Notes

22

CLEANER TECHNOLOGIES

Industrial revolution resulted in the production of a large number of goods and services for the convenience of people. Life became much easier and comfortable. But large scale industrial production resulted in accumulation of huge amounts of wastes, which in turn created pollution of air, water, land and adversely affected plant and animal life. The environment of earth is loaded with wastes much beyond its carrying capacity. The volume of waste and out of service goods and gagets over loaded and pollution must be controlled in order to provide a healthy environment for man and other animals.

Now there is growing context to apply scientific knowledge and methods to develop "cleaner technologies" so that the natural resources and energy are used efficiently and in such a way waste generation can be minimized that the environment is protected from harmful effects of resulting pollution. Industries are engaged in evolving cleaner technology or eco-friendly technology based on improved manufacturing methods that require less raw materials and energy to produce more and even better quality goods and services. Cleaner technology use raw material efficiently and reduce the quality and quantity of waste itself.

OBJECTIVES

After completing this lesson, you will be able to:

- *define waste and describe the methods for reducing, recycling and reusing waste;*
- *explain type of waste found in the surroundings;*
- *define waste management;*
- *explain the methods of safe disposal of nuclear wastes;*
- *cite examples of nuclear hazards and identify their causes, prevention and control;*
- *explain the concept of cleaner technologies;*
- *describe the concept of life cycle analysis;*
- *explain the concept of eco-mark.*

Notes

22.1 TYPES OF WASTES

Waste is an unwanted or discarded material that can not be used in its present form. Waste can be classified into the following categories:

(1) **Industrial solid waste**

The major producers of solid waste are:

- Thermal power plants producing coal ash/ fly ash;
- The integrated iron and steel mills producing blast furnace slag;
- Non-ferrous industries like aluminium, copper and zinc producing red mud and tailings;
- Sugar industries generating press mud;
- Pulp and paper industries producing lime mud;
- Fertilizer and allied industries producing gypsum;
- Hospitals producing bio-medical waste.

(2) **The major producers of liquid effluents**

1. Cement
2. Thermal power plants
3. Iron and steel
4. Fertilizer
5. Zinc smelters
6. Copper smelters
7. Aluminium smelters
8. Oil refineries
9. Distilleries
10. Pulp and Paper
11. Pharmaceuticals
12- Dyes and dye intermediates
13. Pesticides
14. Petrochemicals
15. Tanneries
16. Sugar and
17. Basic drugs

(3) **Municipal solid waste**

Vegetable rejects from domestic units and vegetable markets, plastic material, building debris ,bio-medical waste etc.

(4) **Industrial liquid waste**

There is hardly an industrial process that does not generate liquid effluents. Often these are discharged into the rivers or streams without any treatment. As a result, these effluents pollute river that adversely affects aquatic life and the river ecology. The industrial waste waters often contain valuable materials that can be recovered. This approach improves quality of effluent discharged into the river on one hand fetches additional income to the

industry on the other hand. As an example, the recoverable material from industrial waste waters of different industries are given below:

Industry	Recoverable matter
Pulp and paper	Ligno-sulphate, sodium salts
Textile	Caustic soda
Distillery	Potassium salts, yeast
Fertilizer (phosphatic)	Calcium sulphate, fluoride
Coke oven	Ammonia, ammonium sulphate, tar, naphthalene, phenol

(5) **Municipal liquid waste**

Sewage from hotels and residential colonies.

(6) **Gaseous waste**

Various gases are emitted from industrial installations that have potential use but are not being utilized. For example, Oil and Natural Gas Commission (ONGC) is flaring gas worth Rs 750 crores per annum. This can be converted into methanol and petrol. Carbon dioxide emitted from various sources can be used to produce calcium carbonate. Sulphur dioxide emitted can be converted into either elemental sulphur or gypsum. Waste heat from hot gaseous emissions can be recovered for suitable use.

(7) **Radio-active waste**

Most of such waste is generated from nuclear power plants. The waste is highly hazardous to living animals and hence needs careful planning for its disposal and treatment.

