment.

How it affects the environment?

CFCs are unlikely to have any direct impact on the environment in the immediate vicinity of their release. However, as VOCs, they may be slightly involved in reactions to produce ground level ozone, which can cause damage to plants and materials on a local scale.

At a global level however, releases of CFCs have serious environmental consequences. Their long lifetimes in the atmosphere mean that some end up in the higher atmosphere (stratosphere) where they can destroy the ozone layer, thus reducing the protection it offers the earth from the sun's harmful UV rays. CFCs also contribute to Global Warming (through the Greenhouse Effect). Although the amounts emitted are relatively small, they have a powerful warming effect (a very high Global Warming Potential).

How its exposure affects human health?

Chlorofluorocarbons enter the body primarily by inhalation of air containing chlorofluorocarbons, but can also enter by ingestion of contaminated water, or by dermal contact with chlorofluorocarbons. Inhalation of high levels of chlorofluorocarbons can affect the lungs, central nervous system, heart, liver and kidneys.

Symptoms of exposure to chlorofluorocarbons can include drowsiness, slurred speech, disorientation, tingling sensations and weakness in the limbs. Exposure to extremely high levels of chlorofluorocarbons can result in death. Ingestion of chlorofluorocarbons can lead to nausea, irritation of the digestive tract and diarrhoea. Skin contact with chlorofluorocarbons can cause skin irritation and dermatitis.

Chlorofluorocarbons are involved in the destruction of the stratospheric ozone layer resulting in increased exposure to UV radiation which is known to cause skin cancer. Moreover, exposure to chlorofluorocarbons at normal background levels is unlikely to have any adverse effect on human health.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 8 **20 minutes**

Answer the following questions:

Circle the correct answer.

QUESTION 1

What are greenhouse gases? They are gases that

A. harm the Earth.

B. humans exhale when they breathe.

C. help the Earth stay cool despite the sun's rays.

D. trap some of the energy leaving the Earth’s surface.

QUESTION 2

Which of the following groups are all greenhouse gases?

Carbon dioxide, methane,

A. CFCs, and nitrous oxides.

B. nitrous oxides, and oxygen.

C. CFCs, and helium.

D. nitrous oxides, and helium.

QUESTION 3

Which statement best describes the 'Greenhouse Gas Effect'?

Greenhouse gases in the atmosphere

A. cause sunlight to scatter so that the sky appears blue.

B. trap the sun's energy and use it to warm up the Earth.

C. lead to air pollution which is harmful to the environment.

D. trap some of the energy leaving the Earth's surface, therefore maintaining warm temperatures essential for life on Earth.

4. Name at least 3 sources of greenhouse gases.

i) ____

ii) ____

iii) ____

5. How does marine pollution occur?

____

____

____

6. What is the effect of DDT on human?

____

____

____

Thank you for completing your learning activity 8. Check your work. Answers are at the end of this module.

REVISE WELL USING THE MAIN POINTS ON THE NEXT PAGE.

SUMMARY

You will now revise this module before doing Assessment 6. Here are the main points to help you revise. Refer to the module topic if you need more information.

