Lecture 12 Causes, effects and management of nuclear hazards and industrial wastes.

The spontaneous emission of particles and rays by an unstable nucleus is called Radioactivity and such substances are called Radioactive Substances eg. Radium, Uranium, Thorium. Radioactive pollution can be defined as the release of radioactive substances or high-energy particles into the air water, or earth as a result of human activity, either by accident or by design. Sometimes natural sources of radioactivity, such as radon gas emitted from beneath the ground, are considered pollutants when they become a threat to human health. The sources of Radioactive wastes are

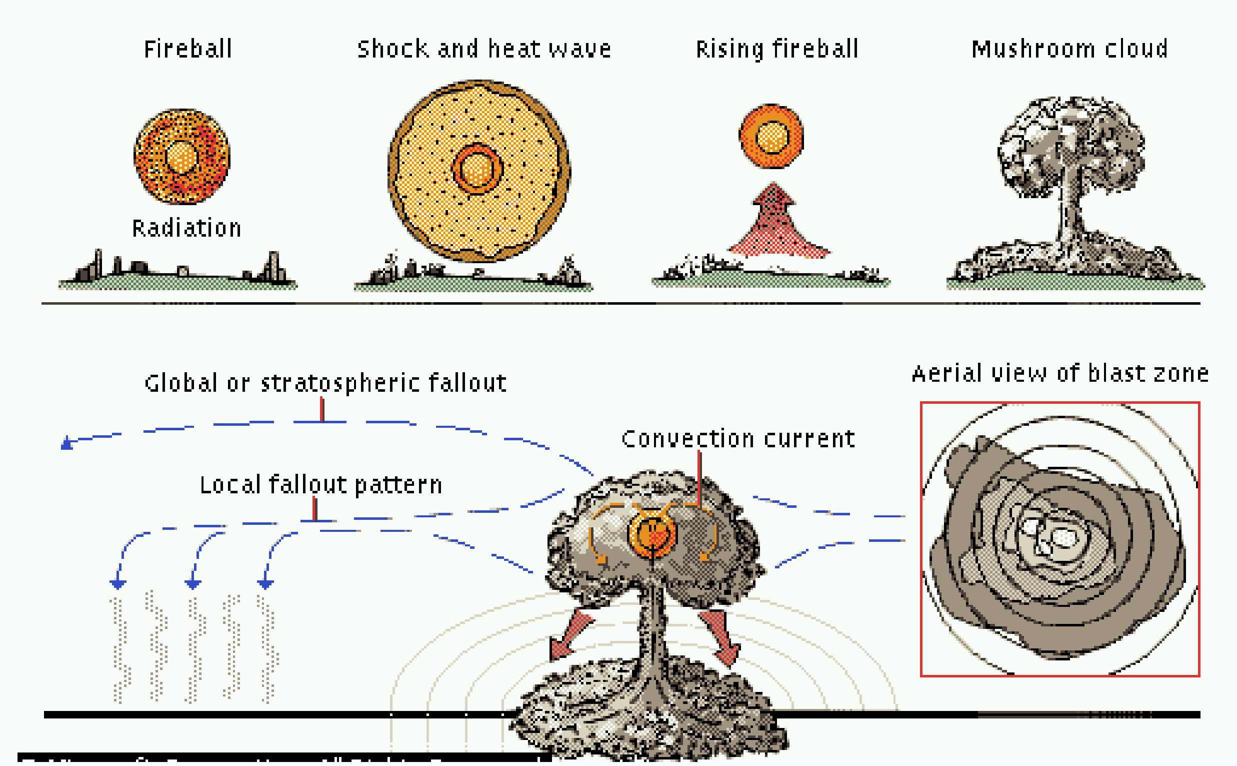
1) Natural sources: Solar radiation, Radionuclides in the earth Crust, Human Internal radiation, environmental Radiations.
2) Anthropogenic Sources: The sources of such waste include : 1) nuclear weapon testing or detonation; 2) the *nuclear fuel cycle,* including the mining, separation, and production of nuclear materials for use in nuclear power plants or nuclear bombs; (3) accidental release of radioactive material from nuclear power plants..

Since even a small amount of radiation exposure can have serious (and cumulative) biological consequences, and since many radioactive wastes remain toxic for centuries, radioactive pollution in a serious environmental concern even though natural sources of radioactivity far exceed artificial ones are present. The faster a radioisotope is decaying, the more radioactive it will be. Another factor in deciding how dangerous a pure radioactive substance will be is the energy of the radiation. Some decays yield more energy than others. This is further complicated by the fact that few radioisotopes decay immediately to a stable state, but rather to a radioactive decay product leading to decay chains.

Radioactive pollution that is spread through the earth's atmosphere is termed *fallout*. Such pollution was most common in the two decades following World War II, when the United States, the Soviet Union, and Great Britain conducted hundreds of nuclear weapons tests in the atmosphere. France and China did not begin testing nuclear weapons until the 1960s and continued atmospheric testing even after other nations had agreed to move their tests underground.

Three types of fallout result from nuclear detonations: local, tropospheric and stratospheric.

