4. Chemical industries and productions

At the end of this chapter, you will be competent to:

- Investigate the natural resources used as raw material, in chemical industries and productions, in Sri lanka.
- Investigate the application of chemistry in the
  - * Limestone based Industry
  - * Salt Industry
- Production of industrial gases and,
- Production related to plant raw materials.

4.1 Sources of natural resources that are used in local industries.

Many end products used by us are made using natural raw materials. These natural resourses are obtained from the land, ocean, atmosphere and plants around us.

- **Land**

Land consists of different types of rocks, minerals and soil. Soil is formed by the weathering of rocks. Minerals, rocks and soil are very valuable resources for many industries and products in our country. Some of the important resourses and the locations they are found are given in Table 4.1.

Table 4.1

Areas	Resources
Kankasanthurai	Limestone/Coral
Jaffna	Limestone
Pulmudai	Mineral Sand/Coral
Talava	Graphite
Seruwila	Copper/magnasite
Elahera	Dolomite/Quartzite/Gems/Feldspar
Marawila/Nattandiya/Madampe	Silica sand
Bogala	Graphite
Kochchikade	Clay for tiles and bricks
Rupaha	Dolomite/Quartzite/Marble/Quartz
Ratnapura	Gems/Mica/Quartz
Meetiyagoda	Keolin/Coral/Quartz/Dolomite
Matale & Badulla	Feldsper
Eppawala	Apatite
Boralesgamuwa	Clay
Hambantota	Mineral Sands/Dolomite/Quartz

Assignment 1

Find out and make a list of other areas of the country (not given in the list) where raw materials for different chemical industries are found.

You have already learnt about the three types of rocks, such as the **igneous, sedimentary and metamorphic** rocks. Granite which is an igneous type is common in Sri Lanka. Granite contain the minerals **quartz, feldspar and mica.** These minerals are known as **essential minerals.** Gravel and sand are formed by the weathering of quartz, while clay is formed from weathering feldspar.

In addition to these, Sri Lanka is endowed with huge amounts of industrial mineral resources that include **apatite, calcite, clay, graphite, ilmenite, kaolin, mica, quartz, rutile, silica sand and zircon.** Minerals are naturally occuring inorganic substances with a definite composition and physical properties.

Fig. 4.1. Some types of rocks and minerals found in Sri Lanka

Some of the main rocks and minerals used in industries in Sri Lanka are given in Table 4.2

Table 4.2

Rock or Mineral	Industries where it is used
Apatite	Phosphate Fertilizer industry
Calcite	Tooth paste, Anti acids, Chewing gum, Glue and Soap
Clay	Cement industry, Pottery industry, terra-catta
Dolomite	Fertilizer industry
Feldspar	Ceramics industry, fancy goods
Graphite	Pencil industry, Lubricants, Electrodes
Ilmenite	Pigment production, High quality paint industry
Kaolin	Ceramic industry,Glossy paints, wall fitters
Mica	Manufacture of capacitors, Insulators for high voltage electrical equipment
Quartz	Porcelain industry
Rutile	Production of pigments
Silica sand	Glass industry
Zircon	Gem industry, ceramic industry
Granite and other igneous rocks	Building construction
Monazite	Gem industry
Limestone	Cement industry/Lime stone industry/ Bleaching powder
Cement clay	Cement industry
Shell coral	Production of lime and bleacing powder
Salt	Flavouring food, caustic soda industry

Sri Lanka is endowed with glittering gems too. That is why Sri Lanka is known as 'Ratna Deepa' which means "The island of Gems".

- **Ocean**

Sri Lanka is surrounded by the sea which is a major source of many important resources. Some of them are salts, sand, ilmenite and common salt. Sea water has a salinity of about 3.5%. This means that every 1kg of sea water (brine) contains 35g of salt dissolved in it.

The percentages of the salts present in this 3.5% are given in Table 4.3.

Table 4.3

Name of compound	%	Formula
Sodium chloride	77.75	NaCl
Magnesium chloride	10.09	$MgCl_2$
Magnesium sulphate	4.73	$MgSO_4$
Calcium sulphate	3.60	$CaSO_4$
Potassium sulphate	2.46	K_2SO_4
Calcium carbonate	0.35	$CaCO_3$
Magnesium bromide	0.21	$MgBr_2$

Almost all these compounds are resources for various kinds of industry.

- Common salt

Sodium chloride is the common salt used in day to day life. It is used to enhance food flavour and also in several industrial productions. It is used to produce sodium hydroxide, sodium carbonate, sodium bicarbonate and bleaching liquids.

- wMinerals

Valuable minerals can also be obtained from sea. Copper, nickel, mangnese etc. are found lying on the ocean floor. In addition to mineral deposits, ocean contains other types of riches.

- Sand

Sand is another mineral resource. Mineral sands contain ilmenite, rutile, zircon, garnet, monazite and silimenite. Ilmenite, monazite and zircon are found in the beach sand deposits along the coast. But sufficiently concentrated deposits are found only in some areas. eg. Pulmoddai north of Trincomalee, Kaikawela near Induruwa, Polkotuwa near Beruwala, north of Negombo and Kudrimalai in Mannar. Garnet is found in Dewinuwara, Thangalla and Hambanthota.

