5.1 Introduction to solid wastes

The particular lesson introduces the concept of solid wastes, its definition, management of solid wastes, hazards of mismanagement of solid wastes and the elements of a typical solid waste management system

5.1.1 Solid waste

Any solid material in the material flow pattern that is rejected by society is called solid waste. All human activities viz., domestic, commercial, industrial, healthcare and agriculture generate solid waste. The quantity and nature of the waste vary with the activity and with the level of technological development in a country. Solid wastes are all the wastes arising from human and animal activities that are normally solid and are discarded as useless or unwanted.

Solid waste is the term used to describe non-liquid waste materials arising from domestic, trade, commercial, agricultural, industrial activities and from public services. Wastes that arise from a typical urban society comprise of garbage, rubbish (package materials), construction and demolition wastes, leaf litter, hazardous wastes, etc. If not managed properly, these wastes can have an adverse impact on the environment and public health arising from contamination of soil, water and pollution of air and through spread of diseases via vectors living on waste. The relationship between public health and the improper storage, collection and disposal of solid wastes is quite clear. Because of their intrinsic properties, discarded waste materials are often reusable and may be considered a resource in another setting. Ecological phenomena such as water and air pollution have also been attributed to improper management of solid wastes

From the days of primitive society, humans and animals have used the resources of the earth to support life and to dispose wastes. In those days, the disposal of human and other wastes did not pose significant problems as the population was very small and the area of land available for the assimilation of such wastes was large. However, today, serious consideration is being given everywhere to this burgeoning problem of solid wastes. Rapid population growth and uncontrolled industrial development are seriously degrading the urban and semi-urban environment in many of the world's developing countries, placing enormous strain on natural resources and undermining efficient and sustainable development.

5.1.2 Solid waste management

Management of solid waste may be defined as that discipline associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid wastes in a manner that is in accord withthe best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations. In its scope, solid waste management includes all administrative, financial, legal, planning, and engineering functions involved in the whole spectrum of solutions to problems of solid wastes thrust upon the community by its inhabitants

5.1.2.1 Solid waste management in India

India, as any other developing country, is currently facing an acute problem in the management of Municipal Solid Wastes. Open dumping of waste is wide spread throughout the country. This is because of the mistaken belief that it is the easiest and cheapest disposal method. Also there is insufficient will and allocation of resources to improve the prevailing disposal practices. The deposition of wastes along roadsides and on riverbanks and on marginal lands and then 'hoping' it will go away is both naive and dangerous. It is inevitable that chemical and biological contaminants in waste will pollute the surrounding natural environment and find their way back to humans to affect health, quality of life and working activities. Thus, in the ultimate run the society has to pay dearly for open dumping.

Solid waste management has become a major environmental issue in India. The per capita of MSW generated daily, in India ranges from about 100 g in small towns to 500 g in large towns. The population of Mumbai grew from around 8.2 million in 1981 to 12.3 million in 1991, registering a growth of around 49%. On the other hand, Municipal Solid Wastes generated in the city increased from 3 200 tonnes per day to 5 355 tonnes per day in the same period registering a growth of around 67% (CPCB 2000). This clearly indicates that the growth in Municipal Solid Wastes in our urban centres has outpaced the population growth in recent years. This trend can be ascribed to our changing lifestyles, food habits, and change in living standards. Municipal Solid Wastes in cities is collected by respective municipalities and transported to designated disposal sites, which are normally low lying areas on the outskirts of the city.

Now-a-days the concern for solid waste management has increased and government has created lot of awareness among the public for proper separation of solid wastes at the source level itself, so that it will become easier for treatment / disposal.

Hazards of mismanagement of solid wastes

There are innumerable potential hazards due to the mismanagement of solid wastes. It has the potential to pollute all the vital natural resources viz., land, water and air. Some of the hazards caused by solid wastes are listed below:

- Environmental pollution from waste leachates and gas evolving from dumped solid waste
- Air pollution from smoke by burning of waste and health hazards to the people through inhalation of dust and smoke
- Health hazards to waste workers and pickers through direct contact with waste.
- Generation of noxious odours
- Promotion of micro organisms that cause diseases
- Attraction and support of disease vectors (rodents and insects that carry and transmit disease carrying micro-organisms)
- Unaesthetic appearance

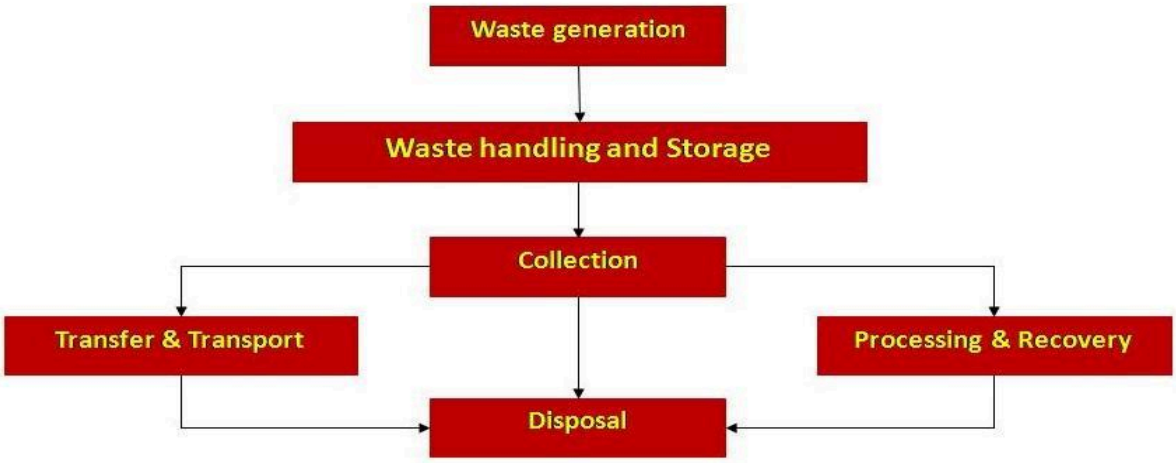
- Poor living ambience

5.2 Functional elements of a solid waste management system

The following are the key functional elements for implementing a solid waste management system:

- source reduction
- onsite storage
- collection and transfer
- processing techniques
- disposal

The following flow chart describes the relationship between the key functional elements of a solid waste management system



5.2.1 Waste generation

Waste generation encompasses activities in which materials are identified as no longer being of value (in their present form) and are either thrown away or gathered together for disposal.

5.2.2 Waste handling, sorting and storage

Waste handling and sorting involves the activities associated with management of wastes until they are placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Sorting of waste components is an important step in the handling and storage of solid waste at the source. For example, the best place to separate waste materials for reuse and recycling is at the source of generation. Households are becoming more aware of the importance of separating newspaper and cardboard, bottles/glass, kitchen wastes and ferrous and non-ferrous materials. On-site storage is of primary importance because

of public health concerns and aesthetic consideration. Unsightly makeshift containers and even open ground storage, both of which are undesirable, are often seen at many residential and commercial sites.

5.2.3 Collection

It includes not only the gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a material processing facility, a transfer station, or a landfill disposal site.

5.2.4 Processing and Recovery

The recovery of sorted materials, processing of solid waste and transformation of solid waste that occurs primarily in locations away from the source of waste generation are encompassed by this functional element. Waste processing is undertaken to recover conversion products and energy. The organic fraction of Municipal Solid Waste can be transformed by a variety of biological and thermal processes. The most commonly used biological transformation process is aerobic composting. The most commonly used thermal transformation process is incineration.

Waste transformation is undertaken to reduce the volume, weight, size or toxicity of waste without resource recovery. Transformation may be done by a variety of mechanical (eg shredding), thermal (e.g. incineration without energy recovery) or chemical (e.g. encapsulation) techniques.

5.2.5 Transfer and Transport

It involves two steps: (i) the transfer of wastes from the smaller collection vehicle to the larger transport equipment and (ii) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site. The transfer usually takes place at a transfer station.

5.2.6 Disposal

The final functional element in the solid waste management system is disposal. Today the disposal of wastes by landfilling or uncontrolled dumping is the ultimate fate of all solid wastes. A municipal solid waste landfill plant is an engineered facility used for disposing of solid wastes on land or within the earth's mantle without creating nuisance or hazard to public health or safety, such as breeding of rodents and insects and contamination of groundwater.