- Local fallout is quite intense but short-lived.
- Tropospheric fallout (in the lower atmosphere) is deposited at a later time and covers a larger area, depending on meteorological conditions.
- Stratospheric fallout, which release extremely fine particles into the upper atmosphere, may continue for years after an explosion and attain a worldwide distribution.



Types of radioactive waste:

Low level Waste (LLW) is generated from hospitals and industry, as well as the nuclear fuel cycle. It comprises paper, rags, tools, clothing, filters etc which contain small amounts of mostly short-lived radioactivity. It does not require shielding during handling and transport and is suitable for shallow land burial. To reduce its volume, it is often compacted or incinerated before disposal.

Intermediate level Waste (ILW) contains higher amounts of radioactivity and some requires shielding. It typically comprises resins, chemical sludges and metal fuel cladding, as well as contaminated materials from reactor decommissioning. It may be solidified in concrete or bitumen for disposal. Generally short lived waste (mainly from reactors) is buried in a shallow repository, while long lived waste (from fuel reprocessing) will be disposed of deep underground.

Transuranic Waste arises mainly from weapons production, and consists of clothing, tools, rags, residues, debris and other such items contaminated with small amounts of radioactive elements -- mostly plutonium. These elements have an atomic number greater than uranium -- thus transuranic (beyond uranium). Because of the long half-lives of these elements, this waste is not disposed of as either low level or intermediate level waste. It does not have the very high radioactivity of high level waste, nor its high heat generation. The United States currently permanently disposes of transuranic waste at the Waste Isolation Pilot Plant.

High level Waste (HLW) arises from the use of uranium fuel in a nuclear reactor and nuclear weapons processing. It contains the fission products and transuranic elements generated in the reactor core. It is highly radioactive and hot. It can be considered the "ash" from "burning" uranium. HLW accounts for over 95% of the total radioactivity produced in the process of nuclear electricity generation.

Waste Stored Safely Now

- After it is removed from the reactor, used fuel is stored at nuclear plant sites in steel-lined, concrete vaults filled with water.
- The water cools the used fuel and acts as a shield, to protect workers from radiation.
- This used fuel looks just like it did when it was placed in the reactor.
- The radioactive waste remains locked inside the uranium pellets, which are still encased in the metal fuel rods.

This used fuel has been stored safely at nuclear plant sites ever since the late 1950s, when the first nuclear power plants began making electricity. What is needed is a permanent repository for existing and future high-level waste. Initially, it was thought that spent fuel rods could be reprocessed and only to provide new fuel but also to reduce the amount of nuclear waste. However the cost of producing fuel rods by reprocessing was found to be greater than the cost of producing fuel rods from ore. Presently, India does operate reprocessing plants to reprocess spent fuel as an alternative to storing them as nuclear waste. At each step in the cycle, there is a danger of exposure to harmful radiation to possess several health and environmental concerns.

Effect of Radioactive wastes

Radioactive waste causes

- Soil pollution
- Water pollution

In these two pollutions, pollution hazards finally enter into the food chain the human who is the final victim of radioactive pollution as he is at the end of all reactions and interactions.

Effects of radioactive pollution:

The effect of radioactive pollution depends upon

- ✓ Half –life
- ✓ Energy releasing capacity
- ✓ Rate of diffusion
- ✓ Rate of deposition of the contaminant.
- ✓ Various atmospheric and climatic conditions such as wind, temperature, rainfall also determine their effects.

The possible general effects of radioactive wastes are categorised into

1) Somatic Effect
2) Genetic Effect
3) Biomagnification

Somatic effect: Affects somatic cells. It appears within individual and disappears with the death of the individual.

Immediate effects	: Anaemia, Reduced immune response, Haemorrhage , skin burn, mouth ulcers , CNS Damage
Delayed effects	: Eye cataract, Leukemia, Cardiovascular disease, Premature ageing ,Reduced life span , reduction of fertility

Genetic Effects: The radiation affects the genes of the gamete cells. The changes are not apparent in the individual. The effects are exhibited by offspring and in the subsequent generations. They affect the DNA, RNA replication and chromosome. It causes

- Mutation
- Chromosomal aberration
- Chromosomal fragmentation
- Inhibition of RNA,DNA synthesis

Radioactive Pollution Incidents:

The two best known examples illustrating the effect of fallout contamination are the bombing of Hiroshima and Nagasaki, Japan in 1945, and the Chernobyl Nuclear Power Station disaster in April 1986. Within five years of the American bombing of Japan, as many as 225,000 people had died as a result of long-term exposure to radiation from the bomb blast, chiefly in the form of fallout.

The disaster at the Chernobyl Nuclear Power Station in Ukraine on April 26, 1986 produced a staggering release of radioactivity. In ten days at least 36 million curies spewed across the world. The fallout contaminated approximately 1,000 square mites (2,590 sq. km) of farmland and villages in the Soviet Union. In addition to the hundreds killed at the time of the explosion, scientists predict the eventual Soviet death toll from the Chernobyl accident is around 200,000; the estimated mortality in western Europe may be around 40,000.

Control of Radioactive pollution

The main objective in managing and disposing of radioactive (or other) waste is to protect people and the environment. This means isolating or diluting the waste so that the rate or concentration of any radionuclides returned to the biosphere is harmless. To achieve this for the more dangerous wastes, the preferred technology to date has been deep and secure burial. Transmutation, long-term retrievable storage, and removal to space have also been suggested.