- **Atmosphere**

Atmosphere is the blanket of air which surrounds the earth. Atmosphere can be divided into several layers.

Of these layers, the layer which contains the resource materials that we concern here is the troposphere. Troposphere starts at the earth surface and extends up to about 8-14.5 km high.

The composition of air is given in the Figure 4.2.

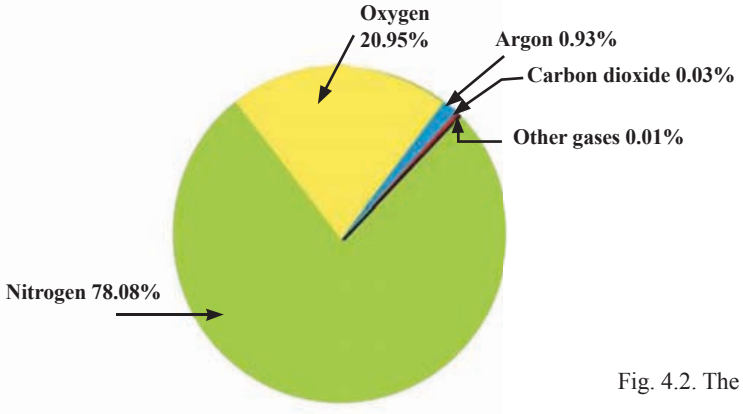


Fig. 4.2. The composition of air byvolume

Nitrogen, oxygen and carbon dioxide present in the atmosphere are used as raw materials in many industries.

Plants

Plants are a good source of several raw materials for industries. Some plant materials used in industry are given in Table 4.4.

Table 4.4.

Name of the plant	Plant materials used	Industry/Production
Jack, Teak, Nadun, Halmilla, Buruta etc.	Mature trunks	Timber
Coconut,	Husk of fruit	Fibre (coir)
Jute, Pineapple	Mature Leaves	Fibre
Rubber	Latex from the trunk	Latex industry
Papaya	Latex from the fruit	Medicinal products
Coconut, Palm tree	Oil from the kernel	Soap industry / Food industry
Pine tree	Bark	Paper making industry
Turpentine, Acacia (Kihiri)	Stem/bark	Essential oils, Gum, filler and Glue production
Mango, Pineapple, Citrus, Papaya	Fruit	Cordial and food industry

Wood apple, Pineapple, Mango, Melon	Fruit pulp	Jam production
Cinnamon/Citronella/ Lemongrass/Eucalyptus	Leaves	Essential oils
Cinnamon	Bark	Essential oils
Clove	Bark, Leaves	Essential oils
Gliricidiya	Whole plant	Thermal power

Assignment 2

Find out and make a list of plant products (not given in the above list) and the industries in which they are used.

A natural resource used in industry should be available over a long period of time. Further, the resource should be in a place of easy reach.

When selecting an area to set up an industry, it is necessary to consider the following factors.

1. Availability of raw material
2. Power supply
3. Capital investment
4. Technology
5. Trained and skilled workforce
6. Transport and marketing facilities
7. Disposal of effluents
8. Impact on the environment and organisms

It is necessary to take steps with regard to the following, in order to overcome challenges from the community and the consumer.

1. Obtaining technical advice
2. Management of human and physical resources
3. Production of an output of required standards
4. Obtaining the approval of the government and other authorised institutions.
5. Mechanism for disposal of effluence.

Assignment 3

If a person hopes to start an industry, prepare a report on how he should plan, taking the following factors, into consideration.

1. Production / Industry
2. Raw materials
3. Institutions from which technical assistance is obtained
4. Investment
5. Skilled personnel
6. Targets
7. Disposal of effluence
8. Impact on environment

4.2 Limestone based industries in Sri Lanka

Varieties of limestone in Sri Lanka and their occurrence

Limestone is of sedimentary origin. Chemical compound found in limestone is calcium carbonate ($CaCO_3$). If magnesium carbonate is also present with calcium carbonate it is called dolomite ($CaCO_3.MgCO_3$). Valuable dolomite deposits are found in Kandy, Matale, Nalanda, Habarana, Kandarawa, Balangoda, Bibile, Badulla and Welimada. Miocene limestone of the Jaffna peninsula is very pure Calcium carbonate.

Miocene limestones

These limestones extend to great depths covering the area from Puttalam in the north west coastal belt of the island to Jaffna. The main impurities found in the limestone of Puttalam are clay, and silica .

This limestone is used to manufacture cement. Miocene limestone is not popular in making lime due to its off white colour. According to Geological Survey Department, sources of miocene limestones are suffcient only for about 60 years.

Coral

Another variety of limestone is the **Coral deposits**. Though coral is found at various places along the coast, best known coral beds are found from Ambalangoda to Matara. Loosely packed stick coral are found here. Other areas where coral beds are found are Jaffna, Kalkudah, Kuchchaveli and Delft island. According to Geological Survey Department, about 300 lime kilns are identified from Akurala to Hambantota.

