



**LAND MANAGEMENT, ENVIRONMENT & SOLID-WASTE:
INSIDE EDUCATION AND BUSINESS IN CENTRAL ASIA
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MICRO-CREDENTIAL

**CIRCULAR ECONOMY
FOR LAND AND WASTE MANAGEMENT**

4.- Solid Waste Streams and Material Flows

Reading: Solid waste types and material flows.



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UNIT 9 TYPES OF WASTES AND WASTE GENERATION

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9.1 INTRODUCTION

It is worthwhile to note that in many instances the waste from making a product is made of same material as the product. Waste is the remaining or residual material which has become valueless when given bulk of material was converted into a useful product. The above definition may be very closely related to industrial waste but the gravity of problem is identified when it is understood that while chemical nature of the material may remain unchanged its physical state may alter. So while producing a product the waste may be solid, liquid or gaseous. It may even be mixture of three states and get mixed with supplementary materials. The waste from domestic and commercial activities may even be of different materials. In both cases the volume of waste may be larger than the product. Packaging of products like food and appliances may become problems of volume and many times difficult to handle. The industrial and medical wastes may present health problems.

Objectives

After studying this unit, you should be able to know

- what constitutes waste,
- the ways how are the wastes generated,
- strategies of solid waste management,
- the Indian scenario in respect of solid waste, and
- that management of waste must have holistic approach.

9.2 WASTE AND TYPES OF WASTES

Historically the management of waste has been an engineering function. The waste management initiated with the evolution of technological society. The improved technology introduced the practice of mass production and created problems of disposal of wastes. The material flow in a technological society follows path in which energy is consumed, products are generated and wastes are discarded. Figure 9.1 presents the most simplistic and primitive model. The complexities by way of realizing residual value from apparently valueless waste were introduced at a later stage. Such a situation is depicted in Figure 9.2 which shows attempts at recovery of available value from material.

However, such complex recovery operation will depend upon detailed understanding of waste, the process of manufacturing and a highly developed technology and handling facility for recycling of waste.

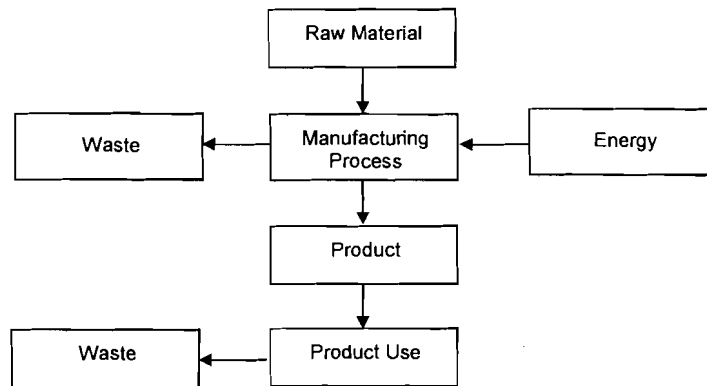


Figure 9.1 : Waste Generation in a Production Process

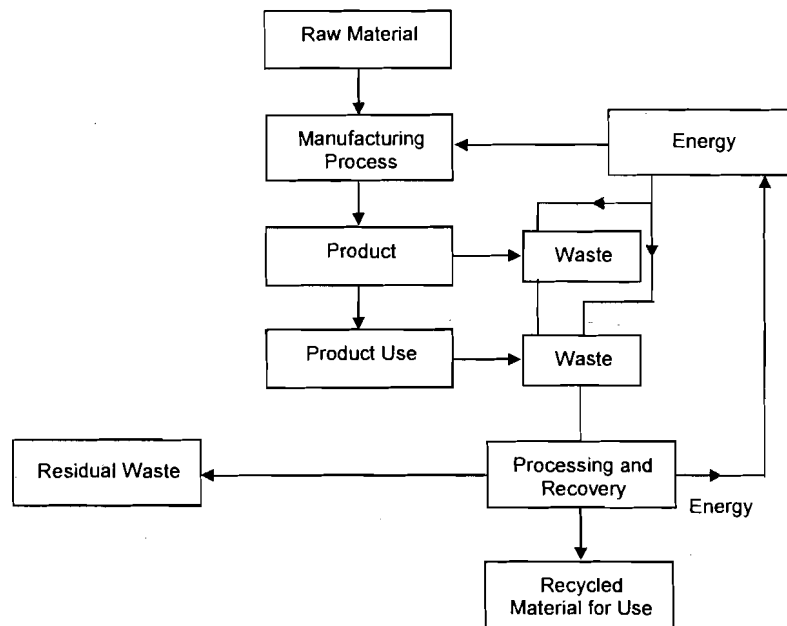


Figure 9.2 : Waste Generation, Recovery of Energy and Recycled Material from Waste

It may be imperative to understand that the raw material used in an industrial process might have been mixed, harvested or otherwise manufactured. Each of these processes would have left some waste behind. It may also be understood that use of product which leaves some waste may be totally a non-industrial activity. Commercial and domestic activities are such. It is also comprehended that manufacturing process may be replaced by agriculture resulting into waste byproduct and useful product. What it means is that man is involved in several activities and all of them are capable of using energy and producing waste while yielding some useful product or service.

