THEME 1

Chemistry and industry

Topic 1: Chemical industries

Performance objectives

Students should be able to:

1.1 identify chemical industries in their locality

1.2 explain how these chemical industries have influenced their lives and Nigeria's economy

1.3 describe the environmental problems created by the chemical industries

1.4 suggest some solutions to solving some of these environmental problems

The solid raw materials in Earth's crust are called mineral resources. They often contain one or more valuable minerals mixed with impurities and dirt. Before starting to mine, the mining company must consider many aspects, for example, how much ore is present, how pure the ore is, how physically accessible it is, what the costs of access roads and buildings will be and how available materials and workforce are. The costs of extracting the ore must be weighed up against the market value of the metal or mineral to determine whether it is worthwhile to mine it. Many of the same considerations apply to the siting of any chemical plant, as chemical industries use raw materials that come from the Earth, which must be mined and processed. The same principles also apply to the **exploration**, **exploitation** and refining of crude oil.

Types of chemical industries

There are many types of chemical industries in Nigeria. They have an effect on everyone's life as well as the Nigerian economy. Chemical industries can also affect the environment, but there are ways that the production of useful items can be balanced with protecting the environment as much as possible.

History of oil exploration

Crude oil was discovered in Nigeria in 1956 at Oloibiri in the Niger Delta after half a century of exploration. The first oil field came on stream in 1958. After independence in 1960, exploration rights in onshore and offshore areas adjoining the Niger Delta were extended to foreign companies. In 1965 the EA field was discovered by Shell in shallow water south-east of Warri.

In 1970, the world oil price rose dramatically and Nigeria was able to reap instant riches from its oil production. Nigeria joined the Organisation of Petroleum Exporting Countries (OPEC) in 1971 and established the Nigerian National Petroleum Company (NNPC) in 1977, which is a state-owned and state-controlled company.

Figure 1.1 shows where the major oil and gas fields are located in Nigeria.

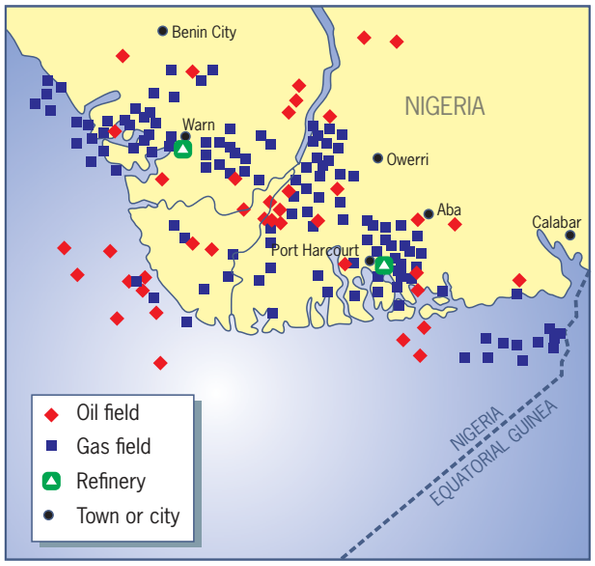

Figure 1.1 The major oil and gas fields in Nigeria

Petroleum production and export play a dominant role in Nigeria's economy and account for about 90% of the country's gross earnings. This dominant role has pushed agriculture, the traditional backbone of the economy from the early fifties and sixties, to the background.

The petrochemical industry in Nigeria has been evolving over the last fifteen years and the refining of crude oil is focused around the three centres located at Kaduna, Warri and Eleme.

The Kaduna Refining and Petrochemical Company is situated in northern Nigeria. The refinery produces premium motor spirit (petrol), liquefied petroleum gas (LPG), diesel and fuel oil, wax, asphalt, linear alkyl benzene, benzene and kerosene solvents.

The Warri Refining and Petrochemical Company produces the normal refinery products, such as LPG, petrol, kerosene, jet fuel, diesel oil, fuel oil, plus polypropylene and carbon black.

Port Harcourt has two refineries at Alesa-Eleme. Apart from the normal petrochemical products, the complex also has an ethylene plant and produces polyethylene, ethylene glycol, polypropylene and polyvinyl chloride.