Shell deposits

Shell deposits are another variety of limestone. Shell deposits are found in Hungama. Percentage of calcium carbonate is very high, (about 98%) in these shell deposits. Little impurities are present in shell deposits. Calcite is another variety of limestone deposits. Best known calcite deposites are located in Balangoda. These deposits are not used in the production of lime. They are used mainly in the ceramic industry.

Activity 4.1

Add a few drops of a dilute acid to similar samples of different types of limestones and test for the gas evolved by passing the gas through limewater. What is the conclusion you can make regarding the composition of limestone?

Cement industry

Demand for cement is increasing daily as it is used in the construction of buildings, bridges, roads to dams etc. It sets into a hard mass when treated with water. It is also known as **Portland Cement**. It is the most common type of cement used in many countries of the world, for general construction purposes.

Do you know?

It was Joseph Aspdin who has given the name 'Portland Cement' because he found the hard mass obtained from it is similar to the rock found near portland in England.

Limestone and clay are the main raw materials used in the cement industry. They are dried and mixed in the ratio 3:1. The mixture is then ground in to a fine powder. This mixture is fed into the rotary kiln.

For your knowledge.....

Shell deposits are formed from the shells of oysters, clams and bivalves

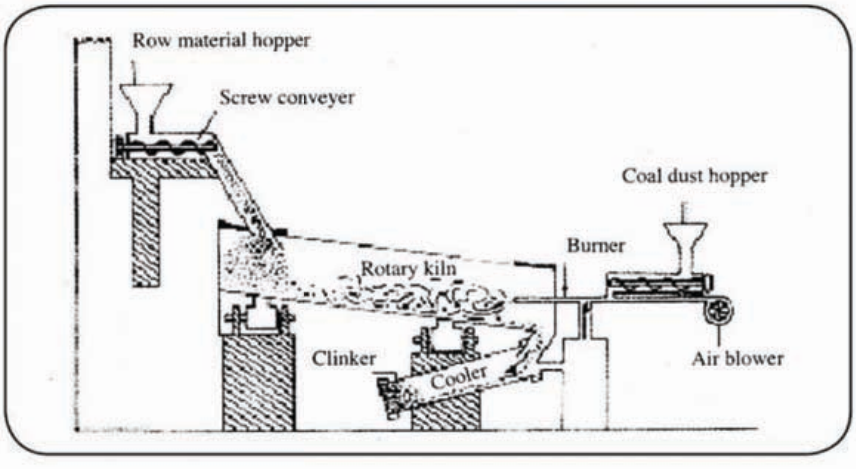


Fig. 4.3 Rotary kiln

The mixture is heated to a temperature of 1400-1600 ^{0}C. The rotary kiln is inclined at an angle of about 10^0 and it rotates on its axis slowly. The raw materials are introduced from the upper end. The mixture travels down the kiln as it rotates. Series of reactions occurs in the rotary kiln.

Calcium carbonate ($CaCO_3$) present in limestone is decomposed to calcium oxide and carbon dioxide.

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$$

Sisilica (SiO_2) and alumina (Al_2O_3) Present in clay reacts with calcium oxide forming calcium silicate ($CaSiO_3$) and calcium aluminate ($Ca_3(AlO_3)_2$)

$$CaO + SiO_2 \longrightarrow CaSiO_3$$

$$3CaO + Al_2O_3 \longrightarrow Ca_3(AlO_3)_2$$

This mixture is allowed to cool and obtained in the form of pebbles called cement clinker. Clinker is very hard and is not decomposed easily. Therefore clinker can be stored for sometime until used for cement production.Cement is produced by mixing clinker powder with gypsum ($CaSO_4.2H_2O$) and grinding the mixture to a fine powder. The purpose of mixing gypsum with clinker is to have desired setting qualities in the finished product.

When water is mixed with cement the mass becomes very hard in a few hours. This process is known as setting of cement.Addition of gypsum increases the time of setting and makes it easier to work with.

Uses of cement

- In building construction - A mixture of cement, sand and water are used in construction work.This mixture is called mortar.
- In preparing concrete - Concrete is a mixture of metal, coarse sand and cement. This is used in making buildings slabs, beams pillars, bridges, roads, etc.
- In making reinforced concrete (RCC) - reinforced concrete is made by depositing concrete around skeletons of steel rods.

Assignment 4

Make a report on how a cement factory in the vicinity affects;
1. the environment.
2. the health of the people.

Quicklime

Quicklime is calcium oxide (CaO). Quicklime is also called burnt lime,caustic lime and lime. This is a widely used chemical compound. It is a white crystalline solid. In commercial quicklime, compounds such as magnesium oxide, silicon oxide, aluminium oxide and iron oxide are also found in small quantities.

Calcium oxide is produced by the thermal decomposition of limestone Calcium carbonate is decomposed in a lime kiln by heating above 825 ^{0}C. Calcium oxide and carbon dioxide are produced:

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$$

A diagram of a traditional lime kiln is given in Figure 4.4.