Municipal solid waste is a potential source of the following useful materials

- Raw material to produce manufactured goods
- Feed stock for composting and mulching processes
- Can be used as a fuel

5.3 Quantity of solid waste estimation

Information on waste quantity and composition is important in evaluating alternatives in terms of equipment, systems, plans and management programmes. Based on the quantity of wastes generated, one can plan appropriate means for separation, collection and recycling programmes. That is to say, the success of solid waste management depends on the appropriate assessment of quantity of wastes generated. This lesson deals with the estimation of quantity of solid waste

The quantity of solid waste generated depends on a number of factors such as

- food habits,
- standard of living
- degree of commercial activities
- seasons

The quantity of solid waste can be expressed in units of volume or in units of weight. The advantage of measuring quantity in terms of weight rather than weight is that weight is fairly constant for a given set of discarded objects, whereas volume is highly variable. Waste generated on a given day in a given location occupies different volumes in the collection truck, on the transfer station, in the storage pit or in a landfill. In addition, the same waste can occupy different volumes in different trucks or landfills. Hence, its always preferable to express the quantity of solid waste on weight basis.

The best method for estimating waste quantity is to install permanent scales at disposal facilities and weigh every truck on the way in and again in the way out. At disposal facilities without permanent scales, portable scales can be used to develop a better estimate of the weight of waste being deliverd. Selected trucks are weighed and environmental engineers use the results to estimate the overall weight of the waste stream. Weighing all trucks entering the disposal facility is a tedious job and hence a method of truck selection must be done. A simple approach will be to weigh every nth truck (for instance, every 4^{th} truck) that delivers waste to the facility. This approach assume that the trucks weighed represent all trucks arriving at the facility. The total waste taonnage can be estimate can be estimated with the following equation

$W = T\ (w/t)$

Where,

W is the total weight of the waste delivered to the facility

T is the total number of trucks that delivered waste in the facility

w is the total weight of the truck that were weighed

t is the number of trucks that were weighed

Similarly the total weight of waste delivered for the whole year is summed up and total tones of waste generated in a year can be calculated.

The quantity of solid waste is often expressed in kg per capita per day so that the waste streams in different areas can be compared. The quantity is typically calculated with the following equation

Q = 1000 T / 365 * P

Where, Q – Quantity of waste in kg per capita per day

T – Tonnes of waste generated in a year

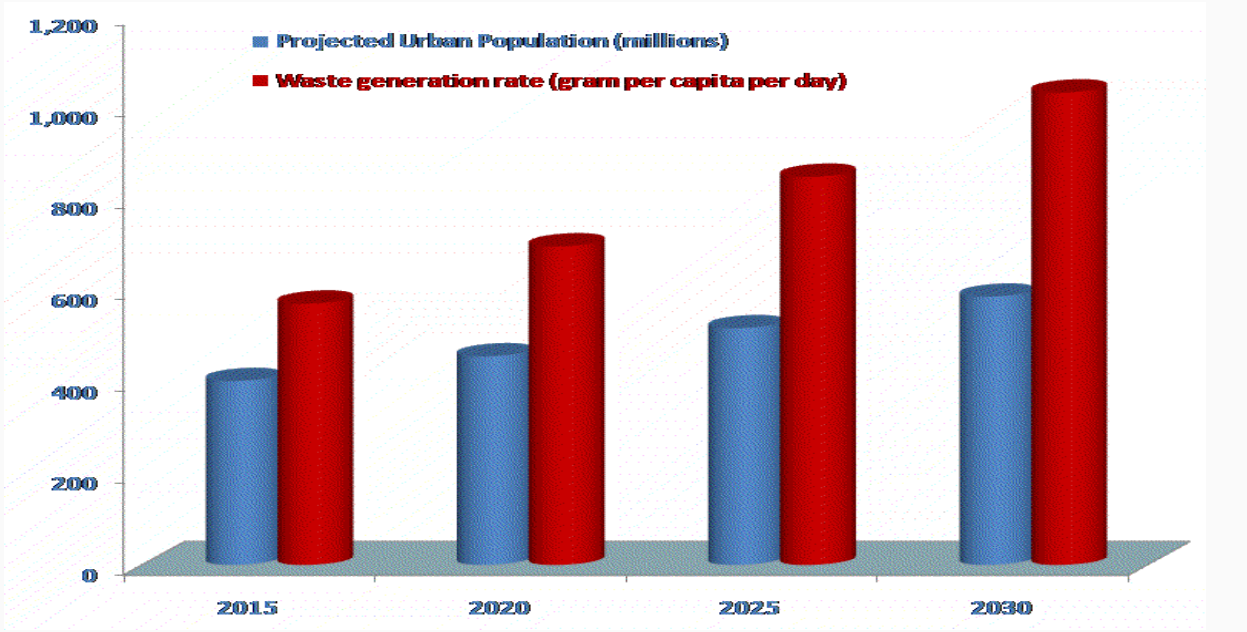
P – Population of the area in which the waste is being generated

Data on quantity variation and generation are useful in planning for collection and disposal systems. Indian cities now generate eight times more municipal solid wastes than they did in 1947 because of increasing urbanization and changing life styles. Municipal solid wastes generation rates in small towns are lower than those of metro cities, and the per capita generation rate of municipal solid wastes in India varies in towns and cities. It was also estimated that the total municipal solid wastes generated by 217 million people living in urban areas was 23.86 million t/yr in 1991, and more than 39 million ton in 2001. Waste generation rate in Indian cities ranges between 200 - 500 grams/day, depending upon the region's lifestyle and the size of the city. The per capita waste generation is increasing by about 1.3% per year in India.

5.4 Waste generation and GDP

The per capita waste generation rate is strongly correlated to the gross domestic product (GDP) of a country (Table 2). Per capita waste generation is the amount of waste generated by one person in one day in a country or region. The waste generation rate generally increases with increase in GDP. High income countries generate more waste per person compared to low income countries due to reasons discussed in further sections. The average per capita waste generation in India is 370 grams/day as compared to 2,200 grams in Denmark, 2,000 grams in US and 700 grams in China.

Country	**Per Capita Urban MSW Generation (kg/day)**	
	1999	**2025**
Low Income Countries	0.45 - 0.9	0.6 - 1.0
Middle Income Countries	0.52 - 1.1	0.8 - 1.5
High Income Countries	1.1 - 5.07	1.1 - 4.5



The urban population of India is approx. 341 million in 2010. Figure 1 suggest the projected MSW quantities are expected to increase from 2015 to 2030 and that per capita per day production will increase to 1.032 kg, and urban population as 586 million in 2030.

5.5 Composition to solid waste

Its very important to know about the composition of solid waste before managing them. Hence comes the objective of this lesson, which will deal with the composition of a typical solid waste, the factors affecting the composition and the changing composition over a period of time

Materials in solid wastes can be broadly categorized into three groups, Compostable, Recyclables and Inerts. Compostable or organic fraction comprises of food waste, vegetable market wastes and yard waste. Recyclables are comprised of paper, plastic, metal and glass. The fraction of solid wastes which can neither be composted nor recycled into secondary raw materials is called Inerts. Inerts comprise stones, ash and silt which enter the collection system due to littering on streets and at public places.

Waste composition dictates the waste management strategy to be employed in a particular location. Organics in municipal solid wates are putrescible, and are food for pests and insects and hence need to be collected and disposed off on a daily basis. The amount of recyclables like paper and plastic in solid wastes dictates how often they need to be collected. Recyclables represent an immediate monetary value to the collectors. Organics need controlled biological treatment to be of any value, however due to the general absence of such facilities, organics do not represent any direct value to informal collectors.

A major fraction of urban municipal solid wastes in India is organic matter (51%). Recyclables are 17.5 % of the municipal solid wates and the rest 31% is inert waste. It has to be understood

that this composition is at the dump and not the composition of the waste generated. The actual percentage of recyclables discarded as waste in India is unknown due to informal picking of waste which is generally not accounted. Accounting wastes collected informally will change the composition of municipal solid wastes considerably and help estimating the total waste generated by communities.

Waste composition varies with the socio-economic status within a particular community, since income, for example, determines life style, composition pattern and cultural behavior.