Government incentives

After Nigeria's independence in 1960, the Nigerian government set national objectives and targets through a number of development plans to place the country on the path of development and to ensure the socio-economic well-being of its citizens. These plans had to stimulate the growth of industries that could benefit the nation as a whole. Nigeria had to become more self-sufficient and less dependent on foreign trade. The aim was also to create jobs and make full use of its natural resources. The important sectors that were identified for development were agriculture, iron and steel, and the chemical industry.

Nigeria's agricultural activities centre around the production of traditional cash crops, such as cocoa, cotton, rubber, groundnut and palm produce.

Iron and steel is very important for the development of infrastructure in any modern society. Nigeria wants to boost its economy by agricultural irrigation, farm mechanisation, new roads and bridge construction and housing developments. All these developments require iron and steel products.

Nigeria has all the raw materials needed for the production of iron and steel. There are iron and steel production plants at Ajaokuta (Ajaokuta Steel Company) and Aladja (Delta Steel Company). Three mills that produce steel sheets are located at Oshogbo, Jos and Kastina. Due to several factors, these factories do not work at full capacity.

Nigeria needs a chemical industry for its own sustainable development. The chemical industry depends on the knowledge and application of chemistry and chemical technology. For example, the use of fertilisers and pesticides can be used to increase agricultural output. Similarly, processing minerals into valuable products by using chemical technology can boost the country's

economy and improve the quality of life of its people.

Chemical industries

In Nigeria chemical industries are founded on a wide variety of raw materials. Among the most important are coal, molasses, salt, mineral ores, water, air and fats and oils of animal and plant origin. Since chemical industries produce a variety of products, it is useful to classify the industry on the basis of its products:

- *Commodity or basic chemicals* are chemicals produced in large quantities in continuous plants. They are also known as heavy chemicals and are relatively low in cost. Their applications can be linked to their chemical structure. Examples of basic chemicals are acids (such as hydrochloric acid, phosphoric acid and sulphuric acid), alkalis (such as ammonia and sodium hydroxide) and industrial gases (such as nitrogen and oxygen). Organic chemicals and alcohols also fall into this class. Many chemical plants are located in Ota (Ogun State) Nigeria.
- *Fine chemicals* are similar to commodity chemicals, but they are produced in small quantities by batch plants and their costs can be relatively high. Fine chemicals include drugs, food additives and fragrances that are used in the manufacture of pharmaceuticals, food products, soaps and lotions, and many others. Some large manufacturing plants are located in Agbara Industrial Estate, Ogun State.
- *Speciality chemicals* are mixtures of different chemical substances that are designed and produced for specific applications. The producer company holds the formulations of the products. Specialised products cover a wide range of products, such as adhesives, detergents and soaps, dyestuffs and pigments, fertilisers, pesticides and herbicides, pharmaceuticals and plastics. Some of these products are manufactured in Lagos State (Industrial Estate, Ilupeju) and Ogun State (Agbara Industrial Estate).

These classes of chemicals are interlinked. Sulphuric acid, for example, is an inorganic acid and is used as feedstock by many industries. It is used to manufacture fertilisers, other acids and their salts, to purify petroleum products and for many processes in the synthesis of dyes, paints, pharmaceuticals, detergents, lead acid batteries and many others.