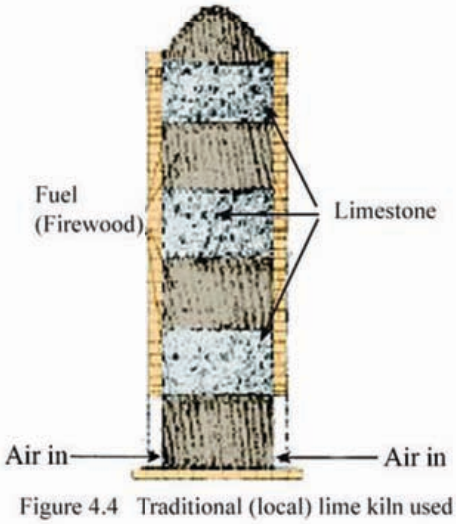


Figure 4.4 Traditional (local) lime kiln used in Sri Lanka

A diagram of a modern lime kiln is given in Figure 4.5

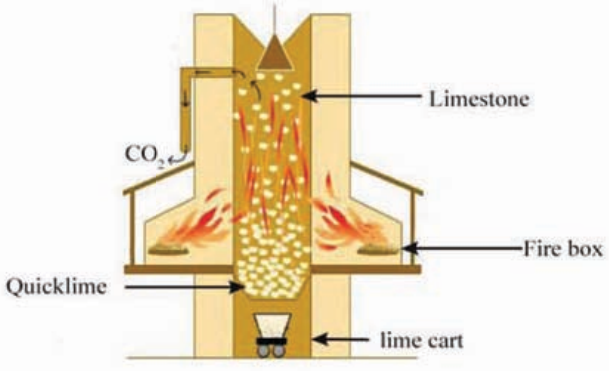


Fig 4.5 - A modern lime kiln

Uses of calcium oxide

- Preparation of mortar and plaster.
- Production of glass.
- Paper making-Calcium oxide is used as a coagulant, in bleaching and to dissolve lignin in wood.
- To neutralise the acidity in agricultural soils.
- Control pollution.
- Forensic science - To reveal fingerprints
- Purification of citric acid, glucose and dyes
- As a carbon dioxide absorber
- Pottery, paint and food industry

Slaked lime

Calcium hydroxide or **slaked lime** is prepared by adding water to calcium oxide. Heat is given out during the reaction.

$$CaO\,(s) + H_2O\,(l) \longrightarrow Ca(OH)_2\,(s) + \text{heat}$$

Bleaching powder

Bleaching powder is manufactured by passing chlorine (Cl_2) over slaked lime ($Ca(OH)_2$).Calcium hypochlorite ($Ca(OCl)_2$) calcium chloride ($CaCl_2$) and water are formed. Some water evaporates off and the remaining powder is called bleaching powder.

It is widely used for water treatement as a disinfectant and as a bleaching agent. This contains more chlorine than liquid bleach - calcium hypochlorite.

Properties of bleaching powder

Bleaching powder is a white solid. It has a strong smell of chlorine. It is not much soluble in water. There are two types of bleaching powder - a dry form and a hydrated form. It is safer to use the hydrated form. Precautions should be taken in handling bleaching powder. It should always be kept in a cool, dry place.When using bleaching powder always add bleaching powder to water and not water to bleaching powder.

Warning
Don't add water to bleaching powder. Add bleaching powder to water.

Uses of bleaching powder

1. For disinfecting drinking wat
2. For disinfecting water in swimming pools.
3. For bleaching cotton, paper and linen.
4. Production of chloroform.

Assignment 5
Collect information about the environmental effects due to lime kilns, and prepare a report.

4.3 Salt industry

There are two methods of producing common salt on a large scale.

1. By the solar evaporation of sea water in salterns.
2. Mining of rock salt from dry deposits

Of these two methods, the first methods is the one used in Sri Lanka.

The composition of sea water is given in Table 4.5.

Name of the compound	Chemical formula	Amount in 1L of sea water/g
Sodium chloride	NaCl	29.11
Magnesium chloride	$MgCl_2$	3.58
Magnesium sulphate	$MgSO_4$	2.34
Calcium sulphate	$CaSO_4$	1.44
Magnesium bromide	$MgBr_2$	0.05
Calcium carbonate	$CaCO_3$	0.12
Potassium chloride	KCl	0.72

Table 4.5

Assignment 6

Prepare a list of places where salterns are found in Sri Lanka.

In selecting a suitable place for a saltern, the following factors have to be taken into consideration.

1. Should be a fooolat lanlose to the sea.
2. Availability of strong sun light and wind throughout the year.
3. Soil should be clayey.
4. Minimum rainfall.

A saltern has three types of tanks.

1. Shallow and large tanks
2. Medium size tanks
3. Small tanks

Steps in salt production

1. Sea water is pumped into the shallow tanks.Sea water gets concentrated as evaporation of water takes place in these tanks.When the concentration of salt is double the initial concentration, calcium carbonate starts to get precipi tated in the shallow tanks.
2. Next the mother solution is sent to the medium size tanks. Calcium sulphate gets precipitated when the concentration of brine increases by four times.
3. Then the mother solution is allowed to flow into the third type of tank and here sodium chloride (common salt) is precipitated,when the concentration of the mother solution increases by 10 times. After precipitation of sodium chloride, the remaining solution which is rich in magnesium chloride is bitter. As it is bitter in taste this solution is called bittern.