- Nuclear devices should never be exploded in air. If these activities are extremely necessary they should be exploded underground.
- In nuclear reactions, closed-cycle coolant system with gaseous coolants of very high purity may be used to prevent extraneous activation products.
- In nuclear and chemical industries, the use of radio-isotopes may be carried under a set of soil or water instead of power or gaseous forms.
- In Nuclear mines, wet drilling may be employed along the underground drainage.
- Nuclear reactors must be enclosed in broad concrete walls to prevent the radiations that emerge out.
- Workers should wear protective garments and glass spectacles should be screened from radiation.
- Extreme care should be exercised in the disposal of industrial waste contaminated with radionuclides. The spend rods are very radioactive containing about 1% U 235 and 1% plutonim.

Deep Underground Disposal

Geologic repositories deep underground have been endorsed by independent scientific organizations around the world including

- The National Academy of Sciences,
- The National Research Council,

❖ The Congressional Office of Technology Assessment.

Nearly every other country with a nuclear energy program, including Germany, France, Japan and Sweden, has determined that Deep Geologic Disposal is the safest system of permanent nuclear waste management.

Effects of industrial effluents

Industries need a wide variety of raw materials and chemicals which are later discharged as effluents. Acids, alkalis, toxic metals, pesticides and other poisonous substances such as cyanide, dyes, oils, detergents, resins, rubbers are a few to mention. Heated effluents that impart thermal loading on receiving waters and effluents containing radio active materials are also of prime concern. Some of the effluents such as from tanning and meat packing may also contain pathogenic bacteria. The nature and extent of pollution depends on the materials present in the effluent and on the quantity discharged.

Effects on water courses

Color : The effluents contain dyes in higher concentrations which impart color to the receiving streams and they persist for longer distances. Photosynthesis of phytoplankton is affected by these colors.

pH value : The extreme alkalinity makes the receiving water unfit for any purpose. Further, it is deleterious to most of the aquatic life.

Suspended impurities : The colloidal and suspended impurities produce turbidity in the receiving waters. The turbidity and color along with the oil and scum create an unsightly appearance.

Depletion of oxygen : Natural substances such as starch and dextrin and inorganic substances such as sulfide and nitrite present in the effluent exert an immediate oxygen demand. The stream will then be devoid of oxygen and the aquatic life are affected adversely.

Toxic substances : Chromium, sulfide, chlorine and aniline dyes present in these wastes are directly toxic to fish and microbial organisms which carryout purification. Thus the self purification of the water body is affected.

Oils : Various oils (mineral) in the effluent interfere with the oxygenation of stream as they form a blanket on the surface and prevents the entry of oxygen at air/water interface.

Dissolved minerals : The mineral materials, mostly sodium salts increase the salinity of the water and consequently it becomes unfit for irrigation.

Effects on land

1. The excess content of sodium (60%) and boron (2 mg/l) are deleterious to crops.
2. The high sodium alkalinity combined with salinity impairs the growth of plants.
3. Texture of the soil is affected by sodium and penetration of roots is prevented.
4. Soil permeability is also affected by sodium and ultimately the soil will lose its productivity.
5. Suspended and colloidal impurities clog the pores and form a mat on the surface of soil preventing the passage of air, water etc.

EFFECTS OF WATER POLLUTION

Pollution	Effects
Domestic waste	Water borne diseases like cholera (Vibrio cholera) typhoid, dysentery and various health problems , depletion of dissolved oxygen, objectionable odour.

Industrial effluents	It causes deleterious effects on living things and may bring death or sub lethal pathology of kidneys, liver, lungs, brain and reproductive system.
Agricultural waste	Excessive fertilizer leads to accumulation of nitrates in children called methemoglobinaemia. Richness of nutrients results in eutrophication.
Eutrophification	During eutrophification, algal bloom release toxic chemicals into the aquatic system. Algal Bloom leads to oxygen depletion and an increase in CO_2 level. Thus aquatic organisms begin to die which leads to succession.
Bioaccumulation (or) Biological magnification	Aquatic plants and animals can accumulate certain pesticides in their body tissues in greater concentration than in water. This phenomenon is commonly referred to as biological magnification or biological amplification eg.,DDT. It is more threatening as its concentration continuosly increases in successive trophic levels in a food chain which results in many health hazards. DDT absorbed by fish eating birds 25 ppm ↑ DDT in large fish 2 ppm ↑ DDT in small fish 0.5 ppm ↑ DDT in zooplankton 0.003 ppm ↑ DDT in water 0.000003 ppm or 0.003 ppb
Lead (pb)	Anaemia, vomiting, damage of liver, brain and kidney
Arsenic(A)	Mental disturbance, lung cancer, ulcer, kidney damage
Mercury(Hg)	Abdominal pain, headache, diarrhea, chest pain
Cadmium(Cd)	Growth retardation, diarrhea, bone deformation, kidney damage, anemia, damage to lever
Barium(Ba)	Excessive salvation, diarrhea, paralysis
Chromium(Cr)	Gastro intestinal ulceration, diseases of central nervous system, cancer, nephritis
Zinc(Zn)	Vomiting, renal damage
Copper(Cu)	Hypertension, uremia, coma
Temperature:	Reduction of dissolved oxygen , Increase in Biological Oxygen Demand Early hatching of fish eggs and fish mortality, Mitigation of aquatic biota
Radioactivity	Serious skin cancer, carcinoma, melanoma, breast cancer, leukemia, DNA breakage and cataract
Siltation	Reduced visibility, Reduction in direct light penetration, Decrease in photosynthetic rate, Chances of anaerobic digestion in the benthos zone.
Oil	Reduction of dissolved oxygen in the water, Reduction in the light penetration, Direct oil coating makes the fishes unable to respire and clog their gill slits, hydrocarbons cause necrosis, paraffins like methane and ethane are asphyxiants.

