COURSE CODE:	EMT 304
COURSE TITLE:	Hazardous Substances Management
NUMBER OF UNITS:	3 Units
COURSE DURATION:	3 hours per week

COURSE DETAILS:

Course Coordinator: Dr. Mrs. O.O. Olayinka

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Office Location: EMT Dept COLERM

Other Lecturers:

COURSE CONTENT:

The nature, origin and classification of hazardous toxic substances, Characteristics of wastes and hazardous substances, Identification of hazardous substances, sources and pathways of hazardous substance. Geological and Environmental factors affecting choice of disposal site, contamination of water bearing strata; soil, plants, food webs and bio-concentration. Analysis of hazardous and toxic substances. Regulations and law governing the sale, importation, transportation, storage and disposal of hazardous and toxic substances. Regulations and law governing the sale, importation, transportation, storage and disposal of hazardous and toxic substances.

COURSE REQUIREMENTS:

This is a compulsory course for all 300 level students in the EMT Department. It is compulsory that students should participate in all the course activities and have minimum of 75% attendance in order to be qualify to write the final examination.

READING LIST:

1. Environmental Science Text Book pg 578-592, Daniel B. Botkin & Edward A Kelles
2. Anderson D.D and Burnhem I (1992).. Towards sustainable waste management; Issues in Science & Technology 9(1); 65-72
3. Kovacs W.I. 1993 "Solid Waste Management; Historical and future perspectives Resources, conservation and recycling 8: 113 – 130

Zim , K.I, and Mayes J. 1990. T. W. Management of Hazardous Substances in the Environment.

LECTURE NOTES

EMT 304 (HAZARDOUS SUBSTANCE MANAGEMENT)

Hazardous substance is defined as substance that causes a significant mortality or an increase in serious irreversible or reversible illness to human being.

Two basic terms have been used to describe substance known to have harmful effects on human beings
i) Toxic ii) hazardous

i) Toxic can be regarded as a narrow group of substance that is capable of causing death or various injuries to human beings & animals.
ii) Hazardous is a broader term referring to a substance that causes immediate or long term effect to people and their environment.

SOURCES OF HAZARDOUS SUBSTANCE INTO THE ENVIRONMENT

Hazardous substance gets to the environment via two routes: (a) Natural (b) Anthropogenic sources.

(a) Natural sources: these are sources that exist independently of human activities and include natural occurring minerals, metals or gases which are found in certain geographical areas. E.g Radium occurs in large concentration in soil and ores containing uranium, granite and shaleon. Radium can leak to residential housing via cracks in concrete walls, it has been estimated that about 20000-30000 lung cancer death per year in the USA is attributed to radium. Another source of naturally occurring hazardous substance is from the earth crust e.g. volcanoes & earthquakes. Toxic gases like SO2, nitrogen oxides,NO2 are emitted into the atmosphere via volcanic eruption, also hazardous substance can be found naturally in plant e.g. contaminated product like aflatoxin that is produce from groundnut, the most prominent effect of aflatoxin is liver damage.

(b)ANTHROPOGENIC SOURCES

These are sources created by human activities. It can be said that the anthropogenic source s represent two edged sword. There has been tremendous increase due to improvement and better practices. For example, treatment of surface water with chemicals kills microorganism that causes various human and animal diseases. Some of these chemical treatments are known to produce by product like chloroform which has adverse effect. Also the advancement has increased the wide range of useful product like nylon, industrial solvent, fertilizers, pesticides. Agrochemicals have resulted in the production of more food at relatively cheap price, however, these important group of chemicals has done a lot of harm to various ecosystem.
From all the various anthropogenic sources, their release into the environment may either be routine or accidental.

Routine release may occur repeatedly over many years and these may be from natural or man made sources. e.g.(cigarette smoking, solvent for dry cleaning, disinfection of water, use of building materials e.g. concrete, asbestos etc)

Accidental release of hazardous are unpredictable, it can occur for a very short or longer period. It can also be natural or human induced.