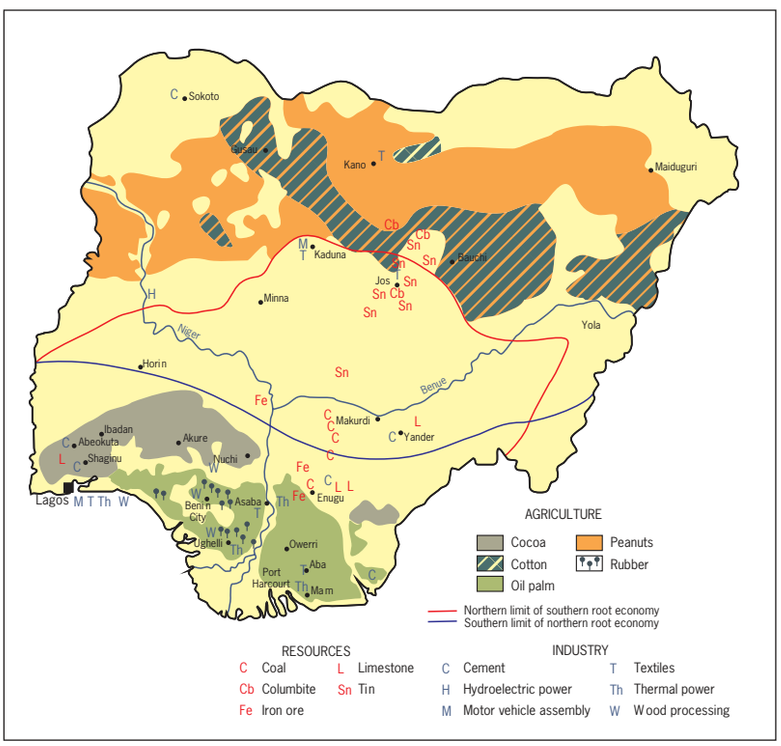

Figure 1.2 The location of industries in Nigeria

Activity 1.1 Chemical industries in the locality

Do research to answer the following questions.

1. Where is the closest chemical industry to you?
2. What is the name of the industry?
3. What does the industry produce?
4. Are the raw materials used in the industry found in the same area?

Careers in chemical industries

Nigeria is rich in fossil fuels and minerals, and there is a demand for chemists, engineers and artisans in these fields. Career opportunities also exist in the fine chemical, pharmaceutical, food and waste management industries. Chemists and engineers can also teach or do research.

A qualified chemist is known as an **analytical chemist**. Analytical chemists examine the composition, structure and characteristics of materials by examining and identifying the various elements or compounds that make up the substances, as well as the processes and changes that they undergo. They are absolutely crucial to the pharmaceutical industry because pharmaceutical companies need to know the identity of compounds that they hope to turn into drugs.

Analytical chemists are used in all sorts of laboratories, for example laboratories in health, water, food, cosmetics and oil industries. They also identify the presence of pollutants in soil, water and air. Analytical chemists analyse samples by using a range of analytical techniques, instruments and software, such as chromatography and spectroscopy, and interpret and report the data they obtain.

Industrial chemists deal with new industrial products. They work on new ideas and then design, test and build prototypes of these products.

Quality control chemists prepare and test samples from all phases of manufacturing or other handling processes. They have to determine if the product meets the standards of quality and specifications. Their testing methods include basic laboratory work and using sophisticated analytical instruments. Cosmetics, drugs, soaps, food products and drinks and many other products that we use every day must meet specific standards before they can be sold to the public.

Activity 1.2 Identify careers in the chemical industries

Identify and research any career that uses the skills and knowledge of a chemist or interview a friend and family member who works in the chemical field.
Write a short report about the career you have researched.

Importance of chemical industries

Chemical industries produce industrial chemicals and are central to the modern world economy. Chemical companies convert raw materials, such as oil, natural gas, air, water, metals and minerals, into more than 70 000 different useful products. Without the knowledge of chemistry, we would not be able to produce anything that was not already available on Earth. All the materials, products and objects that you use every day, such as steel, glass, plastics, pharmaceuticals, soaps, detergents, fuels and paper, were manufactured with the help of the chemical industry.

Importance of chemical industries to the individual

Before the nineteenth century, people died at a young age due to poor nutrition and diseases, and life expectancy was around 30. Life expectancy has increased in all countries since the start of industrialisation. The chemical industry has contributed the most to improving the standard of living for humans and is the main reason why people live so much longer today.

- Chemists developed drugs that are used in medicines. These medicines, such as antibiotics and vaccinations, have helped to bring many diseases, which killed millions of people, under control. Research is ongoing to develop cures for HIV/AIDS and malaria, which are two of the biggest killers of people in Nigeria.
- Chemists developed fertilisers and pesticides, which allow farmers to increase their crop yield and feed more people with nutritious food. This means that agricultural land is able to supply more food and support more people. A healthy, balanced diet improves the health of the whole nation.
- Chemists invented many different types of plastic and other synthetic materials. This has changed the way we live. We use plastics and objects made from plastics every day. Foodstuffs can now be packaged to keep them hygienic and fresh to last longer.
- Chemists constantly isolate, develop and synthesise new materials that impact on our lives. For example, the development of semiconductors has led to the miniaturisation of electronic equipment, which has changed the communications industry. We now have pocket-sized mobile phones and calculators.
- A strong chemical industry employs many skilled and unskilled workers. The workers receive wages that help them to support their families. They may also have other benefits, such as health care and medical support, retirement and insurance packages, which improve the life of the workers and their dependants. Some companies might also assist in the further education and training of their workers and thus improve their skills level, position in the company and earnings.