Synthetic detergent	Complex formation between DNA and mercury or cadmium results in birth defects. Although detergents are not highly toxic to fishes they do cause damage to gills and remove the protective mucus from skin and the intestine.

Effect of Solid waste

Any material that is thrown away or discarded as useless and unwanted is considered as solid waste. At first glance, the disposal of solid waste may appear to be a very simple and mundane problem. In this age of lasers, microcomputers, and space flight, it hardly seems possible that garbage disposal should present any great challenge. But many factors make solid waste disposal a complex problem of huge proportions for a modern industrial society.

Classification of solid wastes

Domestic and municipal wastes: These include garbage and rubbish, like waste paper, plastic, cloth from households, office, hostel and market.

Industrial wastes: The two general categories are process and non-process wastes. The non-process wastes are common to all industries such as packaging, office and cafeteria wastes. Process wastes are more complex and specific to the industrial plants. Their composition depends on type of products produced.

Agricultural wastes: These include cereal and millet straw, paddy husk, sugarcane trash and other crop residues.

Special wastes: The waste materials which endanger public health and welfare and seriously affect environment are : a) Radioactive wastes from atomic power stations, labs and hospitals b) Toxic wastes such as pesticides, heavy metals, pharmaceuticals c) Biological products such as antibiotics, enzymes, pathogens.

Auxiliary operations necessary for solid waste treatment

i) Transport and handling

ii) Pulverization

iii) Compaction

Transport and handling

Solid wastes are collected from source, transported in trucks with hydraulic and pneumatic system to a central place and to compact the waste to a high density, for disposal.

Pulverization

Pulverization of solid wastes is carried out prior to loading, land filling, compacting or incineration to facilitate these processes. Taw roll, impact and gyratory crushers and hammer mills are used for pulverization. It makes the solid waste homogenous and helps in greater initial settlement. The land can be more easily reclaimed and built on.

Compaction

Compaction and balling of solid wastes using hydraulic or pneumatic processes lead to reduction in refuse volume, reduction in collection and transport time and cost, lesser storage area and safety hazards and cleaner storage area.

The most effective way to ameliorate the solid waste disposal problem is to reduce the generation and toxicity of waste. But, as people search for better life and higher standard of living they tend to consume more goods and generate more wastes. Consequently society is searching for improved methods of waste management and ways to reduce the amount of waste management system. This consists of reducing the amount of toxicity of the wastes at the source, recycling, reusing or composting as much of the waste as is economically reasonable. Burning the waste that cannot be economically recycled to generate heat reduces the need for fossils and nuclear fuels.

Recycling and waste reduction play an important part in any waste management strategy. But engineering analysis clearly shows that these options alone cannot solve the solid waste problem. At the same time, according to best estimates, it may be possible to reach recycling technologies that must be developed, additional markets must be found, and industry must produce more products that are easy to recycle. All the same, even if all of these steps are successfully taken more than 160 million tons of solid waste still have to be treated by other means, such as waste – to – energy combustion and land filling.

Technologies in solid waste management

Solid waste management is a difficult process because it involves many disciplines. These include, technologies associated with the control of generation, storage, collection, transfer and transportation, processing, marketing, incineration and disposal of solid wastes. All of these processes have to be carried out within existing legal and social guidelines that protect the public health and environment and are aesthetically acceptable. They must be responsive to public attitudes and the disciplines included in the disposal process include administrative, financial, legal, architectural, planning and engineering functions. For successful integrated solid waste management plant, it is necessary that all these disciplines communicate and interact with each other in a positive interdisciplinary relationship .The various techniques employed in solid waste management include,

1) Composting

2) Sanitary land filling (Controlled tipping)

3) Thermal process (Incineration and pyrolysis)

4) Recycling and reuse

COMPOSTING

It is being increasingly realized that composting is an environment friendly process to convert wide variety of wastes into valuable agricultural inputs. This process minimizes the environmental problems. Composts are excellent source of humus and plant nutrients, the application of which improves soil biophysical properties and organic matter status of the soil. Composting can be defined as the biological conversion of organic wastes into an amorphous dark brown to black colloidal humus like substance under conditions of optimum temperature, moisture and aeration. Nutrient content of compost depends largely on the nutrient content of the wastes. Composting is a process in which the organic portion of solid waste is allowed to decompose under carefully controlled conditions. It is a biological rather than a chemical or mechanical process; decomposition and transformation of the waste material are accomplished by the action of bacteria, fungi, and other microorganisms.