Wastes are divided into the following two categories according to their hazard potential:

(i) **Hazardous waste:** These belong to a special category of wastes containing certain chemicals, metals, and pathogenic organisms that can cause serious health problems and damage to the environment even at low concentration. Indiscriminate disposal of these wastes into environment without proper treatment could lead to complex hazardous pollution of river water, land and ground water resources.

(ii) **Non-hazardous waste:** All other wastes which are not covered under the hazardous category are included in this group.

22.2 CONCEPT OF CLEANER TECHNOLOGIES

Generation of enourmous amounts of wastes has caused alarming situation threating human wellbeing. Cleaner technology is using technology in industries in such a way that environment is protected from harmful effects of waste accumutation and the resulting pollution. This

led environmentalists, scientists and technologists to think seriously about cleaning the environment by reducing industrial and other types of wastes. The aim is to make industrial manufacturing processes cleaner and more sustainable by redesigning them taking clues from nature, that is, how nature deals with wastes. In nature, waste or the left over of one organism becomes food of another organism, so that nutrients of the earth are endlessly recycled.

- One way to emulate nature is to recycle and reuse the chemicals used in industries instead of dumping them into the environment.
- Industries may interact in such a way that they establish a "resource exchange" programme in which waste of one industry or manufacturer is utilized as raw material by another-industry- similar to food web in nature.
- Use of CNG by automobiles instead of petrol, as an automobile fuel, is an example of cleaner technology which has reduced pollution of the environment.
- Instead of throw away economy which creates huge amount of waste, the manufacturers can make more money if their product is redesigned so that it uses minimum amount of raw materials lasts longer, easy to maintain, repair, remanufacture, reuse or recycle e.g. 'Carrier' a leading manufacturer of air-conditioning equipments are very efficient, easy to repair, remanufacture and recycle.
- Detoxifying hazardous wastes by chemical and biological methods to reduce their toxicity.
- Bioremediation is the process in which a living organism (plant/animal/bacteria) is deployed to make a hazardous wastes harmless. For example bacteria and enzymes help to destroy toxic and hazardous substances or convert them in harmless compounds.

Various plants have been identified which can help to clean up soil and water contaminated with chemicals such as pesticides, organic solvents, radioactive matter and toxic metals such as lead, mercury and arsenic.

The concept of **cleaner technology** is being practiced in different parts of the world under various names such as low and non-waste technologies, environmentally sound technologies, waste recycling, residue utilization and resource recovery technologies.

However ultimate cleaner technologies will be based on renewable resources as raw material and energy and transformation through highly efficient biotechnologies to produce environmentally harmless products.

INTEXT QUESTIONS 22.1

1. Name the six categories of waste found in the surroundings.

_____

2. State the various ways the gaseous wastes can be used up.

_____

3. Define cleaner technology.

_____

4. What is "throw away" economy? How is it responsible for accumulating waste?

_____

22.3 WASTE MANAGEMENT

The following section describes about waste management methods:

What is waste management

Waste management deals wth tackling or managing the waste after it is produced. Lot of effort has to be used in managing the waste, the easiest solution being it or burn it.

However, the prime aim should be to reduce production of waste. Waste reduction deals with the problem before the waste is produced rather than managing it after it has been produced.

Thus our priorities to tackle the problem of waste management should be in the order as shown below:

First Priority	Second priority	Last Priority
Waste Prevention	Reuse and Recycle	Waste management
• Change in manufacturing process to stop production of harmful chemicals. • Useless of harmful resources or materials • Reduce packaging materials in products • Make products that last longer and are easy to repair.	• Reuse products • Repair products • Recycle • Compost (biodegradable) • Reassembled/recyclable products	• Treat waste material to reduce toxicity • Bury waste in land fills. • Incinerate waste • Release waste into the environment for dispersal and dilution.

The three Rs strategy of waste management involves **reduce, reuse and recycle.**

22.4 METHODS FOR REDUCING, RECYCLING AND REUSE OF WASTES

(a) **Reducing**

Reducing consumption and redesigning the product (s) are the best ways to cut waste production.

