Solid Waste: Solid waste encompasses the highly heterogeneous mass of discarded materials or throwaway from the urban community as well as the more homogenous accumulation of wastes generated by agriculture and industrial activities. Any unwanted or discarded material from residential, commercial, industrial, mining and agricultural activities that causes environmental problems may be termed as solid waste.

Solid Waste Management: According to Britannica, "Solid-waste management, the collecting, treating, and disposing of solid material that is discarded because it has served its purpose or is no longer useful. Improper disposal of municipal solid waste can create unsanitary conditions, and these conditions in turn can lead to pollution of the environment and to outbreaks of vector-borne disease—that is, diseases spread by rodents and insects."

Sources of Solid Waste: The following are major sources of solid waste:

1. **Residential:** Residences and homes where people live are some of the major sources of solid waste. Garbage from these places include food wastes, plastics, paper, glass, leather, cardboard, metals, yard wastes, ashes and special wastes like bulky household items like electronics, tires, batteries, old mattresses etc.
2. **Industrial:** Industries are known to be one of the biggest contributors of solid waste. They include light and heavy manufacturing industries, fabrication plants, canning plants, power and chemical plants and generate variety of waste depending on type of industrial unit.
3. **Commercial:** Commercial facilities and buildings such as hotels, markets, restaurants, go downs, stores and office buildings generate waste including plastics, food wastes, metals, paper, glass, wood, cardboard materials, special wastes and other hazardous wastes.
4. **Institutional:** The institutional centers like schools, colleges, prisons, military barracks and other government centers also produce huge quantities of solid waste.
5. **Construction and Demolition Areas:** Construction sites and demolition sites also contribute to the solid waste problem. Construction sites include new construction sites for buildings and roads, road repair sites, building renovation sites and building demolition sites. Some of the solid wastes produced in these places include steel materials, concrete, wood, plastics, rubber, copper wires, dirt and glass.
6. **Municipal services:** The urban centers also contribute immensely to the solid waste crisis in most countries today. Some of the solid waste brought about by the municipal services include, street cleaning, wastes from parks and beaches, wastewater treatment plants, landscaping wastes and wastes from recreational areas including sludge.
7. **Agriculture:** Crop farms, orchards, dairies, vineyards and feedlots are also sources of solid wastes. Among the wastes they produce include agricultural wastes, spoiled food, pesticide containers and other hazardous materials.
8. **Biomedical:** This refers to hospitals and biomedical equipment and chemical manufacturing firms. In hospitals there are different types of solid wastes produced. Some of these solid wastes include syringes, bandages, used gloves, drugs, paper, plastics, food wastes and chemicals. All these require proper disposal or else they will cause a huge problem to the environment and the people in these facilities.

Urban or Municipal Solid Wastes (MSW): All nonhazardous solid waste from a community that requires collection and transport to a processing or disposal site is called refuse or municipal solid waste (MSW). **Refuse** includes **garbage** and **rubbish**.

Garbage is mostly decomposable food waste; rubbish is mostly dry material such as glass, paper, cloth, or wood. Garbage is highly putrescible or decomposable, whereas rubbish is not. **Trash** is rubbish that

includes bulky items such as old refrigerators, couches, or large tree stumps. Trash requires special collection and handling.

Composition of MSW: The average composition of MSW is: 30 to 40% organic matter, 30 to 40% fine materials, 5% paper, 1% glass, 1% metals and 1% plastic. Actual composition of MSW varies demographically.

Municipal or Urban Solid Wastes include the following wastes:

1. Domestic Waste;
2. Commercial Waste;
3. Community Waste;
4. Construction Waste;
5. Institutional Waste

Classification of urban wastes: Urban wastes are classified into:

Bio-degradable wastes: Those wastes that can be degraded by micro organisms are called bio-degradable wastes. E.g. Food, vegetables, tea leaves, dry leaves, etc.

Non-biodegradable wastes: Urban solid waste materials that cannot be degraded by micro organisms are called non-biodegradable wastes. E.g. Polythene bags, scrap materials, glass bottles, etc.