The products (agricultural, industrial or services) have become the requirement of man for a better and comfortable life and high standard of living. In this quest the people tend to consume more goods and benefit from more services and thus allow more waste to be generated. One type of waste, i.e. gas which we have already seen is capable of diffusing in the air fast and as such need not be handled or management in the same way as the solid or liquid waste. The industries produce all three types of wastes and we will see now how the liquid and solid wastes may be managed. The other sources, i.e. commercial and domestic mainly produces solid wastes and need a very comprehensive treatment.

9.2.1 Sources of Solid Waste and Classification

Before we focus attention on industrial waste it is worthwhile to look at universal waste problem. The solid waste is any solid material in the material flow pattern that is rejected by user. A solid material is defined by its *angle of repose* and it has a significant angle of repose. The angle of repose is a characteristic that defines its fluidity. The material having no angle of repose will adopt a flat horizontal surface and thus the angle the pile of a material will make with the horizontal is the angle of repose. A solid material can be handled with such equipment as conveyors, front end loaders and shovels. If the waste cannot form a heap or pile on its own and needs containment walls for storage, it is generally considered as liquid waste.

Wastes are classified by several schemes. They are regarded solid, liquid or gases based upon physical state. The solid waste may be from different sources as domestic, industrial or commercial. They may be grouped as materials of different types such as glass, metal or paper. Physical or chemical properties call for such classification as **combustible, compostible, recyclable**. The wastes may vary in safety level and may be regarded *hazardous* or *non-hazardous*. Household and commercial wastes together are often referred to as *municipal solid waste* (MSW). Though MSW may not make the major portion of 6 or 7 billion tons of total solid waste produced in the world, the study and management of MSW attracts greater attention of engineers, administrators and politicians because it is that part of waste with which people come in direct contact. It is not difficult to realize at this stage that if not removed properly and at right time MSW has a great potential to jeopardize health of people. Therefore, governments and NGOs pay great attention to MSW management and management of MSW has acquired high political profile.

It is also realized that household waste is most difficult to handle because of diverse range of its constituents. It comprises such materials as organics (food), packages and containers, metals, glass and paper. These components are mixed together, thoroughly. Their composition in a given geographical location may change seasonally. The MSW in quantity and nature varies from country to country. Developed countries produce much more waste and urban areas contribute more to MSW than rural areas. As we pointed out earlier in this section. Greater human effort has been attracted by MSW management but system devised have had such component activities as collection, separation, storage, transportation, disposal, energy recovery, recycling etc. These activities are also applicable to others, notable industrial wastes. Therefore, those engaged in industrial waste management may greatly benefit from experiences of MSW managers.

What follows now is brief description of solid waste sourcewise.

Domestic Solid Waste

Single or multifamily households reject a variety of solid waste. The domestic solid waste includes following :

Garbage

Mainly it consists of food remains from preparation and eating. This material is organic in nature and highly putrescible. Garbage attracts flies, rats and different vermin and produces bad odour. The population of vermin thriving on garbage poses great health problem.

Rubbish

Although mainly non-putrescible inorganic and organic materials like paper, plastic, glass and metal products, the rubbish also includes yard and garden wastes. Small amounts of ceramics, dirt and dust also add to rubbish.

Ashes

Ashes are the results of combustion processes required for cooking and heating. Ashes are abundantly produced if wood and coal are used as fuel.

Bulky Wastes

Furniture, mattresses, appliances and similar large items form bulky domestic wastes. Normal collection methods and tools cannot be used for handling such bulky wastes. They will require special equipment.

Commercial and Institutional Solid Waste

This category of waste is emitted from such establishments as offices, banks, retail stores, restaurants, schools and hospital waste, because of their peculiar nature of disease carrying substances and bandages is now dealt with as a category in itself. However, all above mentioned establishments generate rubbish because of packaging materials. In earlier practice on site incineration of rubbish was adopted to reduce volume to be handled and thus ash was also produced. However, because of prohibition on small scale incineration for the fear of increased local air pollution ash is generated only to the extent of cooking in some restaurants.