- Crude oil, one of the natural resources of PNG, is a complex mixture of hydrocarbons and other compounds. It varies from a light coloured liquid to thick, dark oils.
- Petroleum products are produced from the processing of crude oil.
- Carbon (C) is often referred to as the building block of life. It has many allotropes but the three most well-known are amorphous carbon, diamond, and graphite.
- Most of the carbon compounds are essential for life.
- Fossil fuels are any class of materials of biological origin found in the Earth's crust that can be used as a source of energy. This includes coal, petroleum, natural gas, oil shales, bitumens, tar sands, and heavy oils.
- Petroleum projects in PNG are covered by Petroleum Prospecting Licences (PPLs).
- Polymerisation is the scientific process for production of plastics. They are mostly produced from petrochemicals but researchers are investigating other sources of raw materials. Plastics can be processed using the thermoset or thermoplastic type.
- The use of plastic has brought about environmental and human concerns. However, today it is addressed with growing awareness by using biodegradable plastics.
- Metals and compounds of metals are extracted from rocks called ores. In PNG, metals mined include copper, gold, nickel, cobalt and some lead and zinc.
- Mining operations include OK Tedi, Porgera, Lihir, Misima, Tolukuma, RamuNico, and Simberi. Mining brings about environmental consequences including erosion, formation of sink holes, loss of biodiversity, and contamination of soil, groundwater, and surface water. Six of the 12 world's water suffering the greatest risks from dumping of mine wastes is in PNG.
- Tailings are the wastes from mine processing and can contain as many as three dozen dangerous chemicals including arsenic, lead, mercury, and cyanide.
- Ethanol is produced through fermentation and distillation processes resulting in ethanol by-products of alcohol products such as wine and distilled spirits like whiskey, vodka, and gin.
- Oil extracted from fruits, nuts and seeds are industrially used in cooking, soap making, or as ingredients in other foods such as baked or fried foods.
- Saponification is the chemical reaction when a vegetable oil or animal fat is mixed with a strong alkali forming soap and glycerine.
- Bio-diesel, a renewable, clean-burning fuel used as an alternative for diesel engines, is produced by chemically reacting a vegetable oil or fat with an alcohol.
- Biogas, produced by the breakdown of organic matter in the absence of oxygen, is a renewable source of energy like solar and wind energy.
- Traditional medicine using indigenous plants for treatment of diseases and traditional chemistry, such as lime and salt production and use of traditional dyes, have been associated with PNG for thousands of years.

- The faces of industrial pollution are found in the water we use for drinking and washing, the toxins in the air, the quality of soil and increased natural and environmental disaster which happen with greater ferocity and more destructive than ever before.
- Both ethanol and methanol are liquids that sound alike and have many similar physical characteristics including looks and smell.
- Ethanol is at least safe to consume in moderate amounts and is found in all alcoholic beverages whereas methanol must be avoided at all cost for even small doses can cause blindness or even death.
- Ethanol is used for alcohol, cleaning, solvents, and fuel while methanol is also found in fuels and solvents and is also used to make other chemical products.
- Oil and natural gas are both fossil fuels.
- Oil is found only in the ground, whereas gas can also be produced by decaying organic matter.
- Oil and gas are both used for heating, transportation, and electricity generation, but in slightly different ways.
- Gas is better overall for the environment than oil, especially in terms of greenhouse gas emissions.
- Carbon is the chemical basis for most molecules that are important to maintaining life on earth.
- The carbon cycle is the process in which carbon is exchanged between all parts of Earth and its living organisms.
- The different stages of the carbon cycle include photosynthesis, respiration and decomposition.

Answers to Learning Activities 1- 8

Learning Activity 1

1. Carbon dioxide is the form that carbon takes in our atmosphere, and it is crucial for maintaining life on Earth. However, a recent source of carbon dioxide in the atmosphere – burning of fossil fuels by humans–has greatly increased the amount of carbon dioxide in the atmosphere. This increased level of carbon dioxide threatens to upset the natural carbon balance previously maintained by photosynthesis, respiration and decomposition. This extra carbon dioxide acts like a blanket in the atmosphere, perhaps causing global warming.

2. Photosynthesis

   The radiation from the sun is the only source of outside energy available to our planet. However, some living organisms (such as animals) cannot use the Sun directly to produce food and to keep themselves alive. Consequently, we are all dependent on plants that have special ability to use the sun's radiation. Plants turn sunlight into food by combining the sun's energy with carbon, which plants absorb from the atmosphere in the form of carbon dioxide. Carbon is the key element for photosynthesis, which provides food for all living things on Earth, making it the primary producer.

   Respiration

   While photosynthesis is the way the sun's energy is combined with carbon to produce food, respiration is the way that food is turned into energy for use by a living organism. All of the food animals eat is based on carbon atoms (humans can eat carbohydrates, proteins and lipids). Animals use oxygen to convert this food into energy they can use, and to maintain a steady supply of carbon atoms that are necessary for building animal cells. Respiration also returns carbon dioxide back to the atmosphere as a waste product, where plants can reabsorb it in the process of photosynthesis.