Importance of chemical industries to the nation

Nigeria's economy is based on the production and export of petroleum products. This industry is responsible for 90% of its foreign earnings. This money is used to drive the economy of the country.

Raw materials

Nigeria is blessed with a wealth of raw materials that are used to manufacture products in the country or exported to earn foreign revenue. Examples of raw materials are iron ore, coal, columbite (a mineral that contains mainly niobium), limestone, tin, cocoa, cotton, palm oil, peanuts and rubber.

Energy requirements and transport

The majority of Nigerians use traditional biomass, such as wood, charcoal, and waste, for cooking and heating. Two-thirds of electricity generation comes from thermal power stations that use natural gas and coal. The rest is hydroelectricity.

In addition to oil, Nigeria holds the largest natural gas reserves in Africa, but has limited infrastructure in place to develop the sector. Gas is supplied to a variety of industrial users in and around Lagos. The gas originates in the Niger Delta area and is piped

to Lagos via the Escravos pipeline. A number of major industrial users utilise this gas, such as Guinness's Ogba and Benin breweries.

Nigeria has the second largest road system in sub-Saharan Africa, but the country's roads are poorly maintained. This is the main cause of the country's high traffic accident death toll. The railways are also in need of maintenance. A strong and efficient chemical industry can earn the foreign currency needed to update the road and rail **infrastructure**.

Environmental impact

All mining activities, including the mining of oil and gas, as well as chemical industries have an impact on the environment. Most of the time, the impact is negative and without the necessary regulations these activities can cause widespread damage and degradation of the land.

The environmental costs and impact on the community must be kept in mind by a company, local community or government when they consider the location of a mine, quarry, plant or refinery. The negative impacts should be considered alongside the positive economic benefits to the community of increased business for the local economy and improved infrastructure, such as road and rail links. Safety regulations and practices must be maintained to avoid the risk of the accidental release of harmful materials to the air, water or soil. Such practices will protect those working in the factory as well as those living nearby. Chemists can contribute to minimising waste by making more efficient use of materials, for example, unused gases can be recycled rather than simply emitted into the air.

The oil industry has a reputation of causing a lot of pollution. The Niger Delta is one of the most polluted regions in the world. Pollution and environmental damage have had a serious impact on people living in this area. Oil contamination is widespread in Ogoniland and the people live with pollution every day. Oil spills have caused land, air and water pollution, which has severely affected surrounding villages by decreasing fish stocks and contaminating water supplies and farmland.

In December 2011 Shell announced that 40 000 barrels of crude oil had spilled near the Nigerian coast. This spill was among the worst off the Nigerian coast in 10 years.

Other chemical plants can also cause pollution in the air, water and soil if spillages of chemicals occur or **effluent** and emissions are not monitored and regulated. Chemical plants, such as thermal power stations and iron smelting (in a blast furnace) also release large volumes of carbon dioxide gas into the atmosphere. Carbon dioxide is a greenhouse gas and contributes to global warming. The improper disposal of waste from factories and radioactive waste from nuclear plants are also a major source of pollution.

Sustainability and the future

According to the World Commission on Environment and Development, sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It implies growth without degrading the environment.

There should be a balance between human activities and the natural world. The chemical industry plays a very important part in sustainable development, because all raw materials originally formed part of the natural world. Removing the raw materials from their original source already has an impact on the environment. **Beneficiation** of raw materials and manufacturing of new compounds have an even greater effect on the environment. In fact, all industrial activities impact on the environment to some degree. Society has

coined the phrase 'environmental footprint' when they refer to the impact our actions have on the environment. The chemical industry should strive to reduce their environmental footprint to as small as technically and economically possible.

Although the chemical industry in Nigeria is relatively small by international standards, it plays a significant part in the country's economy. The image of chemistry has suffered because of the irresponsible behaviour of some chemical companies in the past. Pollutants have been illegally dumped and have contaminated the air, soil, groundwater, rivers and the sea. Pollution resulting from the generation of energy remains a problem. Accidents in mines and chemical plants have claimed the lives of many workers. Nevertheless, the chemical industry is at the very heart of development and systems need to be developed to improve the image of chemistry through government, industry and society.