With proper control of moisture, temperature, and aeration, a composting plant can reduce the volume of raw organic material by as much as 50 per cent. In addition, composting can stabilize the waste and produce an end product that may be recycled for beneficial use. The end product is called **compost** or **humus**. It resembles potting soil in texture and earthy odor, and it may be used as a soil conditioner or mulch.

A complete municipal solid waste (MSW) composting operation includes sorting and separating, shredding and pulverizing, digestion, product upgrading, and finally marketing. Sorting and separation operations are required to isolate organic, decomposable waste materials from the plastic, glass, metal, and other non biodegradable substances. Solid waste sorting and separation methods are a key part of MSW recycling operations.

Shredding and pulverizing serve to reduce the size of the individual pieces of the organic waste, resulting in a relatively uniform mass of material. This facilitates handling, moisture control, and aeration of the decomposing waste. Size reduction also helps optimize bacterial activity and increases the rate of decomposition. After size reduction, the wastes are ready for the actual composting or digestion step. Digestion may take place in open windrow or in an enclosed mechanical facility.

A windrow is a long, low pile of the prepared organic waste, usually about 3m (10 ft) wide at the base and about 2 m (6 ft) high. Most windrows are conical in cross section and about 50 m (150 ft) in length. The composting waste is aerated by periodically turning each windrow. Turning frequency varies with moisture content and other factors. When moisture content is maintained at about 50 per cent, windrows are turned two or three times a week and in some cases daily.

Generally, open – field windrow composting takes about 5 weeks for digestion or stabilization of the waste material. An additional 3 weeks may sometimes be required to ensure complete stabilization. Temperatures in an aerobic compost windrow may reach 65^{o}C (150^{o}F) because of the natural metabolic action of thermophilic microbes that thrive at such elevated temperatures. The relatively high temperatures destroy most of the pathogenic or disease-causing organisms that may be present in the waste.

Open-field windrow composting requires relatively large land areas. To reduce land requirements, various types of enclosed mechanical systems can be used in lieu of the open-field method. A variety of mechanical type compost systems are available. Oxygen is supplied to the waste material by forced aeration, stirring, or tumbling. In addition to reducing land requirements, enclosed mechanical compost facilities can reduce the time required for stabilization from about 5 weeks to about 1 week.

Composting is the aerobic, thermophilic degradation of organic matter present in the refuse by microbes, predominantly by fungi and actinomycetes, which are favoured by semi moist condition that prevail in the process. The control parameters for optimum composting include, temperature ($40^{O}C$), moisture (40.7%), pH (4.5 – 9.5), nutrients (C:N ratio 40:1); C:P ratio (100:1), air (0.5 – 0.8 m / d / kg volatile solid) and particle size (6-25 mm).

The digestion of the waste is carried out naturally in an outside decomposition area in windrows (for five weeks) or in mechanized composting plants (for 4 to 6 days). In natural system, the garbage is mixed with nutrient source (sewage sludge / animal manure) and a filler (wood chips) to provide entry of air. The mixture is turned over twice a week and the process is completed in 4-6 weeks. The darkening of refuse, fall in temperature and a musty odour indicate completion of the process.

Before the stabilized compost or humus can be sold for use as a mulch or soil conditioner, it must be processed further to upgrade or improve its quality and appearance. This includes drying, screening, and granulating or pelletizing. Sometimes, the compost is placed in bags, although bulk sale is more efficient and economical. Compost can increase the organic and nutrient content of soil and improve its texture and ability to retain moisture.

Co-Composting

An interesting example of integrated waste management is co-composting of municipal solid waste and sewage sludge. Sewage sludge adds nitrogen, phosphorous, and other elements that enrich the solid waste and help the composting process. The sludge is first dewatered so that it does not add too much moisture to the compost pile. The dewatered sludge and organic portion of MSW must be thoroughly mixed. At a time when ocean disposal of sludge has been banned and sludge incinerators meet with much public opposition, co-composting may offer an increasingly viable technique for processing both sludge and MSW organics prior to final disposal.

Vermicomposting

The key role of earthworms in improving the soil fertility is well known for a longer period. Earthworms feed on any organic wastes, consume three to five times their body weight and after using 5 to 10 per cent of the organic wastes for their growth, excrete the mucus coated undigested matter as worm casts. Worm casts consist of organic matter that has undergone physical and chemical breakdown through the activity of the muscular gizzard, that grinds the material to a particle size of 1-2 micron. The nutrients present in the worm casts are readily soluble in water for the uptake of plants. Vermicastings are rich sources of macro and micronutrients, vitamins, enzymes, antibiotics, growth hormones and immobilized micro flora.

Vermicompost refers to organic manure produced by earthworms. It is a mixture of worm castings, including humus, live earthworms, their cocoons and other micro organisms. Vermicomposting is an appropriate method for disposal of non-toxic solid and liquid organic wastes. It helps in cost effective and efficient recycling of animal wastes (Poultry droppings, horse, piggery excreta and cattle dung), agricultural residues and industrial wastes using low energy.