CLASSIFICATION OF WASTE AND HAZARDOUS SUBSTANCE

Hazardous waste consist of individual waste materials and combination of waste that are presently and potentially hazardous to humans and other living organism by means of the physical or chemical characteristics, the process by which they are produce or their effect on human health or the

environment. The criteria used in the classification of hazardous substances include type of hazard involved e.g. Toxicity, Explosiveness, Flammability or Corrosiveness. The generic category of substance cab be used e.g., pesticides, wood preservatives, solvent and medicine etc. It can also be classified base on technological origin i.e. oil refining, electroplating. Presence of specific substance can also be classified e.g. cadmium, Pb, C. Radioactive substance is classified separately because of their toxicity and their long life activity.

A brief list of some types of substance classified hazardous include:

Compressed gas

Flammable liquids and flammable solids

Oxidizing materials

Corrosive materials

Poisonous materials

Ethiolegic agents e.g. bacterial and virus causing infection diseases and radioactive irradiation.

Hazardous waste can cause considerable pollution of air, water and soil even before they are officially disposed off this can occur during transit such as when vehicle carrying hazardous waste of dangerous chemical get involved in an accident. Widespread pollution has also occurred during temporary storage of waste in pumps and open tanks where they can volatilize in the air or leak into surface water or the soil and the water.

ANALSIS OF HAZARDOUS SUBSTANCE

The natural environment had survived great damage as a result of man industrial activities; one of the most obvious examples of disturbance to the ecosystem is the obliteration of plant and animal community by the deposition of waste generated from industrial operation which in most cases is toxic. In analyzing hazardous substance, sample preparation is most vital because these determine a lot about the waste materials.

PREPARATION FOR SAMPLES

In preparing for sampling, drum to be sampled should be moved to a separate staging area prior to opening. The staging area should be cleared of other drums, equipment and traffic to prevent the smell of contaminated and possible fire or explosion. As an analyst, the level of protection for drum sampling is determined by the research of the drum content and by the generated laboratory result. if a lesser degree of respiratory protection is chosen continuous monitoring must occur during drum sampling activities to ensure that personnel are not being over exposed to volatile materials.

DRUM SAMPLING

Manual method with non sparking metals alloy tools are used when drum shows no sign of over pressurization, damage or corrosion and are not air reactive or explosives. If drum shows virtual signs of being pressurized, corrosion, explosives or certain reactions then remote opening device are recommended. No destructive techniques are to be used whenever it is impossible to open drum for sampling.

GENERAL SAMPLING PROCEDURE

The sampling method will be determined by the type of container, access to the container and the physical state of the sample in the container (liquid, sludge or solid)

LIQUID WASTE

Liquid sample from drums are usually collected with glass tubes. The glass tubes are normally 122cm long and 6-8mm inside diameter. The larger diameter tube may be necessary to sample viscous liquids. The glass tubing is placed inside the open drum at least 30cm of tubing should remain above the drum or liquid to prevent contact with the contaminated material. Sufficient time must pass to allow the liquid level in the glass tubing to reach the level of liquid in the drum. The top of the glass tube is capped with a stopper or personnel with appropriate gloves may also cap it. While capping, the glass tube is removed from the drum and the bottom inverted into the sample container. The stopper or hand is removed from the glass tube to allow its content to drop into the sample container. If additional liquid is needed to fill the sample container, repeat the previous step.

SLUDGE SAMPLING

For sludge a 40ml of VOA (volatile organic analysis) via fastened to a length of wooden material may be used. The sampling apparatus may be discarded with other waste accumulated during the sampling activities.

SOLID WASTES

A disposable scoop (handling tool i.e spatula) may be used as open top draw while a small handle attached to a length of wooden material may be used to obtain material through a long hole. Sample collection activities require attention to details and rough time that ensure quality and consistency.

While maintaining efficiency the following should be considered during each sampling operation or events.

1) Before collection of sample, thoroughly evaluate the job

2) Prepare all sampling equipment or container prior to the job

3) Place a sample container on flat table surface for receiving sample

4) Collect representative samples and securely close container as quickly as possible

5) Document all steps in sampling processes

6) Minimize sample-sampling derived waste

SAMPLE TYPE

There are two general sampling technique for defining waste and waste stream characteristics.