Common salt dampens when exposed to air. This is due to the presence of magnesium chloride which absorbs water from the atmosphere and dissolves in it. This property is called **deliquescence.**

Do you know?

Density of sea water is measured by a special type of a hydrometer called Baume hydrometer. When using this hydrometer the unit of density is expressed in Baume (^{0}Be). Density of normal sea water is 3.5^0 Be.

Production of iodised salt

Iodine deficiency is a main health problem in some areas of Sri Lanka. As a remedial measure, iodised salts is produced and distributed.

Iodised salt is produced by adding potasium iodate to salt. In the preparation iodised salt, 40-50 mg of potassium iodate (KIO_3) is added to 1kg of salt granules.

Producion of table salt

Table salt is produced by passing hydrocloric acid vapour through concentrated solution of sodium chloride.

By-products of salt industry

Main by - products of the salt industry are gypsum and plaster of paris.

Gypsum collects in the middle tanks.

Gypsum ($CaSO_4 . 2H_2O$) is mainly used in the cement industry.

Plaster of Paris ($CaSO_4 . 1/2H_2O$) is produced by heating gypsum.

Plaster of Paris is a white powder. On mixing with water it sets to a hard mass and expands slightly. Hence it is very useful for making moulds, casts for fractured bones and blackboard chalk.

Uses of plaster of Paris

- In making casts and moulds
- For plastering fractured bones
- For making chalk
- As a fire-proofing material

4.4 Usage of various gases in industry

Nitrogen

Nitrogen is a colourless, odourless and tasteless gas. Under normal conditions nitrogen is inert. About 78.1% by volume of the atmosphere is nitrogen. It is a constituent element in all living tissues and nucleic acids.

At atmospheric pressure, nitrogen condenses (liquefies) at 77 K (-195 °C) and freezes at 35.4 K (-237.6 °C). Liquid mitrogen is represented by the symbol LN_2.

Nitrogen for industrial purposes is produced in large quantities by fractional distillation of liquid air. It is convenient to store nitrogen as liquid nitrogen and used when necessary.

Industrially important compounds like ammonia and nitric acid are manufactured from nitrogen.

Uses of gaseous nitrogen

Due to the inert property of nitrogen it is used for many purposes.

- In ordinary incandescent light bulbs as an inexpensive alternative to argon.
- On top of liquid explosives for safety.
- For the production of electronic parts like diodes and transistors.
- To preserve the freshness of packaged foods priventing oxidative damage.
- Dried and pressurized nitrogen is used asan insulating gas for high voltage equipment.
- In manufacturing stainless steel.
- Filling automotive aircraft tires.
- In the production of ammonia. Ammonia is commonly used in making fertilizers.

This method uses direct combination of N_2 and H_2 in the presence of a catalyst.

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

The catalyst used is finely divided iron along with some traces of molybdenum.

- In the production of Hydrazine (N_2H_2)

Hydrazine is often used as a rocket fuel as it can be stored as a liquid.Hydrazine reacts with oxygen giving gaseous products.

- In the production of nitric acid.

Uses of liquid nitrogen

- In dermatology for removing potentially malignant skin lesions.
- Cryopreservation of blood, reproductive cells and other biological samples and materials.
- Quick freezing of food in food factories
- One metal is dipped in liquid nitrogen and when it gets contracted it can be fitted easily into another metal part.
- In food packaging to remove oxygen and keep food fresh.

Oxygen

Oxygen is a colourless, odourless gas and also it is a supporter of combustion. Its boiling point is - 183°c

Oxygen occurs in the free state as a gas in the atmosphere. Nearly 21% by volume of air is oxygen.

Many methods have been used so far for the large scale preparation of oxygen. But at present only two methods are used.

1. Electrolysis of acidulated water
2. Liquefaction and fractional distillation of liquid air.

Out of these two methods the most commonly used method is the fractional distillation of liquefied (liquid) air. During this process, when all the nitrogen is removed, the liquid left is almost pure oxygen. The gas is compressed by pumps into steel cylinders.

Uses of oxygen

- For artificial respiration to patients with breathing difficulties.
- Used in the oxy-hydrogen flame.
- Used in the oxy-acetylene flame.
- In steel works, oxygen is blown through molten steel to purify it.

Acetylene (Ethyne)

Molecular formula of acetylene is C_2H_2 and its structural formula is

$$H\text{-}C \equiv C\text{-}H$$

It is used as a starting material for a large number of industrially important compounds.

It is a colourless, odourless, inflammable gas.

Acetylene can be prepared from different organic compounds by heating them in the absence of air.But it is usually made commercially by the reaction of calcium carbide with water.

$$Ca\,C_2(s)+2H_2O(l) \longrightarrow Ca(OH)_2\,(aq) + C_2H_2\,(g)$$

Acetylene is stored in metal tanks, dissoved in liquid propenone (acetone) under pressure.

Acetylene burns in air with a very hot flame.