We need to take responsibility for our own environment, social development and economic growth. Only then can we all look forward to a bright future for ourselves and our children.

Minimising the environmental impact of chemical industries

The following are some ways that environmental problems caused by chemical industries can be minimised:

- Chemical industries and chemical plants should always be sited in industrial areas on the outskirts of towns and cities to minimise their impact on the lives of the inhabitants.
- The government must provide clear policies and legislation, and these must be enforced.
- The chemical industry must care for the health and safety of its workers, take responsibility for the environmental impact of their products for their full lifespan (this is called **product stewardship**) and communicate hazards to its workers and the public.
- Consumers must learn to read and understand cautionary labels, use chemicals as directed and dispose of waste chemicals safely.

Recycling

Waste materials are materials produced by human activity. Although local authorities in towns and cities are responsible for waste collection and disposal, it is every person's responsibility to dispose of waste in a proper way. It costs much more money to clean up litter left in streets and public places than to collect waste from households in a formal household waste collection system. So the public is also responsible for cleaning their towns and cities and ensuring that they dispose of litter and waste in the proper bins. We can all contribute to reducing these costs by recycling our waste.

Urban waste is usually dumped in landfill sites and then buried. This uses up valuable land and it costs a lot of money to transport the waste and manage the landfill site. It is becoming more and more difficult to find new landfill sites as old ones become filled up. No-one wants to live near an ugly, smelly landfill site. It is therefore very important that we reduce waste in order not to fill our landfills too quickly.

We can reduce the amount of waste by:

- reusing waste products
- recycling to remove the mass in the waste
- recovering chemicals, gases and metals from the waste.

Only certain materials are suitable for recycling, such as glass, paper, plastics and

metals. Organic waste can be made into compost. Material that cannot be recycled has to be dumped.

Plastic products cause a lot of pollution problems and we can see plastic waste everywhere in our country. The obvious way to get rid of the plastic is to recycle it. Most plastics can be melted and used again to make new products.

Recycling waste means that waste materials are collected and sorted into common types. The raw materials from each of the recycled items can be reprocessed into new products. Recycling can be a source of income for many people. It helps to keep the environment clean. It also saves our resources because new raw materials do not have to be mined or produced.

There are many negative consequences associated with poor waste management. If waste is not disposed of correctly, humans, animals and the environment suffer.

- Poor waste management can cause health hazards and diseases in humans and animals. Waste can be a breeding ground for germs that cause diseases such as dysentery, cholera and dengue fever.
- Waste products can pollute water sources, soil and the environment. Gases from factories and vehicle exhausts can dissolve in rain water to form acid rain. Acid rain makes the soil too acidic and damages crops. Rain can wash waste into rivers and dams and pollute the water. Harmful and toxic chemicals can land up in the soil and affect plant growth.
- Solid waste can block sewage and water drainage systems and cause these systems to overflow and flood the surrounding areas. If the sewage systems overflow, the soil and water will be contaminated by germs from the sewerage.
- Landfill sites need space, and they waste land that could have been used for agriculture or housing.
- Many waste materials contain valuable raw materials that can be recycled. It is far more costly to mine and manufacture new raw materials than it is to recycle them from the waste. By recycling waste materials we also save our resources.

Case study: Wecyclers – a success story

Lagos faces a waste crisis that will only worsen as the city's population soars. The overburdened municipal government collects only 40% of city garbage and a mere 13% of recyclable materials are salvaged from landfills.

Wecyclers works in partnership with the Lagos Waste Management Authority and collects recyclable waste, such as plastic bottles, plastic bags, and aluminium cans from households using low-cost bicycles, which are called 'wecycles'. Wecyclers motivate families to recycle by giving them rewards of redeemable points based on the volume and quality of the recyclable materials they collect. Families can redeem their points for things such as cell phone minutes, food and household goods. Wecyclers sort the materials and sell them to Nigerian recyclers, thereby providing a consistent supply of well-sorted, high-quality recyclable materials to process.