1) Grab sample 2) Composite sample

1) Grab sample is defined as discrete sample representative of a specific location at a given point in time. The sample is collected all at once and at one particular point in the sample

2) Composite samples are non discrete sample composed of one or more sub sample collected at various sampling locations at different point in time.

Note: in analyzing sample, you use standard method of analysis.

Write short note on icp

ICP –inductive couple plasma

AAS –atomic absorption spectroscopy

AES –atomic emission spectroscopy

DEFINITIONS

AERATED LAGOON: this is a basin in which microorganism used for biodegradation. An activated sludge unit is essentially an aerated tank with a high concentration of suspended solid (2500-3000ppm), followed by a settling tank or a clarifier. The process is a continuous system in which microorganism responsible for degradation is mixed with waste water aerated followed by settling of biological solid (sludge) from treated wastes.

The settled sludge is the recycled to the tank to provide a high concentration of microorganism for the degradation of additional waste. Activated sludge has undergone several modifications such as 1) convectional system 2) contact stabilization process 3) extended aeration system

1) Convectional system: convectional activated sludge process in this system all activities are achieved in a single process step. The sludge is mixed with the waste in am mixing box or at the end of the aeration tank. These mixed liquor then flows to the aeration tank during when progressive removal of organic matter occur, no stabilization period is required, time for aeration varies from 6-12hrs

2) Contact stabilization process: in this process oxidation and removal of organic occurs in separate tank. This is applicable to treatment of waste containing high proportion of organic material or substance in suspended or colloidal form, in sludge stabilization period is required to stabilize the organic removed from the tank

3) Extended aeration process: in EAP, the aeration period (detention time) is prolonged to provide sufficient aeration capacity to oxidize all the biodegradable solid and hence reduce or minimize sludge disposal requirements. Detention time ranges from 1-5days

ANAEROBIC DIGESTION OF SLUDGE

The sludge produce during the treatment of waste water is digested in the absence of molecular oxygen. The energy required is made available from organic compound, a fraction of sludge is converted to organic compound (CH_4 and CO_2) thereby reducing the volume of the sludge that must be disposed off. Essentially pathogenic organisms are reduced and important gas is produced (CH_4). A digested sludge is air dried.

In the case of toxic sludge, detoxification is carried out for example; toxic metal can be removed using acid hydrolysis (wet digestion) in combination with electrolysis by a final disposal.

OPERATION OF BIOLOGICAL TREATMENT PROCESS

WASTE WATER PREPARATION AND CHARACTERISTICS: the waste water (industrial or combine industrial i.e municipal) should be characterized according to the following parameters.

1. pH: The optimum biological treatment pH is from 6.5-9.0

2. COD or BOD

3. Solid (suspended solid and dissolved)

4. Total nitrogen

5. Inorganic phosphorus

6. Sulfate

7. Chloride

8. Alkalinity

9. Parameters relevant to specific waste water such as traced organics heavy metals.

Adequate amount of nitrogen and phosphorus are required to support biological structure for a successful biological system.

BOD-N-P ratio should be 100:5:1. if the N and P content are not adequate, proper amount should be added before beginning the treatment

ACCLIMATION PROCEDURE

Acclimation is a process of acclimatizing to a new environment or getting use to a new environment or condition or situation. Microorganism used in biological treatment must be acclimatized to the presence of toxic substance. A bio-oxidation unit is first fed with mixed liquor from a local domestic and industrial biological treatment plants, depending on the nature of the waste in question. Once the unit is filled with fluidized microbial culture (seed) then raw waste may be fed into the unit. If the organic content of the waste is extremely high or toxic, dilution pretreatment may be necessary. Once the system is operation for one detention time (one day) the COD or BOD of the incoming waste (influent) and outgoing waste (effluent) or discharge waste should be measured, when the COD or BOD removal efficiency become stabilized the system can b\e considered acclimatized.