Notes

Some of the ways to reduce resource use are:

- consume less, do not buy unless you absolutely need it.
- redesign manufacturing processes and products to use less material and energy. Example- Fuel efficient cars which will give more milage using fuel.
- redesign manufacturing processes to minimise waste for examples –use of hydrogen peroxide instead of toxic chlorine to bleach paper in the manufacturing process reduces.
- develop products that are easy to repair, reuse,recycle.
- design products which last longer like car tiers which runs for longer distances before they get damaged.
- reduce or get rid of unnecessary packaging or use reusable packaging and recyclable packaging.

(b) **Reuse**

Reuse of products is an important way to reduce resource use, reduce pollution and waste. Reuse means cleaning and using the materials over and over, thereby extending the life span of the products.

- This form of waste reduction reduces the use of material and energy resources, cuts pollution and waste, creates local jobs and saves money, for example recovering automobile parts from old cars in junkyards, recovering and collecting bricks, doors, fine wood works and steel from old houses and reusing them for new constructions.
- In India we had a tradition of using cloths napkins, glass and metal utensils but gradually throw away tissues are substituted for reusable handkerchiefs, disposable paper towels and napkins for reusable cloth ones; throw away paper plates, cups and plastic ones for reusable plates, cups and metal utensils. We are using lot of aluminium foil and plastic bags. We must get back to our good old habit of using more of cotton, jute and metals in our daily life. This will surely reduce the load of garbage.
- While reusing the products, care must be taken to protect the health of people dealing with such objects. For example discarded TV sets, computers and cell phones are dismantled to recover usable parts and in the process one can get exposed to toxic metals like mercury, cadmium and lead. The remaining scrap is dumped in open fields or burned in the open which exposes the workers to toxic fumes of dioxins.

(c) **Recycling**

Recycling is an important way to collect waste material and turn them into useful products that can be sold and used again.

- Recycling involves reprocessing of discarded materials into new useful products. Some common examples are recycled paper products (newspapers, magazines, office and school papers, cardboards), glass, aluminum, steel and some types of plastics.

- Biodegradable organic wastes (kitchen and other biological wastes) can be decomposed by microorganisms and worms and converted into composts which are returned to the soil as manure.
- Primary recycling occurs when waste is recycled into new products of the same type like turning old newspaper into new newspaper material, used aluminum cans into new aluminum cans, waste plastic bags into useful waste collection plastic bags.
- Secondary recycling occurs when waste materials are converted into different products. For example used automobile tyres can be shredded and turned into material to be used as rubberized road surfacing and newspaper can be turned into cellulose insulation, short fibres from paper pulp industry can be converted into paper boards.

INTEXT QUESTIONS 22.2

1. What should be our priority in tackling waste management?

   _____

2. What are the three Rs in waste management?

   _____

3. Give examples of primary and secondary recycling.

   _____

4. What is fuel efficient car? How does it save resources?

   _____

22.5 NUCLEAR HAZARDS, THEIR CAUSES, PREVENTION AND CONTROL

Before discussing nuclear hazards, must know about radiation and radioactive materials. Radiation is a form of energy which is produced when the nucleus of an atom is broken apart called fission producing heat and radiation. Nuclear power plants use this heat to turn water into steam. Steam turns the turbine to produce electricity.

Any radiation and any radioactive materials produced during the fission process are considered as waste products. Radiation emitted natural sources is known as **"background radiation",** because it is present everywhere, all the time. Radioactive atoms are known as "radionuclides".

Water acts as a natural barrier to radiation and can be used to isolate radioactive spent nuclear fuel at nuclear power plants.

Notes

Nuclear hazards or risk and dangers are associated with each step of the nuclear "fuel cycle" "as shown in the fig. (22.1) below.