Types of earthworms

Several types of earthworms are found in our soils. Earthworms can be divided into the following two categories:

1. Epigeic – the surface living worms
2. Endogeic – the burrowing worms

Epigeic: These worms are found on the surface and are reddish brown in colour. They do not process the soil but are efficient in composting of organic wastes. They enhance the rate of organic manure production through biodegradation or mineralization.

eg. *Lampito mauritii, Octochaetona serrata, Perionyx excavatus*

Endogeic: These species burrow and mix the soil, from different horizons in the profile. They ingest organic and mineral fraction of soil, thus promoting the formation of organo mineral complexes. Organo – mineral crumbs are brought from deeper parts of the soil profile to the surface. Different species of earthworms show specificity to soil types, moisture content and temperature.

Method of vermicomposting

- Selection of earthworm: Earthworm that is native to the local soil may be used
- Size of pit: Any convenient dimension such as 2m x 1m x 1m may be prepared
- Preparation of vermibed: A layer, 15-20 cm thick of good loamy soil above a thin layer of (5 cms) broken bricks and sand should be made.
- Inoculation of earthworms: About one hundred earthworms are introduced as an optimum inoculating density into a compost pit of about 2m x 1m x 1m, provided with vermibed
- Organic layering: It is done on the vermibed with fresh cattle dung. The compost pit is then layered to about 5 cm with dry leaves or hay or organic wastes. Moisture content of the pit is maintained by the addition of water.

- Wet organic layering: It is done after four weeks with moist green organic waste, which can be spread over it to a thickness of 5 cm. This practice can be repeated every 4 days. Mixing of wastes periodically without disturbing the vermibed ensures proper vermicomposting. Wet layering with organic wastes can be repeated till the compost pit is nearly full.

Harvesting of compost: At maturation (after 120 days), the moisture content is brought down, by stopping the addition of water. This ensures drying of compost and migration of worms in to the vermibed. The mature compost, a fine loose granular mass (about 1500 kg), is removed from the pit, sieved, dried and packed. Matured vermicompost is rich in nutrients and recommended @ 50 t ha^{-1}.

Characteristics of vermicompost

pH	7.00
EC dsm^{-1}	1.20
Organic carbon%	30.50
Macronutrients	
Total nitrogen %	0.66
Total P_2O_5%	1.93
Total K_2O%	0.42
Micro nutrients	
Fe (ppm)	19.8
Zn (ppm)	0.90
Mn (ppm)	16.50
Cu (ppm)	2.30

Sanitary land filling (Controlled tripping)

Land filling is the most common and economic method of solid waste disposal. The indiscriminate land filling of solid waste in open dumps without adequate control and consideration of sanitation and public health as generally followed in India is dangerous. It results in water pollution, bad odour, fire and breeding of flies and rats.

It should be replaced by sanitary land filling or controlled tipping. The construction of sanitary land filling includes:

1) Deposition of solid waste in such a way to have a working force of minimum area.

2) Spreading and compaction of waste in thin layers

3) Covering of the waste with a layer of compacted cover soil daily.

4) Final cover of the entire construction with compacted earth layer of 1.0 m thick.

The solid wastes in sanitary land fill are degraded by soil microbes. In comparison with other biological treatment systems such as activated sludge and anaerobic digestion, the microbial degradation of solid waste proceeds at a slow rate.

Thermal process

Incineration

Incineration is a process of destruction of waste at high temperature. The combustible wastes are converted through controlled combustion to a residue, which contain no combustible matter. If land suitable for solid waste (SW) land filling operations is not available within economic haul distances, then incineration is necessary. The solid waste is reduced in volume (80% - 90%) and height (98-99%). Incinerator can accept toxic and industrial wastes of any size in solid or powdery form. The other special wastes include hospital wastes, putrifiable organic solids from slaughter houses.

Pyrolysis (Destructive distillation)

Pyrolysis is the process of conversion of biomass into solid, liquid and gaseous energy. Pyrolysis results in the chemical breakdown of organic carbon material into three basic components: 1) gas phase containing mainly hydrogen, CO_2, CO and CH_4 2) tar or oil phase containing simple organic acids, methanol and acetone and 3) char phase made up of pure carbon and inert material. Pyrolysis does not cause pollution of the atmosphere and large quantities of potentially hazardous plastics could be treated.

There is no single prescription for an integrated waste management program that successfully works in every instance. Each situation must be analyzed on its own merit, an appropriate integrated waste management plan must be developed from hard data, and social attitudes and the legal frame work must be taken into account. The waste management disposal field is in a constant state of flux and appropriate solutions should be innovative, as well as technically and economically sound.

Sludge management

Suspended solids removed from wastewater during sedimentation and then concentrated for further treatment and disposal are called **sludge** or **biosolids**. Even in fully aerobic waste treatment processes in which sludge is repeatedly recycled, most of the sludge must eventually be removed from the system. The task of treating and disposing of this material is called **sludge management**.

Sludge characteristics

The composition and characteristics of sewage sludge vary widely. Since no two wastewaters are alike, the sludges produced will differ. Furthermore, sludge characteristics change considerably with time. Wastewater sludge typically contains organics (proteins, carbohydrates, fats oils), microbes (bacteria, viruses, protozoa), nutrients (phosphates and nitrates), and a variety of household and industrial chemicals. The higher the level of heavy metals and toxic compounds, the greater is the risk to humans and the environment. A key physical characteristic is the solids concentration, because this defines the volume of sludge that must be handled.