5.6 Factors affecting quantity and composition of solid waste

Geographic location

The geographical location is related primarily to different climate that can influence both the amount of solid wastes generated and the collection operation. For instance, substantial variations in the amount of yard and garden wastes generated in various parts of India are related to the climate. To illustrate, in the warmer southern areas, where the growing season is considerably longer compared to the northern areas, yard wastes are collected in considerably larger quantities and over a longer period of time.

Season

Seasons of the year have implications for the quantities and composition of certain types of solid wastes. For example, the growing season of vegetables and fruits affect the quantities of food wastes.

Collection frequency

A general observation is that in localities, where there are ultimate collection services, more wastes are c*ollected*. Note that this does not mean that more wastes are *generated*. For example, if a resident has access to only one or two containers per week, due to limited container capacity, he or she will store newspapers or other materials in some specified storage area. However, the same person will tend to throw them away, if there is access to unlimited container services. In this latter situation, the quantity of waste generated may actually be the same but the quantity collected, as it relates to the frequency of collection, is considerably different

Population diversity:

The characteristics of the population influence the quantity and composition of waste generated. The amount of waste generated is more in low-income areas compared to that in high-income areas. Similarly, the composition differs in terms of paper and other recyclables, which are typically more in high-income areas as against low-income areas

Typical waste composition based on income pattern of population

Characteristics	Low income	High income	Comments
Paper	1 to 4 %	20 to 50%	Low paper content indicates low calorific value
Plastics	1 to 6 %	5 to 10%	Plastic is low in low income areas as compared to high-income areas though the use of plastic has increased in recent years.
Ash and Fines	17 to 62 %	3 to 10%	Ash and fines do not contribute to combustion process

Extent of salvaging and recycling

The existence of salvaging and recycling operation within a community definitely affects the quantity of wastes collected.

Public attitude

Significant reduction in the quantity of solid waste is possible, if and when people are willing to change – on their own volition – their habits and lifestyles to conserve the natural resources and to reduce the economic burden associated with the management of solid wastes.

Legislation

This refers to the existence of local and state regulations concerning the use and disposal of specific materials and is an important factor that influences the composition and generation of certain types of wastes.

In a nutshell, elements that relate to waste generation include land use characteristics, population in age distribution, legislation, socio economic conditions, etc.

Changing composition of municipal solid wastes in India

It is rather interesting to study the changes in the composition of waste in India in the past. The following table gives the changing composition of Municipal Waste over the last two decades and is attributed to the changing life styles and increasing consumerism.

Component	% of Wet Weight	
	1971-73 (40 cities)	1995 (23 cities)
Paper	4.14	5.78
Plastics	0.69	3.90

Metals	0.50	1.90
Glass	0.40	2.10
Rags	3.83	3.50
Ash and Fine	49.20	40.30
Total Compostable Matter	41.24	41.80

5.7 Characteristics of solid waste

In order to identify the exact characteristics of municipal wastes, it is necessary that we analyse them using physical and chemical parameters. This lesson will emphasize about the various characteristics of solid wastes and their importance.

5.7.1 Physical characteristics

Information and data on the physical characteristics of solid wastes are important for the selection and operation of equipment and for the analysis and design of disposal facilities. The following physical characteristics are to be studied in detail.

Density

Density of waste, i.e., its mass per unit volume (kg/m^3), is a critical factor in the design of a solid waste management system, e.g., the design of sanitary landfills, storage, types of collection and transport vehicles, etc. To explain, an efficient operation of a landfill demands compaction of wastes to optimum density. Any normal compaction equipment can achieve reduction in volume of wastes by 75%, which increases an initial density of 100 kg/m^3 to 400 kg/m^3. In other words, a waste collection vehicle can haul four times the weight of waste in its compacted state than when it is uncompacted. Significant changes in density occur spontaneously as the waste moves from source to disposal, due to scavenging, handling, wetting and drying by the weather, vibration in the collection vehicle and decomposition

Moisture content

Moisture content is defined as the ratio of the weight of water (wet weight - dry weight) to the total wet weight of the waste. Moisture increases the weight of solid wastes, and thereby, the cost of collection and transport. In addition, moisture content is a critical determinant in the economic feasibility of waste treatment by incineration, because wet waste consumes energy for evaporation of water and in raising the temperature of water vapour. In the main, wastes should be insulated from rainfall or other extraneous water. We can calculate the moisture percentage, using the formula given below

\[Moisture content(%)=\frac{Wet\cdot weight-Dry\cdot weight}{Wet \cdot weight}x 100\]

A typical range of moisture content is 20 to 40%, representing the extremes of wastes in an arid climate and in the wet season of a region of high precipitation. However, values greater than 40% are not uncommon. Climatic conditions apart, moisture content is generally higher in low income countries because of the higher proportion of food and yard waste.

Size of Waste constituents

The size distribution of waste constituents in the waste stream is important because of its significance in the design of mechanical separators and shredder and waste treatment process. This varies widely and while designing a system, proper analysis of the waste characteristics should be carried out.

Calorific Value

Calorific value is the amount of heat generated from combustion of a unit weight of a substance, expressed as kcal/kg. The calorific value is determined experimentally using Bomb calorimeter in which the heat generated at a constant temperature of $25^{O}C$ from the combustion of a dry sample is measured.

The physical properties that are essential to analyse of wastes disposed at landfills are:

Field capacity

The field capacity of municipal solid waste is the total amount of moisture which can be retained in a waste sample subject to gravitational pull. It is a critical measure because water in excess of field capacity will form leachate, and leachate can be a major problem in landfills. Field capacity varies with the degree of applied pressure and the state of decomposition of the wastes.

Permeability of compacted wastes

The hydraulic conductivity of compacted wastes is an important physical property because it governs the movement of liquids and gases in a landfill. Permeability depends on the other properties of the solid material include pore size distribution, surface area and porosity. Porosity represents the amount of voids per unit total volume of material. The porosity of municipal solid waste varies typically from 0.40 to 0.67 depending on the compaction and composition of the waste.

Compressibility

It is the degree of physical changes of the suspended solids or filter cake when subjected to pressure.

5.7.2 Chemical characteristics

Knowledge of the classification of chemical compounds and their characteristics is essential for the proper understanding of the behaviour of waste, as it moves through the waste management system. The products of decomposition and heating values are two examples of chemical

characteristics. If solid wastes are to be used as fuel, or are used for any other purpose, we must know their chemical characteristics, including the following

Chemical: Chemical characteristics include pH, Nitrogen, Phosphorus and Potassium (N-P-K), total Carbon, C/N ratio, calorific value.

Bio-Chemical: Bio-Chemical characteristics include carbohydrates, proteins, natural fibre, and biodegradable factor.

Toxic: Toxicity characteristics include heavy metals, pesticides, insecticides, Toxicity test for Leachates (TCLP), etc.

Lipids

This class of compounds includes fats, oils and grease. Lipids have high calorific values, about 38000 kcal/kg, which makes waste with a high lipid content suitable for energy recovery processes. Since lipids in the solid state become liquid at temperatures slightly above ambient, they add to the liquid content during waste decomposition. They are biodegradable but because they have a low solubility in waste, the rate of biodegradation is relatively slow.

Carbohydrates

Carbohydrates are found primarily in food and yard waste. They include sugars and polymers of sugars such as starch and cellulose and have the general formula $(CH_2O)_X$. Carbohydrates are readily biodegraded to products such as carbon dioxide, water and methane. Decomposing carbohydrates are particularly attractive for flies and rats and for this reason should not be left exposed for periods longer than is necessary.

Proteins

Proteins are compounds containing carbon, hydrogen, oxygen and nitrogen and consist of an organic acid with a substituted amine group (NH_2). They are found mainly in food and garden wastes and comprise 5-10% of the dry solids in solid waste. Proteins decompose to form amino acids but partial decomposition can result in the production of amines, which have intensely unpleasant odours.

Natural fibres

This class includes the natural compounds, cellulose and lignin, both of which are resistant to biodegradation. They are found in paper and paper products and in food and yard waste. Cellulose is a larger polymer of glucose while lignin is composed of a group of monomers of which benzene is the primary member. Paper, cotton and wood products are 100%, 95% and 40% cellulose respectively. Since they are highly combustible, solid waste having a high proportion of paper and wood products, are suitable for incineration. The calorific values of ovendried paper products are in the range 12000 – 18000 kcal/kg and of wood about 20000 kcal/kg, which compare with 44200 kcal/kg for fuel oil.