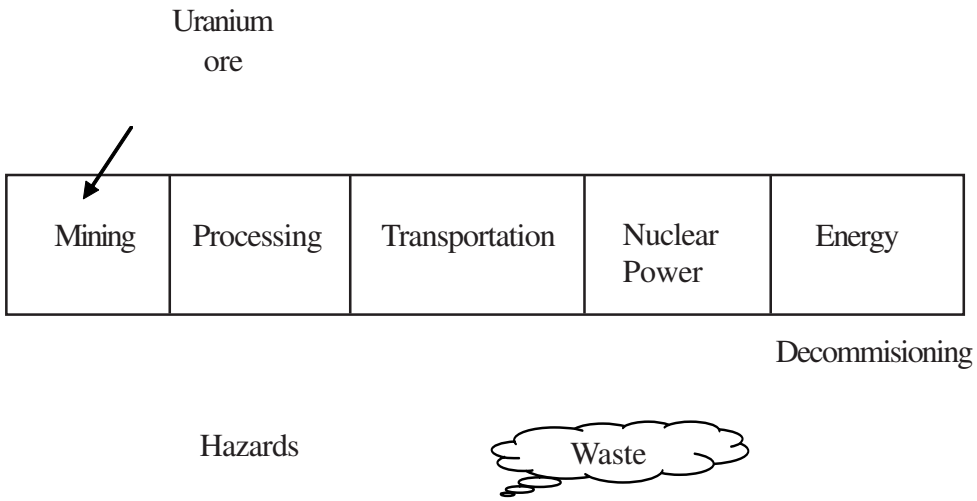

Fig. 22.1: *Fuel cycle*

Nuclear "fuel cycle" begins with

- Mining of uranium ore from the underground mines.
- The ore is then crushed (milled) into sand and then concentrated using a solvent to produce "yellow cake".
- It is then sent to a factory where it is turned into fuel "pellets" which are packed into rods.
- The rods are inserted in the core of a reactor, which undergoes nuclear reaction under controlled conditions to avoid explosion.
- The reaction (fission) produces tremendous heat, which boils water to make steam, the steam turns a turbine to produce electricity.

Each step of the 'fuel cycle', (mining, processing, transportation, nuclear power and energy production) poses a potential threat or hazard which is dangerous for life on earth.

Apart from heat, many new radioactive elements (Stronsium-90 and Plutonium-239) are also produced. These are unwanted and dangerous by products or **"radioactive waste".**

Uranium ore and mill waste remain heaped in deserts because there is no place to store them. They blow around with wind and wash with rain giving out radioactive gas for thousands of years in future.

People are concerned about the safety of nuclear power plants that are currently operating. Radiations can be released from them and nuclear contamination can occur at other points

in the nuclear fuel cycle. The recent accidents have had a great effect on people's attitudes towards power plants safety.

1. Three Mile Island (USA) 1979
2. Chernobyl (Ukrin) 1986

1. Three Mile Island (USA) 1979

Three Mile Island disaster occurred on 14th March, 1979. There was a breakdown of the main pump. The other auxiliary pumps failed to operate and electricity generating turbine stopped. At this point of time emergency coolant should have flooded the reactor to bring down the temperature. The coolant did start to flow but did not cooled the reactor but the faulty meter showed it otherwise. The high temperature resulted in core melt down and radioactive steam was thrown into the atmosphere. This was a nuclear disaster. Pregnant women and children were removed from the accident site. It was over a year before anyone could enter the plant. The damaged reactor was eventually defuelled in 1990 and the situation will be monitored till 2010.

2. Chernobyl (Ukrain) 1986

Chernobyl (Ukrain) on 25 April 1986 a test was being conducted to measure the amount of electricity that would be produced even if the steam was shut off but the turbine would still be spinning. To reduce the output of steam, control rods were lowered into the core. To prevent further delay in testing, the cooling system was manually turned off. This was a serious safety violation. As the test or the experiment continued the energy level of the reactor increased two thousand times, the fuel rods broke and the cooling water turned into steam.

There was a huge explosion and the roof of the reactor ripped off the concrete roof of the reactor. Radioactive fumes spread around and this became the world's worst nuclear accident. People suffered radiation sickness and this increased their chances to suffer from leukemia (blood cancer). Chernobyl put 300-400 million people at risk in fifteen countries.

There is an increasing concern about the safety of nuclear reactors and there is an urgent need to develop ways and means to make nuclear generation safe and as a viable source of clean energy.

Prevention and control

At both Chernobyl and Three Mile Island, it was operators error by the (human error) that caused the disastrous accident when operators manually stopped normal safety actions from taking place. Mechanical designing of the reactor should be such that the reactors should get shut down immediately under such conditions.