Industrial Wastes: The main sources of industrial wastes are chemical industries, metal and mineral processing industries and produce large quantities of hazardous and toxic materials including packing materials, rubbish, organic wastes, acid, alkali, scrap metals, rubber, plastic, paper, glass, wood, oils, paints, dyes, etc. Thermal power plants produce fly ash in large quantites while nuclear plants generate radioactive wastes.

Causes of Solid Waste Pollution:

The reasons for the rapid growth in the quantity of solid wastes are over population, affluence and technology.

A. Over-population: As the number of people producing a pollutant increases, pollution will naturally increase. Same is true for solid waste pollution also which increases with the increase in population.

B. Affluence: i.e. production or per capita consumption. With affluence there is a tendency to declare items a being in or out of fashion and promptly throw away the ones out of fashion. This results in solid waste pollution.

C. Technology: i.e. amount of production produced per unit of economic good. Rapidly growing technologies for most economic goods indicate a shift in technology from the returnable packaging to non-returnable packaging. Returnable glass containers or bottles are being replaced by non-returnable cans, bottles, paper boards and plastic containers. Packaging is largely responsible for causing solid waste pollution because packaging materials like plastic bags and cans etc. are not biodegradable and persist unchanged in disposal operations such as landfills. Plastic can be recycled to make new packs but recycled plastic soon loses its strength, becomes brittle and is easily broken up by wind and rain.

Effect of Improper Solid Waste Management:

1. Due to improper disposal of municipal solid waste on the roads and immediate surroundings, biodegradable materials undergo decomposition producing foul smell and become a breeding ground for disease vectors.
2. Industrial solid wastes are the source for toxic metals and hazardous wastes that affect soil characteristics and productivity of soils when they are dumped on the soil
3. Toxic substances may percolate into the ground and contaminate the groundwater.
4. Burning of industrial or domestic wastes (cans, pesticides, plastics, radioactive materials and batteries) produce furans, dioxins and polychlorinated biphenyls that are harmful to human beings.

Solid waste management: Indiscriminate disposal of solid wastes, especially of hazardous wastes causes adverse environmental effects. The main objective of solid waste management is to minimise these adverse effects before it becomes too difficult to rectify in the future.

Solid waste management is a manifold task involving many activities like:

1. Collection of solid wastes.
2. Disposal of solid wastes.
3. Waste utilisation.

1. Collection of Solid Wastes: Collection includes all the activities associated with the gathering of solid wastes and the hauling of the wastes collected to the location from where the collection vehicle will ultimately transport it to the site of disposal. There are three basic methods of collection.

(a) Community Storage Point: The municipal refuse is taken to fixed storage bins and stored till the waste collection agency collects it daily for disposal in a vehicle.

(b) Kerbside Collection: In advance of the collection time, the refuse is brought in containers and placed on the footway from where it is collected by the waste collection agency.

(c) Block Collection: Individuals bring the waste in containers and hand it over to the collection staff who empties it into the waiting vehicle and returns the container to the individuals.

2. Disposal of Solid Wastes: Before the solid waste is ultimately disposed of it is processed in order to improve the efficiency of solid waste disposal system and to recover usable resources out of the solid wastes. The processing techniques such as compaction i.e. mechanical volume reduction or incineration i.e. thermal volume reduction and manual component separation i.e. manual sorting of the waste are employed to increase the efficiency of solid waste management.

Due to heterogeneity of the city refuse it is important to select the most appropriate solid waste disposal method keeping in view the following objectives:

(a) It should be economically viable i.e. the operation and maintenance costs must be carefully assessed.
(b) It should not create a health hazard.
(c) It should not cause adverse environmental effects.
(d) It should not be aesthetically unpleasant i.e. it should not result in offending sights, odours, and noises.
(e) It should preferably provide opportunities for recycling of materials.

-Salvage or Manual Component Separation: Before ultimate disposal, the manual separation of solid waste components is accomplished to achieve the recovery and reuse of materials. Cardboard, news-print, high quality paper, glass, metals, wood and aluminum cans etc. are manually sorted out or salvaged either for recycling or for resale.

- Compaction or Mechanical Volume Reduction: After separation of reusable or disposable articles, compacters are used to compress the waste materials directly into large containers or to form bales that can be then placed in large containers. Compaction increases the useful life of landfills.