Sludge is treated prior to ultimate disposal for two basic reasons: **volume reduction** and **stabilization of organics**. Stabilized sludge does not have an offensive odor and can be handled without causing a nuisance or health hazard. A reduced sludge volume minimizes pumping and storage requirements and lowers overall sludge-handling costs. Several processes are available for accomplishing these two basic objectives. They include sludge thickening, digestion, dewatering, and co-composting. Incineration is considered as a final disposal option.

Sludge disposal

Widely employed methods for final disposal of waste water sludge have included ocean dumping, land filling, incineration, land application, and sale as fertilizer.

Effect of hazardous wastes

The World Health Organization (WHO) considers waste causing short term hazards such as acute toxicity by ingestion, inhalation or skin absorption , corrosivity or other skin or eye contact hazards or risk or fire and explosion and wastes causing long term hazards including chronic toxicity upon repeated exposure, carcinogenecity, resistant to detoxification process such as biodegradation, the potential to pollute underground or surface water or aesthetically objectionable properties such as offensive smell as “hazardous wastes”.

The major hazardous wastes include,

- Radionuclides
- Xenobiotics
- Heavy metals

Industrial growth, economic development, consumerisation indicate a country’s progress and life standard of individuals. Industrial growth has brought along with new problems, too. Water pollution, air pollution, land pollution, noise pollution, radioactive pollution, solid wastes, depletion of resources, scarcity of good quality water, spreading health hazards, are all the consequences of stupendous industrial activities with less attention to its negative impacts on man and his environment (Ramana, 1999). Nature’s built in mechanisms and self regulation ability has been thrown out of gear by the quantity and complexity of wastes generated by the modern society. As technological progress has followed the industrial revolution, environmental problem solving must follow technological progress. Industrial processes and products thereof both must become environmentally friendly and least damaging.

Hazardous waste management is the most challenging task before the different technologies. Although efforts are continuously on to improve upon the raw material usage, processes and search for alternative eco friendly products, the generation of hazardous wastes and their quantitative contribution requires to be tackled.

Treatment technologies for hazardous wastes

Physical	:	Soil washing, Air \stream stripping, Vitrification, Solidification, Carbon adsorption, Ion exchange.
Thermal	:	Incineration
Chemical	:	Solvent extraction, oxidation, ozonolysis, Electro kinetic removal.
Biological	:	Land farming, composting, bio reactor processes, bio- enrichment, bio augmentation and landfill.

Principles of Biological Treatment methods

"***Biostimulation***" and "***bioaugmentation***" are the two main ways of initiating biological treatment, particularly in land treatment for hazardous wastes. Biostimulation makes use of existing microorganisms and makes conditions favourable for their action by adjustment of nutrients, pH, temperature, growth factors etc. Bioaugmentation involves externally introduced cultures pure or mixed with specific degradation capacities. Bioaugmentation if done for biodegradation, introduced microorganisms should able to remain viable, should compete with the existing microorganisms.

Genetic, biochemical and ecological ability of microorganisms used plays important role in biodegradation. Although a faster kinetic rate will mean a less expensive system, biomass with a slow specific growth rate responds more favourably to shock loadings. Reactors are to be designed so that microbiological systems are properly controlled under various operating conditions to give effluents of acceptable quality.

Treatment systems

Suspended growth and fixed film are the two main categories of treatment systems although combinations of them are widely used. Immobilised systems are less sensitive to toxicity and have higher efficiency in degradation of hazardous wastes. Fixed film systems are more stable due to a higher biomass concentration and resistance to mass transfer. In fixed films, no wash out of organisms occurs even if the growth rate of the organisms is greatly reduced. Land treatment is the most widely used option to treat toxic wastes .

Microbial Cultures for biodegradation

Biological detoxification may be carried out using pure cultures or mixed cultures. Mixed cultures have a potential advantage over pure cultures in the degradation of toxic compounds in hazardous wastes. Mixed cultures are particularly useful when complete degradation of toxic organics to CO_2, CH_4, H_2S, N_2 etc. Enrichment and selection procedures are useful in selecting mixed cultures carrying out degradation.

Biotechnological process for treating liquid waste containing toxic metals

- Adsorption
- Extra cellular precipitation
- Uptake by purified bio polymer

Adsorption of heavy metals to living or dead cells, extra cellular polysaccharide , capsules and slime layer all referred as biosorption. Cell walls and envelops of bacteria, yeast, algae are very efficient in bio sorption due to the charged group present in them. Metals may deposit around cells in the form of phosphates, sulfates or oxides.

Advantages of Biological Treatment methods

- These methods have economic advantages over other methods.
- Diversity of degradation action is possible by biological treatment.
- These methods are robust and have a large capacity for degrading toxic and hazardous materials.