Synthetic organic material (Plastics)

They are highly resistant to biodegradation and, therefore, are objectionable and of special concern in solid waste management. Hence the increasing attention being paid to the recycling of plastics to reduce the proportion of this waste component at disposal sites. Plastics have a high heating value, about 32,000 kJ/kg, which make them very suitable for incineration. But, one should note that polyvinyl chloride (PVC), when burnt, produces dioxin and acid gas. The latter increases corrosion in the combustion system and is responsible for acid rain.

Non-combustibles:

This class includes glass, ceramics, metals, dust and ashes, and accounts for 12 – 25% of dry solids.

Heating value

An evaluation of the potential of waste material for use as fuel for incineration requires a determination of its heating value, expressed as kilojoules per kilogram (kJ/kg). The heating value is determined experimentally using the *Bomb calorimeter test*, in which the heat generated, at a constant temperature of 25°C from the combustion of a dry sample is measured. Since the test temperature is below the boiling point of water (100°C), the combustion water remains in the liquid state. However, during combustion, the temperature of the combustion gases reaches above 100°C, and the resultant water is in the vapour form. While evaluating incineration as a means of disposal or energy recovery, one has to consider the heating values of respective constituents.

Ultimate analysis

This refers to an analysis of waste to determine the proportion of carbon, hydrogen, oxygen, nitrogen and sulphur, and it is done to perform mass balance calculation for a chemical or thermal process. Besides, it is necessary to determine ash fraction because of its potentially harmful environmental effects, brought about by the presence of toxic metals such as cadmium, chromium, mercury, nickel, lead, tin and zinc. One should note that other metals (e.g., iron, magnesium, etc.) may also be present but they are non-toxic.

The following table shows an ultimate analysis of a typical municipal solid waste

Element	**Range (% dry weight)**
Carbon	25-30
Hydrogen	2.5-6.0
Oxygen	15-30
Nitrogen	0.25-1.2
Sulphur	0.02-0.12

Ash	12-30

Proximate analysis

This is important in evaluating the combustion properties of wastes or a waste or refuse derived fuel. The fractions of interest are:

- moisture content, which adds weight to the waste without increasing its heating value, and the evaporation of water reduces the heat released from the fuel;
- ash, which adds weight without generating any heat during combustion;
- volatile matter, i.e., that portion of the waste that is converted to gases before and during combustion;
- fixed carbon, which represents the carbon remaining on the surface grates as charcoal. A waste or fuel with a high proportion of fixed carbon requires a longer retention time on the furnace grates to achieve complete combustion than a waste or fuel with a low proportion of fixed carbon.

The following table shows an proximate analysis of a typical municipal solid waste

Components	**Value (%)**	
	Range	Typical
Moisture	15-40	20
Volatile matter	40-60	53
Fixed carbon	5-12	7
Glass, metal, ash	15-30	20

5.8 Solid waste disposal in rural and urban areas

This lesson educates the various methods of disposing solid wastes, explaining their scope, importance and need.

Disposal is the final element in the solid waste mangement system. It is the ultimate fate of all solid wastes, be the residential wastes collected and transported directly to a landfill site, semisolid waste (sludge) from municipal and industrial treatment plants, incinerator residue, compost or other substances from various solid waste processing plants that are of no further use to society. It is, therefore, imperative to have a proper plan in place for safe disposal of solid wastes, which involves appropriate handling of residual matter after solid wastes have been processed and the recovery of conversion products/energy has been achieved.

Problems due to improper disposal of wastes

- health hazards (e.g., residents in the vicinity of wastes inhale dust and smoke when the wastes are burnt; workers and rag pickers come into direct contact with wastes, etc.);
- pollution due to smoke;
- pollution from waste leachate and gas;
- blockage of open drains and sewers.

Hence it is very much imminent that safe disposal of solid wastes is important for safeguarding both public health and the environment.

Some of the disposal methods of solid wastes are

1. Open dumping
2. Composting
3. Land filling
4. Incineration
5. Gasification
6. Refuse-derived fuel
7. Pyrolysis

Open dumping

Open dumping is an illegal process, in which any type of the waste such as household trash, garbage, tires, demolition/construction waste, metal or any other material dump at any location like along the roadside, vacant lots on public or private property even in parks other than a permitted landfill or facility. Open dumping poses a threat to human health and the environment because it causes land pollution. In the developing countries, municipal solid waste is commonly disposed off by discharge the waste in open dumps around 60-90%, which are environmentally unsafe. Open dumping of nondegradable component like burning of plastic waste is added to create air pollution and uncollected waste pose serious health hazards. As a result of illegal dumping, land area such as property value may decrease and also put negative impact on the scarcity of land in future

Composting

Composting is a natural biological process that carried out under controlled aerobic (requires oxygen) or anaerobic conditions (without oxygen). Organic waste is biodegradable and can be processed in the presence of oxygen or in the absence of oxygen using anaerobic digestion. Anaerobic composting is not common because of the slow degradation rate and produce odorous

intermediate product. Anaerobic digestion however also produces methane gas which is an important source of bio-energy.

Composting is an efficient method to break down organic materials into an end product which is beneficial for soil and plants. Compost is used as an organic amendment to improve the physical, chemical and biological properties of soil. Adding compost helps to increase the ability of the soil to hold and release essential nutrients.

Composting has a long tradition particularly in rural India. Composting is difficult process because the waste arrives in a mixed form and contains a lot of non-organic material. When mixed waste is composted, the end product is of poor quality. The presence of plastic objects in the waste stream is especially problematic, since these materials do not get recycled or have a secondary market. In the absence of segregation, even the best waste management system or plant will be rendered useless. In India, composting is used around 10-12% because composting needs segregation of waste and sorting is not widely practiced

Landfills

A landfill is an area of land onto or into which waste is deposited. The aim is to avoid any contact between the waste and the surrounding environment, particularly the groundwater.

Landfilling will be done for the following types of waste:

- Mixed waste not found suitable for waste processing;
- Pre-processing and post-processing wastes from waste processing sites;
- Non-hazardous waste not being processed or recycled.

Landfilling will usually not be done for the following waste streams in the municipal solid waste:

- Biowaste/garden waste
- Dry recyclables

Landfills minimise the harmful impact of solid waste on the environment by the following mechanisms:

- Isolation of waste through containment;
- Elimination of polluting pathways;
- Controlled collection and treatment of products of physical, chemical and biological changes within a waste dump – both liquids and gases; and
- Environmental monitoring till the waste becomes stable.

Essential components of municipal solid waste landfill

1. A liner system at the base and sides of the landfill which prevents migration of leachate or gas to the surrounding soil.

2. A leachate collection and control facility which collects and extracts leachate from within and from the base of the landfill and then treats the leachate.

3. A gas collection and control facility (optional for small landfills) which collects and extracts gas from within and from the top of the landfill and then treats it or uses it for energy recovery.

4. A final cover system at the top of the landfill which enhances surface drainage, prevents infiltrating water and supports surface vegetation.

5. A surface water drainage system which collects and removes all surface runoff from the landfill site.

6. An environmental monitoring system which periodically collects and analyses air, surface water, soil-gas and ground water samples around the landfill site.

7. A closure and post-closure plan which lists the steps that must be taken to close and secure a landfill site once the filling operation has been completed and the activities for long-term monitoring, operation and maintenance of the completed landfill.

Incineration

Incineration is one of the waste treatment technologies that involve the combustion of organic materials and other substances. This refers to the controlled burning of wastes, at a high temperature (roughly 1200 – 1500°C), which sterilises and stabilises the waste in addition to reducing its volume. Hence, Incineration waste treatment system is normally described as 'thermal treatment'. Incinerator process converts the waste into bottom ash, particulates and heat, which can be used to generate the electric power. The volume of ash is usually 10% of the original volume of the waste. Finally, the ash is typically disposed off in the landfill site. In developing countries, the use of incineration is in few amounts to around 1-5% respectively.