The time required to obtain acclimation depends on:

i) Waste characteristics

ii) The nature of the seed (fluidized microbial culture)

For domestic waste water or combined domestic-industrial waste, the acclimation is required. However, for waste containing high concentration of complex hazardous compound a much longer period of time is generally required.

OPERATIONAL ANALYSIS AND DATA CORELLATION

The extent of an analytical work to be performed while the laboratory units are in operation depends on the scope of work.

The analysis can be performed at various detention time and the data approximated are presented according to the following outcomes.

ANALSIS	RAW WASTE	MIXED LIQUOR	EFFLUENTS
1. COD, BOD, TOC of filtered sample			
2. PH			
3. Suspended solids			
4. Oxygen uptake			
5. Significant ion			

THERMAL TREATMENT OF HAZARDOUS WASTE

Thermal treatments which can be given to hazardous waste include:

1) Plasma Arc 2) Molten salt 3) super heated water 4) incineration

1) Plasma Arc: Pollutants are destroyed at about temp. of 45,000^{o}C and plasma end product is obtained. It is very useful for destroying inert organic pollutant such as PCB (polychlorinated biphenyl) and materials containing them. The main disadvantage of this method is the complete destruction of refractory (resistance) hazardous organic substance. However, it is very expensive.

2) Molten salt: Hazardous chemical such as chemical warfare agents and corrosive solvents can be destroyed by treatment in hot bath of molten salt at 1650^{o}C other methods involves molten mixture of sodium carbonate and sodium sulfate at 900^{o}C, this type has brought about 97.99% destruction of hexachlorobenzene but its effective over a range of other organic compound at about 99%.

3) Super heated water: Water heated at about 370^{o}C can dissolve ordinarily in soluble organic chemical and if oxygen is added to this H_20, the organic pollutant are oxidized to CO_2 and H_2O, inorganic compound in the water combine to form salt

4) Incineration: Combination method or thermal reduction of preheated hazardous waste is aimed at reducing waste to ash. These are several types of incineration system, but the most common are:

1. Multiple hearth incineration

2. Fluidized bed incineration

3. Flash combustion

4. Pyrolysis

5. Atomized suspension

6. Wet oxidation process

7. Passabant ash process

1. Multiple hearth incineration: This incineration system consists of a no of hearth placed one above the other precondition, dewatered. Solid waste is conveyed to the upper hearth of the furnace. Mechanical rate action moves the solid waste from one hearth to the other. Lower hearth and the solid is subsequently dried, burnt, and air is then cooled.

2. Fluidized bed incineration system: In this process, particles of solid are suspended by an upward moving stream of gases in such a manner that the entire mixture acts like a liquid. Intense agitation of the mixture of solids and gases result in high heat transfer rate. The temperature composition and particle size distribution through out the bed is uniform.

Note: dewater solid is fed directly into the fluidized bed (sand bed) to which preheated air is also introduced. Combustion takes place at temperature over 1500^{o}C, at this temperature most of the combustion gases are oxidized and deoxidized.

ADVANTAGES OF FLUIDIZED BED INCINERATION

1. Excellent mixing

2. No moving path in the reaction

3. Operation is near atmospheric pressure

4. No liquid heat exchange surfaces to scale

5. Ash is removed by existing combustion gases

3. Atomized suspension: this process is essentially a high temperature, low pressure thermal oxidation of fine particle of solid to ash. The solid is concentrated by watering and drying. It is then grounded to fine particle size and sprayed as an atomized suspension with a particle size of about 40microns into the stainless cylinder, the wall of the cylinder are maintained at a temperature between 2,500 and 3,500^{o}C and the heat is transferred to the fallen atomized droplet by radiation. The radiation from a metallic wall of the reactor tends to prevent particle from coming in contact with wall, thereby eliminating the damage of the surface and reduction of heat transfer. The amount of breeze and air in the solid controls the concentration of solid that may spray without blocking the opening of the nozzle of the spring of the instrument. The atomized suspension incineration is applicable to oxidation of organic material in concentrated brine solution.