All Nigerians can be proud of Bilikiss Adebiyi, the founder and CEO of Wecyclers. She received the Cartier Women's Initiative Award 2013 for sub-Saharan Africa. Her company also received the International Sustainia Award 2014 in Copenhagen, Sweden.
Information from wecyclers.com

Activity 1.3 The importance of the chemical industries

1. Name the three classes of products produced by the chemical industry and give an example of each.
2. Give three ways in which the chemical industry benefits:
   a) you
   b) Nigeria.
3. The following terms are often used in the media, not only by industrialists, but also by politicians and other influential people: sustainable development; safety, health and environment (SHE); environmental footprint.
   a) Discuss and debate the issues raised in the section on sustainability and the future.
   b) Ask your family and friends for their opinion on the meaning of these terms.
   c) Research the use of these terms by reading relevant articles in newspapers, magazines and on the Internet.
   d) Write an essay on your own conclusions and thoughts on the issue. Include all the pros and cons of the chemical industry and its responsibility towards sustainable development.

Excursions to chemical industries

The only way that you, as students, can grasp the scale and skills involved in the chemical industry is to go on a field trip to a nearby industrial factory or chemical plant.

Figure 1.3 A chemical factory in Lagos

Iron and steel industry

Iron is the second-most abundant metal found in Earth's crust after aluminium. It is not found in the free metallic state except in meteorites. The most common iron ores are haematite (Fe_2O_3) and magnetite (Fe_3O_4). Iron ores are available in commercial quantities in Anambra and Edo states of Nigeria. However, the most important iron ore areas are in Itakpe, Ajaokuta, Jebba and Lokoja in Kogi State. Ore from these areas provide raw materials for the steel industry in Nigeria. Two new steelworks have been set up at Aladja, in Edo State, and at Ajaokuta, in Kogi State.

To make steel the iron ore is mixed with coke and limestone and reduced in a blast furnace in a smelting process. The iron is further heated in a furnace to burn off the impurities.

Factory to visit

Ajaokuta Steel Company

Crude oil exploration and drilling

Geologists and engineers identify oil-bearing rock layers by using aerial photography, examining the surface rocks, core drilling and mapping the Earth's rock layers. Mapping is done by exploding dynamite in deep holes in Earth's crust and recording the reflections of the shock waves from the rock layers. From the

recordings, the geologist can map the rock layers and detect possible oil-bearing areas.

Crude oil is extracted by drilling deep holes, or wells, into the ground. The drilling is done by a rotary rig that is supported by a derrick. When a well reaches an oil-bearing layer, crude oil and gas may shoot up into the air under high pressure. Usually, the crude oil is pumped out. It is sent to oil refineries by pipelines or tankers.

Oil refineries to visit

- Kaduna Refining and Petrochemical Company, northern Nigeria.
- Warri Refining and Petrochemical Company, Delta State, southern Nigeria
- Port Harcourt Refining Company, Alesa-Eleme, Rivers State

Soaps and detergents

Soap is made by boiling animal fat or plant oils with a strong base, such as sodium hydroxide or potassium hydroxide. This process is known as **saponification**. Soap is a waxy substance that enhances the ability of water to wash away grease and oil from our bodies, clothes and dishes.

Factories to visit

- Unilever, Agbara, Ogun State, makes laundry products and soaps.
- Laundry products are made by PZ Cussons, Ilupeju, Lagos.
- Soaps are made by Soap, Ijebu-Mushin, Ogun State

Sugar refinery

A sugar refinery processes raw sugar into white refined sugar. Sugar cane first goes to sugar cane mills that press the juice from the sugar cane. The cane juice is concentrated and allowed to crystallise. This raw sugar still contains molasses that gives it a yellow colour.

In the refinery, the sugar is dissolved to make a syrup and then clarified to get rid of the impurities. The clarified syrup is decolourised and crystallised to form pure white sugar.

Factory to visit

- Dangote Sugar Factory, Apapa Industrial Area, Lagos

Figure 1.4 Sugar on a conveyer belt in a sugar factory

Cement

Cement is a substance that sets and hardens and can bind other materials together. Some types of cement will not set in wet conditions and under water; other types will set under water. Cement is a component of mortar, which is used to stick bricks together, and concrete, which is a combination of cement, sand and small stones.

Factories to visit

- Elephant cement factory in Ewekoro, Ogun State
- Portland cement factory, Ibese, Rivers State
- Dangote cement factory, Lokoja, Kogi State
- Burham cement factory, Apapa, Lagos State