   Decomposition

   While an organism is alive, it acts as a "carbon sink," or as a storage room for carbon atoms, because so many carbon atoms are being used to build the organism's skin, bark, toenails or leaves. However, as soon as an organism dies, these valuable carbon atoms begin to be returned to the environment, where they can be used by other organisms. Decomposers are tiny microorganisms that live in soil and water, and they consume organic waste matter and dead organisms, returning the carbon back into the atmosphere in the form of carbon dioxide.

Learning Activity 2

1. W : light gasoline
   Y : gas oil

2. 7

3. 4 PPLs

4. When crude oil is passed through a fractionating column, the different fractions separate out according to their boiling point.

Learning Activity 3

1. (i) Polymers are very large molecules (called macromolecules). Each polymer molecule is a long chain of atoms mainly carbon. Polymers are made from many smaller molecules, called monomers.
   (ii) A monomer is an atom or small molecule that may bind chemically to other monomers to form a polymer (means many parts).
   (iii) Polymerisation is the process (chemical reaction) that turns monomers into polymers.

2. (i) Compression molding is one of the oldest methods used for converting polymers into useful materials. It uses pressure to force the plastic into a certain shape. One half of a two-piece mold is filled with plastic and then the two halves of the mold are brought together and the plastic is melted under high pressure.
   (ii) Extrusion uses a device called an extruder, forces softened plastic through a shaped die from which it may emerge in almost any form, including a circular rod or tube, and a wide, flat sheet. The driving force is supplied by a screw which provides constant pressure. All extrusion products have a regular cross section. A variation on this method is extrusion blow molding, in which a plastic tube produced by extrusion is sealed around a blowing tube and expanded to the shape of a mold with compressed air.
   (iii) Injection molding involves one or more extruders which force melted plastic into a cold mold where it is allowed to set to the required shape. An adaptation of this method is injection blow molding which is used to make plastic pop bottles. A thick- walled plastic tube is initially injection-molded around a blowing stick and is then transferred to a blowing mold. The tube is reheated and expanded to the shape of the mold by passing air down the blowing stick.

(iv) Calendaring which produces plastic sheets and transfer molding, in which softened plastic is forced by a ram into a mold.

Learning Activity 4

1. D

2. B

3. A solid element or compound which occurs naturally in the Earth's crust is called a mineral. A mineral which contains a high enough percentage of a metal economic extraction is called a metal ore.

4. The method used to extract a metal from its ore depends on where the metal is in the reactivity series located in the Periodic Table.

A metal above carbon in the reactivity series (potassium, sodium, lithium, calcium, magnesium and aluminium) can be extracted by electrolysis.
Extraction of the metal from its ore involves reduction of the metal ions. Electrons are able to reduce any metal ion.
metal ions + electrons $\longrightarrow$ metal atoms (reduction).
non-metal ions - electrons $\longrightarrow$ non-metal atoms (oxidation).

Metals above carbon in the reactivity series could also be reduced by reaction with a more reactive metal but this is more expensive than electrolysis and is only used on a commercial scale for the extraction of titanium.

A metal below carbon in the reactivity series (zinc to silver) may be extracted by heating the metal ore with carbon.
During the reaction, the metal in the ore is displaced from its non-metal anion because carbon is more reactive than the metal. Carbon is used because it is cheap and readily available (coke and charcoal are both carbon). This form of extraction is less expensive than electrolysis. The metal in the ore is said to be reduced by reaction with carbon.

Gold and platinum occur in the Earth as native metal. This means that they are found as the element, not the compound, and so do not need to be reduced. Silver and copper may also be found as native metal.

Learning Activity 5

1. (i) A primary alcohol which melts at - 117.3°C and boils at 78.5°C
   (ii) Burns in air with a blue flame, forming carbon dioxide and water

2. (i) Ethanol C_2H_5OH
   (ii) Methanol CH_3OH

3. Methanol must be avoided at all cost for even small doses can cause blindness or even death.

4. (i) Light, volatile, flammable liquid with a distinctive odour similar to ethanol or drinking alcohol.
   (ii) Burns in air forming carbon dioxide and water.

5. B

Learning Activity 6

1. D

2. B

3. D

Learning Activity 7

1. Calcium carbonate

2. 5 steps

3. To preserve seasonal food

4. 2 to 3 days

5. Sodium chloride

Learning Activity 8

1. D

2. A

3. D

4. (i) Extensive use of chemicals in agriculture.