For disposal of wastes, following treatment methods are adopted

A. Open Dumping: Open dumping of solid wastes is done in low lying areas and outskirts of the towns and cities. Being comparatively cheaper, this method of disposal is used extensively in India. However, major disadvantages are:

(a) Public health hazards are caused by the breeding of flies, mosquitoes rats and other pests.

(b) Obnoxious gaseous and particulate matter is produced by burning of the combustible solid wastes, resulting in air pollution.

(c) Open dumping requires large land areas which further aggravates the problem of land shortage for human habitation.

B. Sanitary Landfilling or Controlled Tipping: Sanitary landfilling involves the disposal of municipal wastes on or in the upper layers of the earth's mantle especially in degraded areas in need of restoration. In landfilling, the solid wastes are compacted and spread in thin layers each layer being uniformly covered by a layer of soil. The final layer is covered by a final cover of about one meter of earth to prevent rodents from burrowing into the refuse and scattering. This is a biological method of waste treatment and bacterial refuse digestion results in decomposition products like CO_2, CH_4, NH_3, H_2S and H_2O which can be harnessed as renewable sources of energy.

In the modern landfills, the bottom is covered with an impermeable liner, usually several layers of clay, thick plastic and sand. The liner protects the ground water from being contaminated due to percolation of leachate. Leachate from bottom is pumped and sent for treatment. When landfill is full it is covered with clay, sand, gravel and top soil to prevent seepage of water. Methane produced by anaerobic decomposition is collected and burnt to produce electricity or heat.
With increase in urbanisation, planned sanitary landfill, backed by modern solid waste management, can provide the community with better environmental management.

C. Composting: Bacterial decomposition of the organic components of the municipal solid wastes result in formation of humus or compost and the process is known as composting. It is another popular method practiced in many cities in our country. In this method, bulk organic waste is converted into fertilizer by biological action.

Separated compostible waste is dumped in underground trenches or compost pile in layers of 1.5m and finally covered with earth of 20 cm and left for decomposition. Some fertilizer and water is periodically added to the compost pile to stimulate microbial (bacteria and fungi) action and to maintain the necessary moisture content (55%). Periodically, the refuse is turned over to allow aeration i.e. penetration of oxygen to all parts of the organic refuse to facilitate aerobic bacterial decomposition. Organic matter is degraded and lot of heat is liberated increasing the temperature of compost by 75^0C and the refuse is finally converted into powdery brown coloured odourless mass called compost or humus that has a fertilizing value and is used in agriculture. Humus contains lot of Nitrogen essential for plant growth apart from phosphates and other minerals.

Advantages:

1. Manure added to soil increases water retention and ion-exchange capacity of soil.
2. This method can be used to treat several industrial solid wastes.
3. Manure can be sold thereby reducing cost of disposing wastes.
4. Recycling can be done.

Disadvantages:

1. Non-consumables have to be disposed separately
2. The technology has not caught-up with the farmers and hence does not have an assured market.

D. Municipal Waste Composting Projects:

Composting is the aerobic and thermophilic decomposition of organic waste to humus by micro-organisms like bacteria, fungi and worms. The process is conducted by a complete automatic system where the crude refuse is dumped into a container or to a belt conveyor and Iron or metallic particles are removed by a magnetic separator.

The wet material is then transferred to a rotatory cylinder which rotates on large tyres. Here aerobic microbes rapidly decompose pulverized wastes under aerobic conditions. The Government encourages feeding of compost plants by municipal wastes. Compost has been used by Indian Agricultural Research Institute to produce blue-green algae coated granulated compost.

E. Vermi Composting:

In Vermiculture, earthworms feed on and degrade a variety of organic waste, eliminate noxious elements and convert the waste into high grade nutrient rich vermi-compost. It is very useful biofertilizer and soil conditioner.

F. Incineration:

Incineration involves burning of solid wastes at high temperature either on batch or continuous type incinerators. The modern municipal incinerators are of continuously burning type. These are equipped with large storage bins, automatic feed hoppers, moving grates, ash discharging systems, pollution control devices like scrubbers and electrostatic precipitators. The unit yields stable residue free from offensive odours. The waste heat of combustion can be utilized for supplementing electricity generation for domestic heating etc. However, the technique involves expensive equipment.