In India the incineration is a poor option as the waste consists mainly high organic material (40–60%) and high inert content (30–50%) also low calorific value content (800–1100 kcal/kg), high moisture content (40–60%) in MSW and the high costs of setting up and running the plants.

Gasification

This is the partial combustion of carbonaceous material (through combustion) at high temperature (roughly 1000°C) forming a gas, comprising mainly carbon dioxide, carbon monoxide, nitrogen, hydrogen, water vapour and methane, which can be used as fuel. Gasification is the solid waste incineration under oxygen deficient conditions, to produce fuel gas. In India, there are very few gasifiers in operation, but they are mostly for burning of biomass such as agro-residues, sawmill dust, and forest wastes. Gasification can also be used for MSW treatment after drying, removing the inert and shredding for size reduction.

Refuse-derived fuel (RDF)

This is the combustible part of raw waste, separated for burning as fuel. Various physical processes such as screening, size reduction, magnetic separation, etc., are used to separate the combustibles

Pyrolysis

This is the thermal degradation of carbonaceous material to gaseous, liquid and solid fraction in the absence of oxygen. This occurs at a temperature between 200 and 900°C. The product of pyrolysis is a gas of relatively high calorific value of 20,000 joules per gram with oils, tars and solid burned residue.

5.9 Introduction to air pollution

INTRODUCTION

This lesson introduces air pollution, its types and sources.

Introduction to air pollution

As we all know, air is the most essential for our living. A person cannot survive for five minutes without air. The important life controlling element, viz. air, sometimes becomes an enemy when it gets polluted. Air pollution is nothing but a system where presence of any substance (solid, liquid or gas) in the atmosphere in such a concentration that may or may tend to cause injuries to human, crops or property and to the atmosphere itself. The substances which cause air pollution are called as air pollutants.

The polluted air affects not only living beings but also non living things and has a deleterious effect on mankind. Air pollution is a serious problem in many countries of the world. Centre for Science and Environment (CSE) has observed that air pollution is the fifth leading cause of death in India after high blood pressure, indoor air pollution, tobacco smoking and poor nutrition, with about 620,000 premature deaths occurring from air pollution-related diseases. Like China, India faces an unprecedented public health crisis due to air pollution. Half of the urban population breathes air laced with particulate pollution that has exceeded the safety standards. As much as one third of urban population is exposed to critical level of particulate pollution. Smaller cities are among the most polluted in the country.

The green think tank released its own assessment and the global study's India specific data during February 2013 warning that the number of premature deaths due to air pollution had increased six fold over the last 10 years.

Air quality data generated by the Central Pollution Control Board (CPCB) for 2007 under the National Air Quality Monitoring Programme (NAMP) presents deadly facts about air pollution levels in Indian cities. CSE has analysed the official data to assess the state of air quality and trend in Indian cities. The most widely monitored pollutants in India are particulate matter (PM),

nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and on a limited scale carbon monoxide. Some of the worst forms of air pollutions are found in Indian cities. The Central Pollution Control Board (CPCB) considers air to be 'clean' if the levels are below 50 per cent of the prescribed standards for pollutants. During 2007 only 2 per cent cities have low air pollution on the basis of PM_{10}. In about 80 per cent of cities (of a total of 127 cities/towns monitored under the NAMP) at least one criteria pollutant exceeded the annual average ambient air quality standards. This has serious public health implications. There are very few cities, which can be termed clean keeping PM_{10} levels (respirable particulates) as criteria however over the years SO_2 levels have fallen sharply in many cities but the NO_2 levels are increasing in many cities.

5.10 Issues of concern in air pollution

Global warming

In past few decades, there has been a large amount of hue and cry regarding the issue of earth getting hotter and hotter year after year. This concept of global warming is predominantly because of major changes in the human lifestyle. Generally, green house gases viz., Carbon dioxide, methane, etc. in the lower atmosphere act as a shield in trapping some of the heat, as it radiates back to the atmosphere from the Earth. Such gases because of their heat and warmth have made survival for life on our mother Earth. But when the quantities of these green house gases increases, excessive heat is generated and makes living almost impossible.

The reasons for increase in quantity of green house gases :

- Continuous and excessive burning of fossil fuels increases carbon dioxide level
- Excessive deforestation leads to increase in carbon dioxide level
- Large scale decomposition of organic matter in swamps, rice fields, live stock yards has lead to increase in methane level
- Level of Chloro Flouro Carbons (CFCs) increasing due to change in human life style

Acid rain

Rainfall through unpolluted environment is slightly acidic with its pH value ranging just less than 7. However, when the environment is polluted with primary pollutants like SO_x and NO_x gases, the resultant precipitation tends become more acidic. This acidity if because of the formation of secondary pollutants like sulphuric acid and nitric acid due to the reaction of water vapour with SO_x and NO_x gases. It has been specified that when the pH value of rainfall is less than 5.6 or below, then the rain is specifically termed as acidic.

Photochemical smog

Photochemical smog is a unique type of air pollution which is caused by reactions between sunlight and pollutants like hydrocarbons and nitrogen dioxide. Although photochemical smog is often invisible, it can be extremely harmful, leading to irritations of the respiratory tract and

eyes. In regions of the world with high concentrations of photochemical smog, elevated rates of death and respiratory illnesses have been observed.

Ozone depletion

Ozone depletion is the most dreaded aspect of air pollution, having wide spread implications, extending over the entire atmosphere. This problem is caused by the reduction of naturally available ozone layer in the atmosphere. Scientists are also becoming aware of the possible connection between ozone depletion and climate change due to global warming. The increased concentrations of green house gases leading to warmer climate at the Earth's surface, infact causes cooling effect at altitudes where the ozone layer is found. This cooling of the stratosphere enhances the chemical reaction that destroys the ozone, leading to further ozone depletion.

Chlorofluoro carbons (CFCs) are the chief agents of ozone destruction. They are largely used and subsequently released in modern world, in refrigeration, air-conditioning, fire extinguishers. These inert CFCs do not disintegrate in the lower atmosphere and do rise several kilometers up into the stratosphere, where they release chlorine atoms in the presence of sunlight. Each chlorine atom from CFCs then reacts with an ozone molecule forming Chlorine monoxide. The Chlorine monoxide thus formed, reacts with another oxygen atom to form a new oxygen molecule and a chlorine atom. The chlorine atoms, thus replenished can go on to break apart thousands and thousands of more ozone molecules, leading to large scale ozone deficits. It has been estimated that each atom of chlorine can destroy up to 1 lakh ozone molecules at a faster rate than the gas is replenished naturally.

5.11 Types of air pollution

Personal air exposure

It refers to exposure to dust, fumes and gases to which an individual exposes himself when he indulge himself in smoking

Occupational air exposure

It represents the type of exposure of individuals to potentially harmful concentration of aerosols, vapors, and gases in their working environment.

Community air exposure

This is most serious, complex, consists of varieties of assortment of pollution sources, meteorological factors, and wide variety of adverse social, economical, and health effects.

- Natural Sources –Volcano, forest fire, dust storms, oceans, plants and trees
- Anthropogenic Sources - created by human beings

5.12 Classification of sources of Air pollution

Air pollutants may be classified by sources as stationary or mobile

-Stationary sources

- Point sources (Industrial processing, power plants, fuels combustion etc.)
- Area sources (Residential heating coal gas oil, on site incineration, open burning etc.)

- Mobile sources

- Line sources (Highway vehicles, railroad locomotives, channel vessels etc.)

5.13 Types of primary air pollutants and their properties

INTRODUCTION

The agent causing pollution in air is termed as air pollutant. Air pollutants are broadly classified into primary and secondary pollutants. This lesson deals with primary pollutants and their properties.

Primary air pollutants

The atmosphere has hundreds of air pollutants from natural or from anthropogenic sources. All such pollutants are called as primary pollutants

The important primary pollutants are:

1. Sulphur oxides, specifically sulphur dioxide
2. Carbon monoxide
3. Nitrogen oxides
4. Lead
5. Hydrocarbons
6. Radioactive substances
7. Hydrogen sulphide

Sulphur dioxide

Sulphur dioxide is an irritant gas, and when inhaled, affects our mucous membranes. It increases the breathing rate and causes oxygen deficits in the body, leading to bronchial spasms. Patients of asthma are very badly affected by this pollutant. Sulphur dioxide is also responsible for causing acidity in fogs, smokes and in rains and hence is the major source of corrosion of buildings and metal objects.