4. Passabant ash process: In this system pressure press is used to dewater the solid prior to the incineration. The major advantage of this system is that fly ash is used as the conditioner for the solid and no chemicals are needed for dewatering.

Note: if the heat value of the solid is not sufficient to maintain combustion, auxiliary fuel must be provided; therefore the value and moisture content of the solid are important in evaluating the incineration system.

BIOTECHNOLOGY OF HAZARDOUS TREATMENT

This is a process in which living organisms are employed in specified condition to change hazardous substance. Example of such hazardous waste include hydrocarbon.

Biotreatment of hydrocarbon contaminated soil. There are several ways in which hydrocarbon can be treated in the soil.

1. BIOREACTOR: This system involves slurring the soil with H_2O and incubating the resultant mixture with microorganism such as yeast under aerobic condition, the retention time may be varied as required. The bioreactor has the potential to operate in bash or continuous culture moulds. Treated material pressed through water separation system and the water is recycled.

2. COMPOSTING: This refers to the use of biological system of microorganism generated from mature compost to break down contaminant. The type of microorganism depends on the composting technology. (static process→fungi, dynamic→bacterial). The contaminants are digested, metabolized and transformed into humus and inert by product such as CO_2, H_20 and salts. The top soil may be treated on or off sites the material is mixed with a suitable bulking agent such as straw, wood or barks and pilled into low mould or heaps. The materials improve the soil structure, while the microorganism generated during the decomposition of organic material degrade the hydrocarbon. This method is efficient for treatment of the soil polluted waste, chlorinated phenol; non chlorinated phenol may take 7days. The compost used in biotreatment is tailored or designed compost in that they are specially made to treat specific contaminant at specific time. However, caution should be taken care of in order to ensure that leaching of organism from compositing site does not occur.

3. MICROBIAL INOCULAR: Selected microbial organisms are added to contaminated soil to degrade hydrocarbon. The organism may be natural, created by natural genetic exchange or produced by genetic manipulation technique. As a result of the complexity of hydrocarbon mixture, a mixture of organism is generated in order to ensure effective degradation. This is particularly useful to enhance the degradation of chlorinated aromatic hydrocarbon. However, the ability of microbial inoculation to remain viable, competitive and genetically stable in the natural environment may be relatively poor depending on the total environmental conditions and there may be political consideration that can restrain the rise of genetically modified organism.

DISPOSAL METHOD OF HAZARDOUS WASTE

The final disposition of waste after various treatment applied to minimize short term hazard to man and the environment is generally termed ULTIMATE DISPOSAL. The type of ultimate disposal method is dependent on nature of waste and geographical consideration of the treatment plant.

1. **SURFACE INPOUNDMENT:** This is a process in which dangerous hazardous wastes are transferred into material designed/constructed and installed under specific condition to prevent any migration

of waste to the adjacent soil or ground water or surface water at any time during active time of impoundment.

RULES GUIDING THE CONSTRUCTION OF SURFACE IMPOUNDMENT

1. The impoundment must be placed upon a foundation which is capable of providing support to the container (liner) and resistant to pressure gradient above and below the container to prevent failure of the liner due to settlement compression or uplift.

2. It is also installed to cover all surrounding likely to be contacted with the waste or leachate.

3. It is designed so that any flow of waste into the impoundment can be relatively shut off in respect to container failure.

4. It is designed to repel birds.

5. Leakages should be prevented.

PRECAUTION CONCERNING SETTLED WASTE (HOW TO HANDLE SETTLED WASTE)

1. **Ignitable** or reactive waste: Ignitable or reactive waste shall not be placed in surface impoundment unless the waste is treated, mixed before or after placement in the impoundment so that resulting waste mixture or dissolution of material is no longer ignitable or reactive.

2. Surface impoundment for such ignitable or reactive waste is basically used for emergency.

INCOMPACTIBLE WASTE; Incompactible waste material shall not be placed in the surface impoundment.

LAND TREATMENT

Treated waste can be converted to inert or (harmless) end products which are transformed into useful product by mixing with other product (additives). This in turn can be applied to damage soil. E.g.