Uses

- It is used in oxy-acetylene flame used for welding and cutting metals.
- For the preparation of vinyl chloride (chloroethene) used to manufacture PVC (Poly vinyl chloride)
- For the production of synthetic rubber.
- It is used to speed up the ripening process of certain fruits, and fruitification in pineapple plants.

4.5 Industries based on plant raw materials

Alcohol and vinegar

The most common alcohol is ethyl alcohol or ethanol. Ethyl alcohol is a volatile liquid. Its boiling point is 78.3 °C. It is used as a fuel and also as a solvent. It has other uses too. A mixture of alcohol with petrel is called gashol and it is used in vehicles as a fuel. The main constituent of allalcoholic beverages is ethyl alcohol. Alcohol is also used as a raw material in many productions.

Percentages of ethyl alcohol in some alcoholic beverages are given in the table 4.6

Alcoholic beverage	Percentage of ethyl alcohol
Wine	12%
Beer	04-05 %
Arrack	20-35%
Whisky	40-50%
Brandy	40-50%

Table 4.6-Percentages of ethyl alcohol in some alcoholic beverages

Activity 4.2

Take a solution of glucose into a beaker and add some yeast into it. Observe what happens for some time.

When yeast acts on glucose, ethanol is formed with the evolution of a gas. When the gas is passed through lime water,it gets milky. This shows that gas evolved is CO_2. Glucose has been converted to ethyl alcohol and CO_2.

$$C_6H_{12}O_6\,(aq) \xrightarrow{\text{Yeast}} 2C_2H_5OH\,(aq) + 2CO_2\,(g)$$

This process of conversion of sugar to ethyl alcohol, under the influence of yeast was known since ancient times.

All beverages of ethanol and more than half of industrial ethanol is still made by this process. Starch from potatoes, maize or other cereals are used as raw materials. Yeast contains the enzyme zymase by which simple sugars (eg.glucose) are converted into ethyl alcohol and carbon dioxide. This conversion of sugar into ethyl alcohol by yeast is known as fermentation. This is the basis of the alcohol industry for centuries.

Raw materials for alcoholic fermentation are;

1. Substances containing fermentable sugar
2. Substances containing starch

Some examples for the substances that contain fermentable sugars are:

- Sweet toddy of coconut, 'Kithul' and palmyrah
- Cane juice
- Molasses
- Dates
- Fruit juices

Examples for natural sources containing starch are:

- Potatoes
- Rice
- Barley
- Maize

Do you know ?

Manufacture of ethyl alcohol from molasses

Molasses is a cheap source of sugar. it is a dark coloured viscous liquid left after the crystallization of sugar from the concentrated sugar can juice. Molasses contains about 30% of sugars; mostly sucrose, glucose and fructose which have not crystallized.

Molasses is converted into ethyl alcohol by the following steps.

1. Molasses is first diluted with water (one volume of molasses to five volumes of water).
2. If the nitrogen content in the molasses is poor,ammonium sulphate or ammo nium phosphate is added.
3. The solution is then made acidic by adding a small amount of suphuric acid. Acidic medium helps yeast to grow,but it is unfavourable to most bacteria. Care should be taken not to add excess acid because yeast cells may be killed.
4. The above solution is transferred to a large fermentation tank and yeast is added to it.

During this period the enzyme invertase present in yeast converts sucrose to glucose and fructose.

$$C_{12}H_{22}O_{11}(aq) + H_2O(l) \xrightarrow{\text{invertase}} C_6H_{12}O_6(aq) + C_6H_{12}O_6(aq)$$

The enzyme zymase present in the yeast under anaerobic conditions brings about fermentation, and forms ethyl alcohol.

$$C_{12}H_{22}O_6(aq) \xrightarrow[\text{yeast}]{\text{zymase}} 2C_2H_5OH(aq) + 2CO_2(g)$$

The fermented liquid is called wash.This wash is now subjected to distillation to increase the percentage of alcohol.

Uses of alcohol

- It is a good organic solvent.
- It is used as a fuel
- Used in making cough syrups.
- In making ayurvedic medicines like 'Arishta'.
- It is used in laquers,paints and varnishes as a solvent.
- In manufacturing dyes,perfumes etc.
- In the manufacture of vinegar.
- In making alcoholic beverages.

Vinegar

Vinegar is a sour liquid containing dilute acetic acid that is obtained by continued fermentation of toddy. In Sri Lanka, the traditional vinegar industry mostly uses coconut toddy as tflamehe main raw material. However during the recent past the industry has suffered to a great extent due to competition from artificial vinegar which is cheaper in the market.

Vinegar manufacture in Sri Lanka consists of a fermentation process followed by an acetification process. Fermentation is effected using yeast which is naturally present in toddy. During this phase, sugar present in sweet toddy is converted into ethyl alcohol.

The enzyme which is necessary for this process is zymase. It is present in yeast. Conversion of ethyl alcohol into acetic acid is known as acetification. The bacteria engaged in this process is *acetobacter*.