Major sources of Sulphur dioxide

- Burning of fuels
- Thermal power plants
- Oil refineries and chemical plants
- Open burning of garbage

Carbon monoxide

Carbon monoxide possesses about 200 times affinity for blood haemoglobin than oxygen. Eventually, then inhaled, CO replaces O_2 from the haemoglobin and form what is known as carboxy-haemoglobin. This carboxy-haemoglobin is of no use for respiratory purposes, and hence when about half of the haemoglobin of the blood is used up in forming carboxy-haemoglobin, death becomes a certainty. Persons dying of carbon monoxide inhalations exhibit characteristics bright pink colour of the flesh due to the presence of pink coloured carboxy-haemoglobin in their bloods.

Carbon monoxide also affects the central nervous system, and is even responsible for heart attacks, and high mortality rates.

Carbon monoxide chiefly originates from automobile exhausts, and is caused by incomplete combustion of organic matter.

Oxides of Nitrogen

Nitric oxide and Nitrogen dioxide are found to be injurious to human health. Nitrogen dioxide is more injurious than nitric oxide.

Eye and nasal irritations are the common problems caused by nitrogen dioxide. Also respiratory discomfort occurs with brief exposure to NO_2.

Hydrogen sulphide

It is a foul smelling gas with a typical odour of rotten egg. Exposure to hydrogen sulphide for short periods may lead to loss of smell sense . This gas may also cause headaches, conjunctivitis, sleepnessness and pain in the eyes. Its higher concentration may block oxygen transfer and damage the nerve tissues. However, hydrogen sulphide is generally not found in any trouble some concentrations in our atmosphere mainly because it is not emitted in automobile exhausts.

Lead

Lead is mainly injected into the atmosphere through the exhausts of automobiles, particularly, by automobiles running on petrol. The concentrations of lead in inhaled air, may cause irritation of mucous membranes of nose, throat and lungs. Lead poisoning may also cause damage to gastro-intestinal tracts, liver and kidney. It may also cause abnormalities in preganancy and fertility. Lead poisoning is also found to be responsible for retarding mental growth in children.

Hydrocarbons

The compounds containing only hydrogen and carbon are hydrocarbons. Hydrocarbons are chiefly released into the atmosphere by automobile exhausts. Substances like formaldehyde cause irritation of eyes, skins and lungs and hence may be quite injurious to health

Radioactive isotopes

The radioactive isotopes viz., Strontium-90, Cesium-137 and Iodine-131 have been the main products of atomic explosives and accidental discharges from atomic and nuclear reactors; although, however, other isotopes may also be present. The serious health hazards caused by such radioactive emissions are anemia, cancers, shortening of life spans and above all the genetic effects, like sterility, embroyo defects, congenital malformations, etc. Radioactivity is notorious for its delayed and long term evil effects on human health.

5.14 Types of secondary air pollutants and their properties

INTRODUCTION

This lesson deals with secondary air pollutants and their properties.

The primary pollutants often react with one another or with water vapour, in the presence of sunlight to form entirely a new type of pollutants called / termed as secondary air pollutants. These types of pollutants are the chemical substances, which are produced from the chemical reactions of natural or anthropogenic air pollutants or due to their oxidation caused by the energy of the sun.

There are two main reasons for making distinction between primary and secondary air pollutants. First, in order to perform and interpret atmospheric chemical research, one must distinguish between primary and secondary air pollutants. The second reason is that emission controls can only be effectively treated at primary anthropogenic air pollutants, their formation process must be understood and somehow interrupted. Controlling the air concentrations of primary anthropogenic pollutants is much easier than controlling the concentrations of secondary pollutants. The distinction between primary and secondary air contaminants is not always clear, as the same chemical can either be directly emitted into or formed by reactions in the air.

As secondary air pollutants are mainly formed by chemical reactions, and chemical reactions usually produce products that are less reactive than their reactants, it would be convenient to assume that secondary pollutants are more inert than primary pollutants. In many cases, it is true. However, as sunlight drives many atmospheric reactions, additional energy can be found in some secondary pollutants.

The most important secondary air pollutants are:

- Sulphuric acid

- Ozone
- Formaldehyde
- Peroxy-acetyl-nitrate (PAN)

Sulphuric acid

It is formed by the simple chemical reaction between sulphur dioxide and water vapour, and is much more toxic pollutant than sulphur dioxide having far reaching effects on environment since it causes acid rain.

Ozone

Ozone is a primary example of a very reactive secondary air pollutant. Thus photoactivation can produce highly reactive products. The peak concentration of ozone is built late in the day, after the sun has had time to drive their formation.

Since ozone has been generally found to occur in the highly motorized areas, particularly during day time, it is believed that it is produced by the photochemical reaction of hydrocarbons and nitrogen oxide. Possibility of formation of such photochemical smog is quite high in places where number of plying automobiles is too high and where inversion smog conditions prevail in the atmosphere.

The presence of ozone gas in the air may cause irritation in the respiratory tract, reaching much deeper into the lungs than the oxides of sulphur.

Formaldehyde

Formaldehyde is an organic chemical that is very prevalent in our environment. It has colorless gas with a pungent odor from a family of gases called aldehydes. Commonly known as a preservative in medical laboratories and mortuaries, formaldehyde is also found in other products such as chemicals, particle board, household products, glues, permanent press fabrics, paper product coatings, fiberboard and plywood. It is a sensitizing agent that can cause an immune system response upon initial exposure. It is also a suspected human carcinogen that is linked to nasal cancer and lung cancer. Formaldehyde exposure is most common through gas-phase inhalation.

Peroxy-acetyl-nitrate (PAN)

It is a secondary pollutant present in photochemical smog. It is thermally unstable and decomposes into peroxyethanoyl radicals and nitrogen dioxide gas. It is a lachrymatory substance.

Peroxyacetyl nitrate, or PAN, is an oxidant more stable than ozone. Hence, it is better capable of long-range transport than ozone. It serves as a carrier for oxides of nitrogen (NOx) into rural regions and causes ozone formation in the global troposphere.

The formation of PAN on a secondary scale becomes an issue when ethanol is used as an automotive fuel. Acetaldehyde emissions increase, which subsequently react in the atmosphere to form smog. Whereas ethanol policies solve domestic oil supply problems, they drastically exacerbate air quality conditions

Peroxy acetyl nitrate irritates the eyes resulting in blurred vision and eye fatigue. It decreases vital capacity due to decrease in both inspiratory capacity and expiratory reserve volume.

5.15 Effects of air pollutants on living beings

INTRODUCTION

Air pollutants have a deleterious impact on both living and non-living beings. In this lesson, you will be learning about the effects of air pollution on living and non-living beings

Effect of Acid rain

When an air pollutant, such as sulphuric acid combines with the water droplets that make up clouds, the water droplets become acidic. When those droplets fall to the ground as rain or snow, the acidity of the water can have damaging effects on the environment. When acid rain falls over an area, it can kill trees and harm animals, fish, and other wildlife. Acid rain destroys the leaves of plants. When acid rain infiltrates into soils, it changes the chemistry of the soil making it unfit for many living things that rely on soil as a habitat or for nutrition. Acid rain also changes the chemical properties of the lakes and streams that the rainwater flows into, harming fish and other aquatic life.

Ozone layer depletion

Air pollutants called chlorofluorocarbons (or CFCs) destroy ozone molecules in the stratosphere. This has left places in the layer where the ozone is thin. These areas of thin ozone are called ozone holes. The ozone layer, located in the stratosphere layer of Earth's atmosphere, shields our planet from the Sun's ultraviolet radiation. Ultraviolet radiation causes skin cancer and damages plants and wildlife.

Tropospheric ozone harms living things

Ozone molecules in the troposphere damage lung tissues of animals and prevent plant respiration by blocking the openings in leaves, called stomata, where respiration occurs. Without sufficient respiration, a plant is not able to photosynthesize at a high rate and will not be able to grow. Ozone is also able to enter the stomata and decay plant cells directly.