Many new designs do have such shut down mechanism to prevent such disasters.

Notes

Huge amount of heat is generated in nuclear power plants, only one third of the heat is used in generating electricity and two third is lost as waste heat. To reduce the harmful effect of the waste heat, costly cooling facilities are constructed and operated. Nuclear power plants are often constructed close to a large water source like lakes, rivers, oceans from where large quantities of water can be drawn directly and returned after cooling process is over.

22.6 SAFE DISPOSAL OF NUCLEAR WASTES

When the world entered the atomic age, the problem or the dangers of disposal of nuclear waste were not fully realized. It is now becoming increasingly clear that safe disposal of nuclear waste is not easy and simple.

Radioactive wastes are of two types (1) low level radioactive wastes (LLW) which include civilian applications of radionuclides in medicine, research and industry, materials from decommissioned reactors, protection clothing worn by persons working with radioactive materials or working in nuclear establishments.

(2) High level radioactive wastes (HLW) results from spent nuclear fuel rods and obsolete nuclear weapons.

Some proposed methods of disposing nuclear waste are:

- bury it deep underground in insulated containers. This is a strategy being pursued in United States.
- shoot it into the space or into the sun. The cost would be very high and a launch accident should be disastrous.
- bury it under the ice sheet of Antarctica or Greenland ice cap. The ice could be destabilized by heat from the waste. The method has been prohibited by international law.
- dump it into deep oceans by keeping the waste into glass and steel cases. But the containers might leak and contaminate the ocean. Both HLW and LLW into the Atlantic ocean. The method is prohibited by international law. Until 1983, European countries had been dumping before 1983 when dumping was stopped, by law 90,000 metric tons waste had been disposed in the ocean.
- change it into harmless or less harmful isotopes. Currently no method is known to do that and the method would be too costly.
- presently waste fuel rods are being stored in special storage ponds at reactor sites or sent to reprocessing plants. Even though reprocessing is more expensive but some countries use reprocessing as an alternative to waste storage.

Thus safe disposal of nuclear waste is a matter of debate.

Potentially usable sites or locations where nuclear waste can be disposed off should have some characteristics like-

- low precipitation;
- deep water table;
- slow moving ground water;
- absence or near absence, of exploitable resources in the area;
- absence of surface waters;
- low possibility of tectonic movement;
- adequate buffer zone (in case the waste gets loose).

INTEXT QUESTIONS 22.3

1. What is 'background radiation'?

   _____

2. What is a radionuclide?

   _____

3. What are the different steps of the fuel cycle?

   _____

4. Name the two recent nuclear disasters and their consequences?

   _____

5. Name three sites which can be used to dispose nuclear waste.

   _____

22.7 LIFE CYCLE ANALYSIS OR LIFE CYCLE ASSESSMENT

Society has become concerned about issues of natural resources depletion and environment degradation. Many industries have started using "clean technology" processes to provide "greener" products. Thus environmental effects or impacts of products and processes have become a key issue, that is why some companies are trying to find out methods to minimize their efforts on the environment. Many industries are actually using pollution prevention methods to check and improve their environmental performance.