Thus, vinegar is produced by the oxidation of ethyl alcohol.

$$C_2H_5OH + O_2 \xrightarrow{\text{acetobacter}} CH_3COOH + H_2O$$

Vinegar from coconut water

Coconut water obtained from matured fruits contains about 3% of sugar. This content is increased to 10% level by adding sugar. This fortified coconut water is then fermented by inoculating the solution with yeast. After alcoholic fermentation for about 3-5 days, some vinegar containing acetobacter bacteria is mixed. Alcohol gets oxidized to acetic acid.

Artificial vinegar can be made by the dilution of glacial acetic acid. Vinegar is used as a preservative and also as a flavouring agent in the food industry.

Essential oils

Essential oils are found in plant materials. They are **aromatic** materials with volatile organic substances. Essential oils (aromatic oils) are used in flavouring foods and in making perfumes.

The major essential oils produced in Sri Lanka are,

- Cinnamon leaf oil
- Cinnamon bark oil
- Citronella oil
- Nutmeg oil
- Pepper oil
- Clove bud oil
- Cardomom oil
- Eucalyptus oil

Cinnamon bark oil, pepper oil and cardomom oil are mainly used in food industry. They are used without adding any chemicals or further processing. Cinnamon leaf oil, citronella oil and clove bud oil are used in many industries like tooth paste, medicated balms, perfumes, soap, etc.

Some plant parts in which essential oils are found are presented in table 4.7.

Name of the plant/plants	Parts where essential oils are found
Veitiveria	Root
Sandalwood	Stem
Cinnamon	Bark of the stem
Cinnamon,Cymbopogan, Lemon grass,Eucalyptus	Leaf
Cloves	Bud
Rose, Jasmine	Flower
Lemon, Orange, Lime (Citrus)	Fruit
Nutmeg	Seed

Table 4.7

Extraction of essential oils

A few oils can be squeezed out of the plant material. eg. citrus oil. This could be done easily because the oils occur in minute sacs in the outer part of the peel. Most of the other plant oils cannot be separated in this way.

Adequate amount of water is added to cover the plant material and is heated by steam. The vapour mixture obtained is then condensed. Oil is separated from water because **aromatic oils** and water are immiscible.

Steam distillation

Most essential oils are extracted by steam distillation. Steam is generated in one vessel and this steam is passed through the plant material placed in another vessel. Atomatic oils present in the plant materials are vaporized and a mixture of aromatic oil and steam is obtained.

When this mixture is cooled **aromatic oils** and water are separated out.

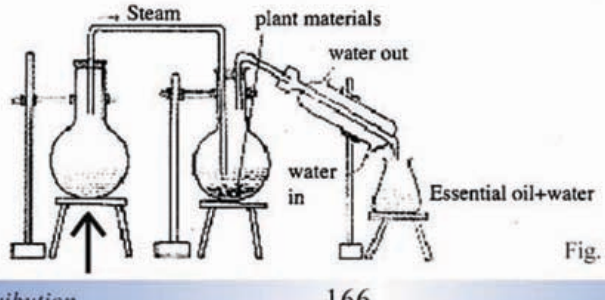


Fig. 4.6 - Steam distillation

Solvent extraction

Organic solvents like ether, chloroform, toluene etc. are used in this method. Here, plant materials are mixed with a solvent and the **aromatic oils** present in the plant material gets dissolved in it. The essential oil is obtained by vaporizing the volatile solvent.

Pressing

Pressing is another way of extracting essential oils. In this method, plant materials are placed between paraffin applied-glass plates and then pressure is applied. When pressed ,oil is absorbed by the paraffin. The oil absorbed by paraffin can be extracted with ether.

Rubber

Botanical name of rubber plant is *Havea brasilliensis*.

Natural rubber is made from the milky white fluid called latex obtained from the rubber tree. To gather the latex from the rubber tree a diagonal cut angled downward is made through the bark. This cut extends from 1/3 to 1/2 of the circumference of the bark.

The amount of latex obtained from a plant daily is about 30 ml. Therefore a thin strip of bark is shaved, from the bottom of the original cut to retap the tree, usually every other day. When the cutting reaches the ground, the bark is allowed to renew itself before a new panel is started.

Latex oozes out from latex vessels which are situated just outside the cambium.

This layer is about 1mm in thickness and known as 'diyapattaya' by tappers.

Composition of latex

Water	52-60%
Rubber	30-41%
Proteins	2.0-7.7%
Sugar	1.5-4.2%
Resin	0.0-3.4%

Latex should be collected as soon as possible after the flow has ceased (ie, after 3-4 hours). If signs of pre-coagulation are observed in the latex, an anti-coagulant should be used.

At present the preferred anti-coagulants are:

- sodium sulphite
- ammonia solution
- formaldehyde (Formalin)
- mixture of formalin and sodium sulphite or sodium carbonate.

Coagulation of latex is due to the acids formed by the bacteria that grow in latex. Latex contains nutrients such as proteins and sugar. Bacteria use these nutrients and organic acids are formed as a result. Coagulation occurs due to these acids.

Anticoagulants are bases such as ammonia solution, sodium sulphite and sodium carbonate.

Formaldehyde is also an anticoagulant, but it is not a base. Bacteria are killed by formadehyde.