Disadvantages of Biological treatment

i. Difference in wastes

Microbial enzymes responsible for degradation are specific for individual compounds , no single organism destroy all wastes.

ii. Concentration of waste chemicals

Higher concentration of toxic chemicals inhibit the survival of key members.

iii. Inhibitory mixtures

Industrial wastes / contaminated sites contain not only the toxic chemicals but also the other chemicals that incompatible with the catabolism of target compounds.

iv. Rate of degradation

Because of the above problems the degradation / treatment process is very slow and hence, development of improved strains essential.

Cloning vector for environmental applications

The environmental applications of genetically engineered organisms requires the use of cloning vector that function under environmental conditions are stably maintained , non transmissible , cost effective , environmentally friendly Modern molecular biological techniques, in particular rapid sequencing, the polymerase chain reaction, and site-directed mutagenesis, allow selective alteration of nearly any protein and provide an avenue into rational protein design to improve catabolic activities protein engineering may improve enzyme stability ,substrate specificity, and kinetic properties.

Construction of bacteria with multiple pathways

Genetic engineering permits the combination of several degradative activities within a single host organism. For eg: Bio remediation efforts are sometimes limited by the survival and or *in situ* performance of an added bio catalyst because of ecological factors that are not easily predicted from laboratory studies. Moreover , the combination of multiple activities in host that is easily and inexpensively cultured to high cell densities would certainly reduce fermentation costs.

Advantages of *in situ* application:

- It allows destruction of contaminants *in situ*
- Minimum risk, and environmental impact
- Minimum cost for removing, treating, and disposing

Engineering stress resistance

Microorganisms used to remediate hazardous wastes are likely to be exposed to a wide variety of environmental stresses . Stress factor can range from high concentration of contaminants, toxic metals, or solvents; through extremes in pH , oxygen tension , temperature , ionic strength, and nutrient concentrations; to conditions of extremely low carbon and nutrient availability. Microorganisms must adapt to these conditions to be able to effect remediation. In some cases genetic engineering may be helpful in augmenting resistance to such stresses, there by facilitating good performance of the degradative organism under adverse conditions.

The following is the list of *in situ* options with order of preference for hazardous waste management.

- Eliminate hazardous waste generation at production process stage
- Do recovery of constituents of hazardous waste
- See if landfill is suitable and economical
- Decompose the waste by physical / chemical/biological means
- Immobilise the waste by solidification or encapsulation so that landfill becomes acceptable.

Improper disposal of hazardous and toxic waste can cause serious damages to health and environment. Recalcitrant, man made compounds and their products are of major concern in this regard. Bioremediation, is one of the most effective innovative technologies to come along in this century to treat these hazardous wastes. They offer complete destruction of contaminants and can often be applied at a lower total cost, at a faster rate. With the advancement of bioreactor designs, the use of genetically engineered microbes, biodegradation technology has been successful in making its impact felt on pollution abatement efforts.

Lecture 12 Causes, effects and management of nuclear hazards and industrial wastes.

1.	Nuclear wastes comprises paper, rags, tools, clothing, filters etc which contain small amounts of mostly short-lived radioactivity is called as	
	a)Medium level waste	**b)Low level waste**
	c)High Level waste	d) Transuranic wastes
2.	Nuclear waste which requires 100% shielding during disposal is	
	a)Medium level waste	b)Low level waste
	c)High Level waste	d) Transuranic wastes
3.	The waste which contains elements having an atomic number greater than Uranium is	
	a)Medium level waste	b)Low level waste
	c)High Level waste	**d) Transuranic wastes**
4.	Radioactive pollution that is spread through the earth's atmosphere is called -----------	
	a) Transuranics	**b)Radioactive fallout**
	c)Radionulides	d)Low level waste
5.	The disaster at the Chernobyl Nuclear fallout contaminated approximately ------------ square miles of farmland and villages in Ukraine , Soviet Union.	
	a)200	b) 400
	c)800	**d) 1,000**
6.	The part of human body is the first to be affected by nuclear radiation?	
	a)Lungs	b) Brain
	c. Bone marrow	d. Liver.
7.	Vitrification is disposing nuclear waste	
	a)Burying below ground	**b)Solidifying in the form of glass**
	c)Ice Sheet Disposal	d) Deep geological disposal
8.	Converting part of the hazardous nuclear waste into a more stable material that decays quickly	
	a) Transmutation	b) Vitrification
	c)Ice Sheet Disposal	d) Deep geological disposal
9.	International Agreement is necessary for	
	a)Ice Sheet Disposal	b) Deep geological disposal
	c)Burying below ground	**d) Space Disposal**
10	Richness of nutrients in industrial waste water leads to	
	a)eutrophic condition	b)oligotrophic
	c)mesotrophic	d)none of the above
11	Increase in the concentration of a recalcitrant compounds along the food chain is	
	a)biomagnification	b)bioaccumulation
	c)biosorption	d)none of the above
12	The main problem associated with managing Indian solid waste is	
	a)segregation	b)high moisture content
	c)season variation	**d)all the above**
13	Sludge is treated prior to ultimate disposal for	

	a)stabilization of organics	b)volume reduction
	c)pathogen reduction	**d)all the above**
14	Integrated waste management is	
	a)co composting	b)composting
	c)vermicomposting	d)all the above
15	Destructive distillation ic called	
	a)pyrolysis	b)incineration
	c)controlled tripping	d)none of the above