Global warming harms living things

Our planet is currently warming much more rapidly than expected because of additional greenhouse gasses that are released into the atmosphere from air pollution. When fuels are burned, some of the pollutants released, such as carbon dioxide, are greenhouses gasses.

Through the process of photosynthesis, plants convert carbon dioxide into oxygen and use the carbon to grow larger. However, the amount of carbon dioxide released by burning fuels is far greater than plants can convert. Cutting down forests exacerbates the problem

Human health effects

- Exposure to air pollution is associated with numerous effects on human health, including pulmonary, cardiac, vascular, and neurological impairments.
- The health effects vary greatly from person to person. High-risk groups such as the elderly, infants, pregnant women, and sufferers from chronic heart and lung diseases are more susceptible to air pollution.
- Exposure to air pollution can cause both acute (short-term) and chronic (long-term) health effects.
- Acute effects are usually immediate and often reversible when exposure to the pollutant ends. Some acute health effects include eye irritation, headaches, and nausea.
- Chronic effects are usually not immediate and tend not to be reversible when exposure to the pollutant ends. Some chronic health effects include decreased lung capacity and lung cancer resulting from long-term exposure to toxic air pollutants.

Effects on human respiratory system

- Both gaseous and particulate air pollutants can have negative effects on the lungs.
- Solid particles can settle on the walls of the trachea, bronchi, and bronchioles.
- Continuous breathing of polluted air can slow the normal cleansing action of the lungs and result in more particles reaching the lower portions of the lung.
- Damage to the lungs from air pollution can inhibit this process and contribute to the occurrence of respiratory diseases such as bronchitis, emphysema, and cancer.

Effect of different air pollutants on living beings

Carbon monoxide

CO (carbon monoxide) combines with haemoglobin to lessen the amount of oxygen that enters our blood through our lungs. The effect of carbon monoxide leads to headaches, reduced mental alertness, heart attack, cardiovascular diseases, impaired fetal development, death.

Sulphur dioxide

It can oxidize and form sulphuric acid mist. Thus, presence of sulphur dioxide is responsible for causing acidity in rains and hence causes corrosion of metal objects and buildings. SO_2 in the

air leads to diseases of the lung and other lung disorders such as wheezing and shortness of breath. Sulphur dioxide also causes eye irritation, chest tightness.

Nitrogen dioxide

Eye and nasal irritations are the common problems caused by nitrogen dioxide. Nitrogen dioxide also results in respiratory infections, irritation of the lung and respiratory symptoms (e.g., cough, chest pain, difficulty breathing).

Ozone

Exposure to Ozone leads to eye and throat irritation, coughing, respiratory tract problems, asthma, lung damage.

Lead

Lead is responsible to anemia, high blood pressure, brain and kidney damage and neurological disorders. Prolonged exposure can cause damage to the nervous system, digestive problems, and in some cases cause cancer. It is especially hazardous to small children.

Particulate matter

Presence of particulate matter leads to eye irritation, asthma, bronchitis, lung damage, cancer, heavy metal poisoning, cardiovascular effects.

Volatile organic compounds.

Volatile compounds can cause irritation of the eye, nose and throat. In severe cases there may be headaches, nausea, and loss of coordination. In the longer run, some of them are suspected to cause damage to the liver and other parts of the body.

Formaldehyde

Exposure to formaldehyde causes irritation to the eyes, nose and may cause allergies

5.16 ISI standards for air pollutants and their abatements

This chapter deals with the Indian standards for Air quality and their abatements

5.16.1 National Ambient Air Quality Standards (Source: Central Pollution Control Board)

Pollutants	Time Weighted average	Concentration in ambient air

		Industrial areas, Residential, Rural and other areas	**Sensitive areas**
Sulphur Dioxide (SO_2), $\mu g/m^3$	Annual Average*	50	20
	24 hours**	80	80
Oxides of Nitrogen as (NO_2) , $\mu g/m^3$	Annual Average*	40	30
	24 hours**	80	80
Particulate Matter (RSPM) (size less than 10 microns), $\mu g/m^3$	Annual Average*	60	60
	24 hours**	100	100
Particulate Matter (RSPM) (size less than 2.5 microns), $\mu g/m^3$	Annual Average*	40	40
	24 hours**	60	60
Ozone (O_3), $\mu g/m^3$	8 hours	100	100
	1 hour	180	180
Lead (Pb), $\mu g/m^3$	Annual Average*	0.5	0.5
	24 hours**	1.0	1.0
Carbon Monoxide (CO) , mg/m^3	8 hours	2	2
	1 hour	4	4
Ammonia, $\mu g/m^3$	Annual Average*	100	100

	24 hours**	400	400
Benzene	Annual Average*	5	5
Benzo Pyrene – particulate phase only, ng/m^3	Annual Average*	1	1
Arsenic, ng/m^3	Annual Average*	6	6
Nickel, ng/m^3	Annual Average*	20	20

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be compiled with 98 % of the time in a year, 2 % of the time, they may exceed the limits but not on two.

5.16.2 Abatement of air pollution

The air pollution and the resultant air quality can be attributed to emissions from vehicular, industrial and domestic activities. The air quality has been, therefore, an issue of social concern in the backdrop of various developmental activities. The norms for ambient air quality and industry specific emissions have been notified. For control of air pollution, with a view to initiate policy measures and to prepare ambient air quality management plans, 321 Air Quality Monitoring Stations are operational covering twenty five States and four Union Territories.

The CPCB has evolved a format for preparation of action plans, which has been circulated to all State Pollution Control Boards/Committees. The action plans emphasize identification of sources of air pollution, assessment of pollution load and adoption of abatement measures for identified sources. Setting up interdepartmental task force for implementation of city specific action plan has also been suggested.

In order to control vehicular pollution, a road map has been adopted as per the schedule proposed in Auto Fuel Policy, which includes use of cleaner fuels, automobile technologies and enforcement measures for in use vehicles through improved Pollution Under control (PUC) certification system. As per the Auto Fuel Policy, Bharat Stage-II norms for new vehicles have been introduced through out the country from first April, 2005. However, EURO-III equivalent emission norms for all new vehicles, except 2-3 wheelers, have been introduced in 11 major cities from April 1, 2005. To meet Bharat Stage-II, EURO-III and EUROIV emission norms, matching quality of petrol and diesel is being made available.

5.17 Introduction to various Disaster:

Disaster is a sudden, calamitous and unfortunate event that brings with it great damage, loss, destruction, and devastation to human life as well as property and also hampers the ongoing developmental projects in a particular area being affected by the disaster. A disaster has been defined in many ways; World Health Organization has defined disaster as any sudden occurrence of the events that cause damage, ecological disruption, loss of human life, deterioration of health and health services, on a scale sufficient to warrant an extraordinary response from outside the affected community or area. Disaster management is very important to survive in the case of a natural or a major man-made disaster and can be defined as the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular, preparedness, response, and recovery in order to lessen the impact of a sudden disaster.

The damage caused by disasters is immeasurable and varies with the geographical location, climate and the type of the earth surface/degree of vulnerability. At times there can be disasters where there is no loss of human life and at times these can also cause a huge loss of life and property. This influences the mental, socio-economic, political and cultural state of the affected area. A disaster can be caused by human activities or due to some natural changes. Disasters are events that are unpredictable most of the times. It is important for any government, state or community to manage disasters by being prepared for it in advance. The government provides legislation, allocates resources and does the rational planning and sustainable development. Disaster management and planning is a key part of government work and an issue to be taken up seriously by the concerned authorities.

Effects of Disaster

A disaster is an event of sudden calamity causing disruption in normal routing and causing a lot of destruction depending upon the intensity of the disaster. Generally, disaster has the following effects in the concerned areas:

- It completely disrupts the normal day to day life.
- Causes a lot of loss in the terms of life and property.
- Leads to a loss of agriculture and animal life as well.
- Disasters hamper developmental projects in an adverse manner.
- Disaster causes destruction to the state of art and infrastructure.
- It negatively influences the emergency systems.
- Normal needs and processes like flood, shelter, health, etc. are affected and deteriorate depending on the intensity and severity of the disaster.