Notes

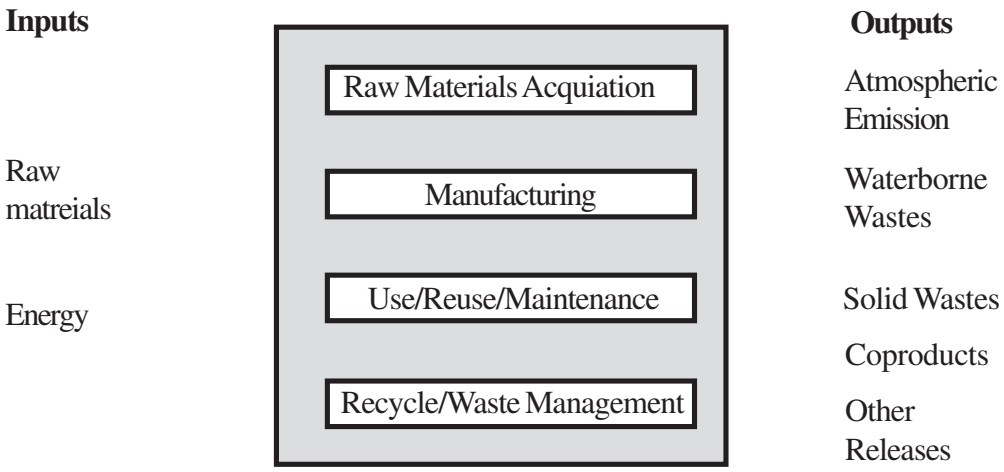

Fig. 22.2: *Life Cycle Stages* (Source EPA 1993)

Life Cycle Assessment (LCA) is actually a concept which considers the entire life cycle of a product. In other words it is a "cradle to grave" approach for assessing industrial production systems. It actually involves all stages of life cycle of the product e.g. raw material extraction, material transportation manufacturing product use and disposal of out of service product etc. The term "life cycle" refers to the major activities in the course of products life span from acquiring the raw material to its manufacture, use, maintenance and final disposal.

Life Cycle Assessment (LCA) is done in a systematic manner:

1. Aim or goal i.e. define or describe the product, process or activity.
2. Inventory analysis i.e. identify and quality energy, water, material used and environmental releases (e.g. air emissions, solid waste disposal and waste water discharge)
3. Impact assessment i.e. assess the human and ecological effects of energy, water and material usage and the environmental releases identified in the inventory analysis.
4. Interpretation i.e. evaluate the results inventory analysis and impact assessment to select the preferred product or service.

Benefits of conducting LCA

- It helps the decision makers to select the product or process that results in the least impact to the environment.
- The LCA data identifies the transfer of environmental impacts from one media to another e.g. eliminating air emissions by chemical washing of gaseous emissions and discarding the pollutants as liquid effluents.
- Human and ecological effects of material consumption and environmental releases to air, water and land in relation to each state of the life stage can be assessed.

22.8 CONCEPT OF ECOLABELLING

Labeling of environmentally beneficial goods and resources extracted by more sustainable methods can help consumers decide which goods and services to buy product ecolabelling can encourage companies to develop green products and services and help consumers select more environmentally beneficial products and services. Eco-labels are also being used to certify that the fish bearing ecolabels were caught by using sustainable fishing methods and also for timber products to certify and trees were harvested in accordance with by sustainable forest management principles.

22.8.1 Objectives of ecolabelling

The main objectives of ecolabelling are as follows-

- Protecting the environment and to make consumers aware of environment issues.
- Encouraging efficient management of renewable resources to ensure their availability to future generations.
- Promoting efficient management of non-renewable resources, including fossil fuels.
- Encouraging protection of ecosystems and species diversity.
- Encouraging proper management of chemicals to prevent pollution .

22.8.2 Ecolabelling in India

Ecolabelling scheme of Government of India supports cleaner (environmentally friendly) production practices. There is strong emphasis on cleaner manufacturing processes in the criteria used for the granting Eco-labels to products. Presently the scheme is limited to household and some consumer products to meet certain environment criteria alongwith quality requirements of Indian standards. The label is known as **'Eco mark'.**

The products for which notifications have been issued for the criteria are: toilet soaps, detergents, paper, architectural points and laundry soaps.

Eco-label is issued by the Central Pollution Control Board (CPCB) is represented by a pitcher or an **'earthen pot'** indicating that the product is not harmful to the environment like as an earthen pot which is made of soil and after its use returned to it the soil. It is without causing any harmful effect on the environment.