1) Treated and sterile sludge when dried can be used for soil conditioner

2) The treated waste can be used i.e the formation of organic based fertilizer prepared under specific condition for conditioning soil.

LANDFILL: Most often holes and outlet are created on land during the excavation or likely activities, treated waste can be use to fill up such outlet, however caution must be exercised to avoid contamination of ground water.

DISPOSAL INTO WATER BODIES: Treated waste can be poured into lagoon, pond, ocean and sea.

MARINE DISPOSAL SYSTEM: The ocean or sea have a great capacity for dilution, therefore it can dilute waste of toxic substance below their toxic threshold. Discharge can be made into marine by pipelines into the water.

The limitations of this method are:

I. There is high retention time.

ii. Accumulation of substance due to geochemical and biochemical mechanism.

The practice of marine disposal has decline in recent years as a result of several international agreements. Only less hazardous material can be disposited into the deep sea while substance such as organohalogen, carcinogen substance, mercury and cadmium compounds as well as plastic are banned. Generally, whether the disposal is into the shore or deep sea, caution is exercised because such discharge can be transported around the world. The most common type of sub surface disposal method is DEEPWELL.

DEEPWELL DISPOSAL SYSTEM

It requires the injection of liquid waste into porous sub surface. This waste are mainly stood below the ground layers which are sealed by impervious strata, this isolated from underground water and mineral resources. Disposal well varies in depth from a few hundred of feet to about 15,000 feet. The capacity of various wells vary from less to 2,000gallons per minutes, waste disposal by this method are usually those which are difficult or more expensive to be disposed by other method. They include liquid containing acids, high BOD waste, nitrate, phosphate and radioactive waste.

1. Refractory organic	These organic binds to resist conventional method of waste water treatment, typical example includes Phenol and agricultural pesticides.
2. Heavy metals	Are usually added to H_2O from commercial and Industrial activities, they have to be removed if Waste H_2O is to be used.
3. Dissolved inorganic solid	Inorganic constituents such as Cd, Na, SO_4^{2-} are added to the original domestic water supply as a result of H_2O use which may have to be removed if d waste H_2O is to be re-used.

ENVIRONMENTAL AND GEOLOGGICAL FACTORS AFFECTING DISPOSAL SITES

Waste product from land has always being returned back to land some are treated before disposal while others are not, but the fact remain that all known system of waste disposal require land for finality, this

implies the only disposal on land remains the ultimate method while others are different means to it. Landfill or controlled tipping is the term used generally to describe the technique of disposal of waste on land.

A controlled or engineered landfill means a systematic compacted deposition of layers of refuse which one can cover daily with protection of surface and sub surface water in an environmental acceptable manner. Landfill design should incorporate environmental acceptable operation condition in the area of location. This standard always presumed to be adhered to with the adequate knowledge of the consequences of negligence.

These consequences are usually lifetime liability of the immediate environment. A sanitary landfill design should incorporate the basic concept of confining, compacting and covering. This known as the 3C's of sanitary landfill site. All these concepts have a basic objective of preventing, ameliorating potential pollution in the operation site.

ENVIRONMENTAL FACTORS TO BE CONSIDERED IN CHOICE OF DISPOSAL SITE

FACTORS	SOME PARAMETERS TO BE CONSIDERED
1. Geology (soil condition)	parent material, soil type, texture, structure
2. Hydrogeology	aquifer (low/high water tables, soil porosity)
3. Land use on/off site	use of adjacent land, land planning it.
4. Surface water	surface runoff, slope, photosynthesis activities, turbidity.
5. Aquatic habitat	ecosystem distribution, eutrophication, mortality of flora/fauna.
6. Terrestrial habitat	land pollution, bioaccumulation, ecosystem distribution.
7. Nuisance impact potential	odour, aesthetic, pest etc
8. Visual landscape	topography

Note: - eutrophication is a condition of excess nutrient being introduced into water bodies.