   (ii) Industrial waste
   (iii) Use of chemicals
   (iv) Deforestration
   (v) Use of aerosols

5. Marine population occurs when harmful chemical particles, industrial, agricultural and residential waste enters the oceans.

6. DDT can cause genotoxicity in humans.

REFERENCES

Brady, James E. and Sense, Fred.*Chemistry: Matter and Its Changes,Fourth Edition,* 2004, John Wiley and Sons, Inc.
Brady, James E. and Sense, Fred.*Chemistry: Matter and Its Changes,Fifth Edition,* 2009, John Wiley and Sons, Inc.
http://www.businessdictionary.com/definition/biodegradable
http://www.biodiesel.org/what-is-biodiesel/biodiesel-basics
http://www.economywatch.com/renewable-energy/advantages-of-biogasl
McClean,Jean.*Chemistry*,1998, Addison Wesley Longman China Limited,
Singapore Malone, Leo J.*Basic Concepts of Chemistry (7th Edition)*, 2004,
John Wiley and Sons, Inc.
Malone,Leo J. andDolter,Theodore O.*Basic Concepts of Chemistry (8th Edition),* 2010, John Wiley and
Sons, Inc.
Olmsted, John III and Williams, Gregory M.*Chemistry, Fourth Edition*, 2006, John Wiley and Sons, Inc. Pratt, Charlotte W. and Cornelly, Kathleen.*Essential Biochemistry, First Edition,* 2004, John Wiley and Sons, Inc.

FODE PROVINCIAL CENTRES CONTACTS

PC NO.	FODE PROVINCIAL CENTRE	ADDRESS	PHONE/FAX	CUG PHONE (COORDINATOR)	CUG PHONE (SENIOR CLERK)
1	ALOTAU	P. O. Box 822, Alotau	6411343/6419195	72228130	72229051
2	BUKA	P. O. Box 154, Buka	9739838	72228108	72229073
3	CENTRAL	C/- FODE HQ	3419228	72228110	72229050
4	DARU	P. O. Box 68, Daru	6459033	72228146	72229047
5	GOROKA	P. O. Box 990, Goroka	5322085/5322321	72228116	72229054
6	HELA	P. O. Box 63, Tari	73197115	72228141	72229083
7	JIWAKA	c/- FODE Hagen		72228143	72229085
8	KAVIENG	P. O. Box 284, Kavieng	9842183	72228136	72229069
9	KEREMA	P. O. Box 86, Kerema	6481303	72228124	72229049
10	KIMBE	P. O. Box 328, Kimbe	9835110	72228150	72229065
11	KUNDIAWA	P. O. Box 95, Kundiawa	5351612	72228144	72229056
12	LAE	P. O. Box 4969, Lae	4725508/4721162	72228132	72229064
13	MADANG	P. O. Box 2071, Madang	4222418	72228126	72229063
14	MANUS	P. O. Box 41, Lorengau	9709251	72228128	72229080
15	MENDI	P. O. Box 237, Mendi	5491264/72895095	72228142	72229053
16	MT HAGEN	P. O. Box 418, Mt. Hagen	5421194/5423332	72228148	72229057
17	NCD	C/- FODE HQ	3230299 ext 26	72228134	72229081
18	POPONDETTA	P. O. Box 71, Popondetta	6297160/6297678	72228138	72229052
19	RABAUL	P. O. Box 83, Kokopo	9400314	72228118	72229067
20	VANIMO	P. O. Box 38, Vanimo	4571175/4571438	72228140	72229060
21	WABAG	P. O. Box 259, Wabag	5471114	72228120	72229082
22	WEWAK	P. O. Box 583, Wewak	4562231/4561114	72228122	72229062

FODE SUBJECTS AND COURSE PROGRAMMES

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics – General / Advance
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and course.

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

GRADES 11 & 12 COURSE PROGRAMMES			
No	**Science**	**Humanities**	**Business**
1	Applied English	Language & Literature	Language & Literature/Applied English
2	General / Advance Mathematics	General / Advance Mathematics	General / Advance Mathematics
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry and Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:

You must successfully complete 8 courses: 5 compulsory and 3 optional.