INTEXT QUESTIONS 22.4

1. What do you understand by life cycle of a product?

_____

Notes

2. What are the objectives of eco-labelling?

_____

3. What is the Indian ecolabel known as and what is the symbol?

_____

WHAT YOU HAVE LEARNT

- 'Cleaner technology' is using technology in industries in such a way that environment is protected from harmful effects of waste accumulation and resulting pollution.
- Waste in our surroundings can be classified in various ways – industrial solid and liquid, municipal solid and liquid, gaseous and radioactive or hazardous and non hazardous
- Industries may interact in such a way that waste of one industry becomes the "raw material" of another.
- Product and process can be redesigned to save accumulation of waste.
- Waste management is reducing or minimize waste, reuse and recycle the waste to make use of the waste.
- The three Rs of waste management are reduce, reuse and recycle.
- Each step of the "fuel cycle" is associated with hazard or risk. The steps are mining, processing, transportation and nuclear power and energy.
- Two important nuclear disaster are Three Mile Island (USA) and Chernobyl (Ukrain).
- It is not possible to control the nuclear radiations once they spread out in the environment accidentally.
- Disposal of nuclear waste must be given serious thought.
- Some special locations or sites must be located for "safer" disposal of nuclear wastes.
- LCA is actually a concept which considers the entire life cycle of a product.
- The ecolabel is issued by Central Pollution Control Board (CPCB) is symbolized a kitchen or "an Earthern Pot" indicating that on life cycle analysis basis.

TERMINAL EXERCISE

1. Define the term 'Cleaner Technology'. What is the main aim of management of this concept?
2. List the six major types of wastes generally produced?

3. Explain briefly the three 'R's of waste management.
4. Explain the following terms: (a) Throw away economy (b) Bioremediation (c) Ecolabelling (d) Ecomark
5. Give three examples by which waste production can be reduced by redesigning products or processes?
6. Explain the term primary recycling and secondary recycling. Give examples.
7. Briefly state the steps of 'fuel cycle' and the hazards that they cause.
8. Explain briefly the two nuclear disasters that took place in 1979 and 1986 with regard to causes, effects and preventive measures.
9. State five sites and locations where nuclear wastes can be disposed off.
10. Explain the concept of life cycle assessment of a product.

ANSWER TO INTEXT QUESTIONS

22.1

1. Industrial solid and liquid; municipal solid and liquid; gaseous and radioactive waste are generally found in the surroundings.
2. Carbon dioxide emitted from various sources can be used to produce calcium carbonate; sulphur dioxide emitted can be converted into either elemental sulphur or gypsum. Gas from petroleum field can be converted into methanol and petrol.
3. Cleaner technology is using industry to produce products and goods with minimum or no waste and pollution production.
4. Throw away economy is using the products or goods once or partially and disposing it off as waste.

22.2

1. Waste prevention should be our priority rather than managing the waste once it has been produced.
2. The three Rs in waste management are waste reduction, reuse and recycle. Reducing consumption and redesigning products we can reduce waste. Reuse of products will reduce waste. Waste can be turned into useful products by recycling.
3. Primary recycling when the waste is recycled into new product of the same type like old newspapers are recycled to produce new newsprint material.

Notes

Secondary recycling occurs when the waste material is converted into different products like old automobile tyres are shredded and turned into materials to be used in rubberized road surfacing.

4. A fuel efficient car gives more milage with less petrol and hence valuable resource like petrol.

22.3

1. We receive large amount of radiation from natural sources. It is present everywhere, all the time. This radiation is known as background radiation.
2. Radioactive atoms are known as "radionuclide.".
3. Mining of the radioactive are, processing to make it enriched, transporting to factories to turn it to fuel pellets, nuclear reaction to produce nuclear energy.
4. Three Mile Island (USA) in 1979 and Chernobyl (Ukrain) 1986. People at the site of the disaster suffered immediately by getting exposed to high dose of radiation. Their chances of cancer increased. Effect of radiation spread out at far away places exposing people to the risks of cancer and other health hazards.
5. Sites with low precipitation, with deep water table and absence of surface water.

22.4

1. "Life cycle" of a product means major activities in the course of life span of a product that is acquiring the raw material to its manufacture, use, maintenance and final disposal.
2. • Protecting environment and make consumers aware of environmental issues.
   - Promoting efficient management of non-renewable resources including fossil fuel.
   - Encouraging protection of eco-systems and species diversity.
   - Encouraging management of resources so that they are protected for future generations.
   - Encouraging proper management of (non toxic chemicals) in products.
3. It is known as "Eco-mark" and the symbol is an "Earthen Pot". The earthen pot symbolizes biodegradable fully harmless material.