Industrial Solid Waste Treatment:

A. High Temperature Incineration of Industrial Solid Waste:

It is a recent innovation where high temperature (–1650°C) is attained using supplementary fuels. The non-combustible fractions of the refuse (metals, glass) can be melted and reused.

Flash type incinerator, multiple hearth, rotary and fluidized bed type incinerators are finding wide applications in industrial waste disposal. If incineration becomes an economical method for solid waste disposal, useful material and energy shall be recovered by the process.

Heat can be recovered by putting a waste heat to boiler or some other recovery device on an existing solid waste incinerator. The heat so recovered can be utilized for generating electricity or for space heating purposes. The solid waste has about one-third the heating value of coal, but unlike coal it has very low sulphur content.

Advantages of Incineration:

i. Volume of the waste is reduced to more manageable levels thereby reducing the transportation costs upto the ultimate disposal site.

ii. Incineration reduces the land requirement to one third of that required if the refuse is to be land filled.

iii. The residue after incineration is free from any degradable materials. Moreover, the stabilised residue eliminates the need to transport the recovered material to the land fill site.

Disadvantages of Incineration:

i. Incineration leads to air pollution unless the plant is designed, equipped and operated to comply with air pollution standards.

ii. Typical air pollutants from incineration are SO_2, flyash, HCl and organic acids.

iii. Operation cost is high. Ordinary incinerators cannot be used for radioactive wastes.

B. Pyrolysis:

The chemical energy of some organic wastes can be recovered by destructive distillation or pyrolysis of the solid waste. The combustible constituents of the solid wastes are heated in pyrolysis reactor at about 1000°C in a low-oxygen or an oxygen free environment. This is an endothermic process and it differs from the conventional incineration.

Pyrolysis of the solid waste yields the following components:

(i) Tar or oil phase containing acetone, acetic acid and methanol etc.

(ii) Gaseous phase containing H_2, CH_4, CO, CO_2 etc.

(iii) Solid phase containing pure carbon, char and inert materials like glass, rocks, metals.

Advantages of pyrolysis include:

(i) Volume reduction by about 90%.

(ii) Possibility of handling potentially hazardous plastics, e. g., PVC in a safer way.

C. Vitrification:

The recent technique insitu vitrification aims at converting the solid wastes into a sort of glass. To accomplish this method electrodes are inserted into the waste heap and a very powerful electric current is passed through it. The strong heat so produced melts glass, plastic, muck, mud and other wastes into glass like solid. It can be dumped anywhere as it leaches very little. However, in this method care is taken to prevent mingling of radio wastes with other organic compounds.

3. Waste Utilisation: A developing country cannot afford wastage. By proper utilisation of solid waste a developing country like India can avail of many advantages.

Resource recovery or waste utilisation is achieved by three techniques:

(1) Reuse i.e. a given material has multiple uses.

(2) Reclamation i.e. a component of the waste is recovered for use in a manner different from its original use.

(3) Recycling i.e. isolating the material from which a given product was made and reintroducing it into the production cycle for production of the same product.

Examples of Waste Utilisation:

(a) Clean water resulting from treatment of industrial effluents and sewage can be reused.

(b) Refilling of used cold drink bottles.

(c) Jute wastes are utilised for making good quality paper, box-boards and hard boards.

(d) Sugarcane wastes are utilised for production of electricity, paper, boards etc.

(e) Waste products of slaughter houses can also be utilised. Blood is used in pharmaceutical industry and hides and skins are used for leather production.

(f) Cattle dung is used in gobar gas plants for making cooking gas.

(g) Cattle dung is used as a manure.

(h) Garbage is used for making compost.

(i) Waste paper is recycled to form paper, cardboard, good quality paper and paper bags etc.

(j) Scrap glass is used in production of new glass.

(k) Aquatic weeds like water Hyacinth (Eichhornia) is utilised by conversion into fertilisers, biogas, animal feed, paper etc.

(l) Plastic is recycled to make new packs, soft waxes, greases and adhesives etc.

(m) Used tyres casings are reused in the manufacture of synthetic rubber,

(n) Fly ash is used as a cement substitute to make bricks etc. Efforts are required to be made to minimise the generation of these wastes and to treat them to recover useful materials i.e. waste utilisation, and to make the residual innocuous and harmless.