PROBLEMS OF HAZARDOUS SUBSTANCE AND MANAGEMENT

Most toxic and hazardous substances are derived from chemicals and related industries that produces plastic, soap, detergent, paints, explosives and numerous organic and inorganic intermediate chemical such associated problems include:

1. Production of such substances annually.
2. Coastal dumping on thousand of unmarked size over the years.

3. Practice of landfill is now becoming unpopular because hazardous substance is been recognized as being dangerous to human health and environment.

4. The need to clean up existing landfill containing hazardous substances that have been previously buried up in other to protect the environment and prevent danger to health.

5. Alternative systems of disposal are expensive and not even available.

6. There are many hazardous substances and the effects of individual substance are unknown, their effect in combination with each other can only be guessed.

7. Growing public awareness in developing countries has made the disposal of hazardous substance more difficult and expensive.

The relative new practice of exporting unwanted hazardous substances to the third world countries where these substances are stored in extremely unsatisfactory and often contamination.

SOME CASES OF SERIOUS ACCIDENT THAT HAVE OCCURRED WORLDWIDE WITH THE RELEASE OF HAZARDOUS SUBSTANCES;

1. September 21, 1921 in oppan Germany: there was a chemical explosion in a ware house at about 60miles of South of Frankfurt where workers use dynamite to break loose 4,000 tonnes caked ammonium nitrate fertilizer (NH_4NO_3). This explosion was recorded as the biggest chemical explosion in Germany history. It killed 561 people and leveled several houses 4 miles away.

2. October 20, 1994(Cleveland USA): A liquefied national gas tank belonging to east Ohio gas company developed a structural weakness which lead to a huge explosion blast and fired killed 131 people.

3. July 28, 1948 Germany: Railway cooperation transporting dimethylether used in the manufacture of acetic acid and dimethylsulphate belonging to Farbean chemical plant exploded at the factory gate killing 207 people, 4,000 people were injured from the resulting fire.

4. Between 1953 and 1961 in minimata (Japan): Methyl mercury poison after eating fish contaminated with high concentration of mercury, within this period 200 death were recorded and several thousand of people were hospitalized.

5. In 1960, Ibadan (Nigeria):They were recorded cases of human poisoning caused by gamaline 20, at UCH Ibadan, the cases were from cocoa producing area of defunct western Nigeria, during these period 110 death were recorded.

6. Floxobarough England (1974): This was Britain biggest peace time explosion and it occurred at the NYPW chemical limited plant, when a plant ruptured the plant producing a raw material use in the manufacture of nylon. 28 workers were killed, 29 injured and over 300 people evacuated.

7. July 10 1976 savaso (Italy): Accidental release of Dioxin due to explosion of it (ICMESA chemical plant). No death was recorded, 193 people injured and 730 were evacuated.

8. 1977 Love canal, Niagara falls(USA); A case of human poisoning , high birth defect from pesticides and industrial chemicals buried on the ground, 25yrs before that time over 64million dollars was spent in the clean up exercise.

9. December 3, 1984 Bhopal (India): Accidental release of poisonous gases e.g. methyl isocyanides as a result of faulty pump from union carbide in a pesticide plant, 2,800 people were recorded dead, 50,000 people were affected and treated for various ailment while 200,000 people have adverse health illness ranging from temporary blindness to permanent disabilities, one of the 629 women who were pregnant at that time, 402 has miscarriage while 82 had still birth also spontaneous abortion and still birth has estimated to have tripled during the period. A year after the leakage thousands were still being treated from the after effect of the disaster. 10,000 people were suffering from lung problem and about 2,500 were still expected to need treatment for the next 4-5yrs then casual laborers could no longer work because of lung damage. 10% of the 85,000 patient registered with government hospital in this area were seriously ill. In February 1989, the supreme court of India awarded damages of 470million dollars against union carbide.

10. June 1988, Koko old bendel state (Nigeria): 3,888 tonnes of toxic waste from Italy was found to be illegally dumped in the fishery pond of koko, the Nigeria government ordered that the waste be returned to Italy and promogated decree 42 to prevent further occurrence. Environmental implication of the episode is yet fully realized.