Types of Disasters

Disasters are inevitable; there is no country that is immune from disaster, though vulnerability to disaster varies. Generally, disasters are of two types – Natural Disasters and Manmade Disasters. Based on the devastation caused and intensity of the disaster, these are further classified into

major/minor natural disaster and major/minor manmade disasters. Some of the disasters are listed below:

Natural Disasters:

Natural disasters are generally unpredictable types of disasters and the destruction caused by these depends upon the intensity of the disasters. These disasters include floods, hurricanes, earthquakes and volcano eruptions that can have immediate impacts on human health, as well as secondary impacts causing further death and suffering from floods causing landslides, earthquakes resulting in fires, tsunamis causing widespread flooding and typhoons sinking ferries. Majorly the cause of these disasters is the change in climate as well as the movements inside the earth like moving of tectonic plates or lava. Depending upon the intensity as well as the destruction caused these can be classified as:

- **Major Natural Disasters**: Major natural disasters include the events of the high-intensity earthquake, floods, cyclone, flash floods, some major landslides and event of draught. These disasters generally cause a high loss of life and property and also lead to displacement of a lot of people from their shelters. Generally, these disasters pose a major threat to the developmental projects as well as the infrastructure of a particular area. Preparedness against these disasters should be on the top of the priority list.

- **Minor Natural Disasters**: Cold wave, heavy rains causing disruption in normal life, heat wave, thunderstorms, mudslides, some minor landslides and low-intensity earthquakes can be few cases of minor natural disasters. These disasters do not cause much loss in the terms of human life as well as property. Though, if care is not taken then these can prove to be fatal for human beings. There is generally not much need for disaster preparedness at the community level but this kind of disaster requires personal preparedness and awareness against these disasters. For example, there can't be disaster preparedness for heat-wave or cold wave at the community level; it is our own responsibility to take care of ourselves in the event of severe cold and heat.

Man-made Disasters:

These are the disaster generally taking place due to human activities and human negligence and can lead to a lot of destruction in the terms of life and property. At times these are really fatal and sometimes these could be a minor event of an emergency and can be handled at the personal level. At most of the times, these take place due to human negligence and hence are unpredictable most of the times, however, the events of wars, attacks etc are predictable disasters. The loss taking place due to these disasters depends upon the intensity of these disasters. These can be classified as:

- **Major Man-made Disaster**: Some major man-made disasters may include the events of forest-fires, event of wars, nuclear attack, major fires, industrial accidents as well as the event of building collapsing or accidents at construction sites causing a lot of loss and damage. Generally, the events leading to human negligence such as industrial accidents, events of fires and construction accidents are unpredictable and cause a major loss in the terms of life and infrastructure. Some major events of industrial fires have been reported in past years that have led to the death of a lot of workers and reported a huge loss of material and machinery. It is advised to have an emergency preparedness for evacuation in the events of an emergency and also industrial units should be vigilant and install all the safety gears as well equipment such as fire extinguishers and emergency alarms in the plant.

- **Minor Man-made Disasters**: Some events of train or road accidents, minor household fire, food poisoning, minor industrial accidents, events of looting, terrorist attacks or event of a fire at shops etc resulting mostly out of personal negligence is termed as minor man-made accidents. These do not lead to a high loss of life through loss of property may be evident in such cases. Personal awareness and caution can help you avert such incidents as well as to escape unhurt in case of such disasters. Hence it is advised to be cautious and vigilant to avoid such incidents.

Different kinds of Disaster

- Floods
- Train Accidents
- Aeroplane Crash
- Tsunami
- Earthquakes
- Wild Fires
- Rock and Snow Avalanches
- Nuclear Accidents
- Drought
- Cyclones
- Tornadoes
- Typhoons

Disaster Preparedness

Disaster preparedness or disaster management activities are aimed to minimize loss of life and damage in the event of a disaster. Disaster management forces can help by removing people and property from a threatened location and by facilitating timely and effective rescue, relief and rehabilitation at the place of disaster. Preparedness is the only way of reducing the impact of disasters as most of the disasters are unpredictable and even if predicted, there is not much time to act. Community-based preparedness and management should be a high priority in physical therapy practice management. Also, it should be the main agenda of the government to appoint a

proper department dealing with the disaster management and preparedness. Every municipality must have a disaster management plan as part of its Integrated Development Plans, according to the Municipal Systems Act. The local authorities should be empowered to act as soon as possible in the event of a disaster. It may take time to get relief and rescue operation to start, so in the meantime, it is the role of Municipal disaster management team to provide rescue work as soon as disaster strikes. Disaster Management has four phases namely:

- **Mitigation**: Mitigation can be defined as the effort to reduce the loss of life and property in the event of a disaster by lessening the impact of disasters. Mitigation is taking action now before the next disaster to reduce human and financial consequences later. Mitigation involves analyzing risk, reducing risk and ensuring against risk. Personal mitigation is a key to national preparedness. Individuals and families train to avoid unnecessary risks. This includes an assessment of possible risks to personal/family health and to personal property. Effective mitigation at the time of disaster requires that we all understand local risks, address the hard choices, and invest in long-term community well-being. Without mitigation actions, we jeopardize our safety, financial security, and self-reliance. For effective mitigation, coordination, planning, and mock activities are very important. Disasters can happen at any time and anyplace; their human and financial consequences are hard to predict, preparedness is the only solution.
- **Rescue**: Disaster can strike any place at any time. The response phase of an emergency may commence with search and rescue but in all cases, the focus will quickly turn to fulfil the basic humanitarian needs of the affected population. The assistance may be provided by national or international agencies and organizations but it is the role of local bodies to act as soon as possible. Effective coordination of disaster assistance is often crucial, particularly when many organizations respond and local emergency management agency capacity has been exceeded by the demand or diminished by the disaster itself. Rescue operation involves providing medication to those hurt and taking people out of the affected area and debris in the events of earthquake and floods etc. There are various rescue teams at national and state level which come into action as soon as disaster strikes. But it is also better if local authorities are also trained as they have the best knowledge about the geographical location and other local conditions.
- **Relief**: This is a coordinated multi-agency response to reduce the impact of a disaster and its long-term results. Relief operation starts as soon as disaster strikes and the main emphasis is laid on providing injured with medication and providing food as well as clean drinking water to the people. Relief activities include rescue, relocation, providing food and water, preventing disease and disability, repairing vital services such as telecommunications and transport, providing temporary shelter and emergency health care. It is very important to provide relief operation as soon as possible to minimize the number of causalities and to provide relief for injured. The relief workers are trained in basic first aid and medication and are also given training on maintaining coordination even in the event of a crisis. The relief operation is best supported only when carried out as a teamwork and all the members of the team should coordinate well with each other and also support one another without any discrepancy.
- **Rehabilitation**: As soon as disaster strikes the first thing that comes to mind is relief and rescue operations. Once emergency needs have been met and the initial crisis is over, the

people affected and the communities that support them are still vulnerable and it is time to start rehabilitation activities. Rehabilitation activities include rebuilding infrastructure, health care, and other basic necessities. These should blend with development activities, such as building human resources for health and developing policies and practices to avoid similar situations in the future. The immediate goal of the rehabilitation phase is to bring the affected area back to some degree of normalcy and to get back to the normal situation as soon as possible. During reconstruction, it is recommended to consider the location or construction material of the property and it should not be hurried rather reconstruction should be done properly and effectively.

5.18 Importance of Disaster Management

Disasters are events that have a huge impact on humans and the environment. Disasters are inevitable, we cannot do anything to prevent these but disaster preparedness is only in our hand. Disasters management requires government intervention and a proper planning as well as funding. It is not necessary that these disasters are always unpredictable. Floods take place in valleys and floodplains, droughts in areas with unstable and low rainfall, and oil spills happen in shipping lanes. This predictability provides opportunities to plan for, prevent and to lessen the impact of disasters. Disasters are inevitable although we do not always know when and where they will happen. But their worst effects can be partially or completely prevented by preparation, early warning, and swift, decisive responses.

Disaster management aims to reduce the occurrence of disasters and to reduce the impact of those that cannot be prevented. The government White paper and Act on Disaster Management define the roles of Local Authorities as well as Provincial and National government in disaster management. Disaster management forces come into action as soon as a disaster strikes and help out in the relief, rescue and rehabilitation process. These are trained individuals and are given extensive training to perform in the event of a disaster or a natural calamity and they work as a team to reduce the loss of life and helping the locals getting back to normal life.