Determination of dry rubber content (DRC) in latex

A special type of hydrometer is used for this, and it is called metrolac meter.

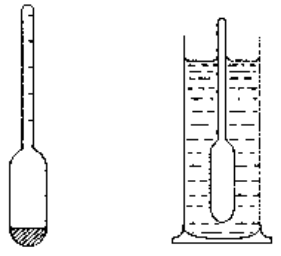


Fig. 4.7 Metrolac meter

When using a metrolac meter first a sample of latex is mixed with water in the ratio of 1:2 and the let the metrolac in it. After taking the metrolac reading, the value is obtained by comparing with a standard table.

Types of rubber that are used for the production of goods and articles are:

1. Sheet rubber
2. Crepe rubber
3. Cubed rubber
4. Centrifuged latex

Production of sheet rubber (smoked rubber)

Diluted latex is poured into trays and dilute acetic acid or formic acid is added to coagulate this. Latex is coagulated and slabs of rubber are formed. These slabs are first passed through smooth rollers and finally through rollers that give a ribbed pattern to the final rubber sheet. The sheets are then hung for about 4 days in a smoke house in which a temperature between 40 ^{0}C-50 ^{0}C is maintained. Smoking dries rubber and also prevents microbial activity on it.

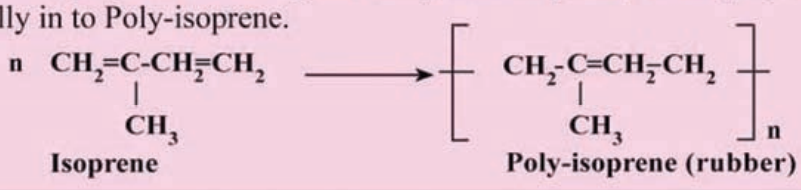
Production of crepe rubber

For preparing crepe rubber coagulum is passed through a creeping machine.

This machine consists of two rollers with longitudinal grooves upon which water is sprayed.The spongy coagulum is converted into a sheet. These sheets have an uneven rough surface.

Do you know?

Rubber is a polymer of the organic compound isoprene, which polymerises naturally in to Poly-isoprene.



Vulcanizing of rubber

Vulcanizing is a process used to improve the mechanical properties of raw rubber. This is done by mixing raw rubber and sulphur well and heating to a high temperature.

Properties of vulcanized rubber

1. It has excellent resilience i.e., objects made from it returns to the original shape, when the deforming load is removed.
2. It has a much higher resistance to wear and tear compared to raw rubber.
3. It is a better electrical insulator.
4. Its water absorption capacity is low.
5. It is more easy to manipulate to produce the desired shapes.

Activity 4.3

Take a piece of rubber into a beaker and add some sulphur into it and heat. Allow the product to cool and compare this with a sample of former piece of rubber.

Uses of rubber

Rubber is used making gums, conveyor belts, tires, tubes, shoes, rubber bands, brake pads, bushes, gloves, insulating covering of wires, shock absorbers.

Industrial Development Board (IDB)and Industrial Technology Institute (ITI) are always ready to give the necessary information about local industries.

Exercises

(1) i) Classify the following rocks as igneous, sedimentary and metamorphic.

granite, sandstone, marble, shale, limestone, gneiss

ii) What are the minerals found in granite?

iii) What chemical compound / compounds are found in the following?

1. Calcite
2. Limestone
3. Dolomite
4. Marble

iv) State one use of each of the following.

1. Limestone
2. Mica
3. Feldspar
4. Kaolin
5. Quartz

(2) i) State three types of limestone.

ii) Write the chemical formulae of

1) Quicklime 2) Slaked lime
3) Limestone 4) Gypsum
5) Plaster of Paris

iii) What is slaked lime?

iv) How is it obtained from quicklime?

v) Name two industries where lime is used in a large scale?

vi) How is bleaching powder manufactured?

(3) i) Name the raw materials used to manufacture cement.

ii) What is the role of gypsum in cement?

iii) a. What is concrete? b. How is it different from mortar?

iv) How is common salt prepared?

v) How is iodised salt prepared?

vi) Describe how table salt is prepared.

vii) State one use of plaster of paris.

(4) i) How is nitrogen produced industrially?

ii) Write two uses of gaseous nitrogen.

iii) Write two uses of liquid nitrogen.

iv) How is oxygen produced industrially?

v) Write two uses of oxygen.

vi) How is acetylene prepared commercially?

vii) Write three uses of acetylene.

(5) i) What is meant by alcoholic fermentation?

ii) Write the equation for the fermentation of glucose.

iii) How is vinegar produced commercially?

iv) Write the chemical equation for the conversion of ethyl alcohol into vinegar.

v) How is artificial vinegar produced?

vi) a).What do you mean by essential oils? b). Name three such oils.

vii) Name three methods by which essential oils are extracted.

(6) i) What is the botanical name of rubber?

ii) Write three anticoagulants of your choice.

iii) Why is it necessary to add anticoagulants to latex?

iv) What is meant by DRC value and how it is measured?

v) What is meant by vulcanizing?

vi) Write three properties of vulcanized rubber.

vii) What are the environmental problems associated with rubber factories ?