Construction and Demolition Waste

Construction is one of very important activities of human population. Great deal of waste material lying around a newly constructed housing and other complexes are not uncommon. In urban areas the law does not permit the constructor to leave lumber, steel, bricks, concrete, plumbing, electrical wiring, etc. around the construction site. Similar materials may litter the area if existing complex is razed. Such remains of construction or demolition often find ready users and management involves sorting and transporting.

Special Wastes

These are the wastes which are not allowed to mix with any other stream. These wastes may be explosive, toxic, radioactive or pathological. Hospital waste was earlier identified as institutional waste along with the idea that hospital wastes have special pathological effects. The special wastes need special techniques for handling and disposal. The industrial wastes are also often called special wastes.

Other Municipal Solid Wastes

This category is created from out of municipal activities such as street refuse, dead animals, abandoned vehicles, park and beach remnants, etc.

Street Refuse

Road and streets are cleaned and several types of materials are collected. Sand, grit and dirt which are inorganic materials are the major constituents of street refuse. In geographical locations where summer is harsh and long grit and dirt may dominate alongwith plastic and paper cups and plates offered by road side hawkers. In colder regions where winter is dominated by snow, sand and cinder used to minimize slipping and skidding also become part of street refuse after ice melting. The leaves falling from tree, particularly in countries of higher latitudes, add greatly to the street refuse. In the countries near tropics the leaves from particular trees fall in great quantities and may litter the streets. Now-a-days burning of these leaves is totally banned and thus they increase the street refuse. Cleaning and removing the waste from roads is the responsibility of municipality.

Dead Animals

Municipalities in urban areas have to fulfill the responsibility of removing dead bodies of animals like dogs. In this country the street dog population is significantly large and domesticated dogs are rare. The former die unnoticed. Other animals like cows are also left to die in open often and these dead bodies are removed by specially trained squads. Localities adjoining wild animal habitats may have wild animals dying in the populated areas and municipality there has the responsibility to remove the dead bodies.

This is not yet common in our country because of significant solvage value of old vehicles but in industrialized developed countries this problem is met when some owners of the vehicle remove the number plate and leaves the vehicle in the open. The ownership of a resold used car cannot be traced and local government has to deal with such abandoned vehicles.

Park, Beach and Landscape Refuse

Parks and beaches are used by people for visits and enjoyment and in the process they leave food packets, wrappers, plates (all paper products), bottles (glass) and cans (metal). The administrators of these places have to collect these leftovers alongwith leaves and foliage from plants and trees maintained as landscape. The problem assumes greater proportion when storm strikes and special refuse removal methods have to be applied.

Industrial Solid Wastes

These are mainly the process wastes produced during manufacturing as discarded material. Sometimes defective products can also become waste. Industrial processes vary largely from one industry to other and the wastes could be solid, liquid or gaseous. Looking at only solid waste, the disposal in each industry will be its characteristic. However, most industrial wastes are covered by government regulation, hence the industry is required to meet the prescribed standards. The industrial wastes are carefully categorized as hazardous and non-hazardous. Even non-hazardous industrial waste is not allowed to mix with municipal solid waste. Hazardous industrial wastes have strict regulations to follow, though industries may have hard time to distinguish. For example, some industries may classify empty paint cans as non-hazardous though paints may not free from harmful effects.

In industries, economy of production, is an important consideration and hence waste reductions is involved in design of product and process. The industries using metals, wood, plastics, ceramics, etc. as raw materials often adopt secondary production line if waste is high in volume. In some cases the solid wastes from industry are deposited in specially designed landfills which require strict monitoring.

Hazardous wastes have specific characteristics of toxicity, ignitability, reactivity and corrosivity. The government brings out lists of hazardous materials based on the properties of materials forming the waste. The industries either are required to treat the waste before disposal or transfer them to licensed agencies which can dispose off the wastes.

It may also be pointed out here that the industries will contribute their share of normal MSW in form of food wastes, paper, dust, dirt, packaging material, etc.

Agricultural Wastes

The wastes are generated in agricultural fields and mostly are residues from crops. Some of the residues are removed but most is ploughed and mixed with soil. The pruning and cutting of vineyard and orchards though uncommon in this country, present a serious disposal problem.

Related with agriculture is animal husbandry and large number of cattle in confined space present manure generation and disposal problem. Though cattles like 10,000 in number is not common in India, with much smaller number of cattle the disposal of dung does pose a problem. If not handled properly this waste may be the cause of health problems.

9.3 SOLID WASTE MANAGEMENT

The objective of solid waste management is the removal of discarded and valueless material from the material flow pattern. Management comprises judicious use of available resources to achieve the objective. The first need to justify the use of resources in removal of the discarded and valueless material is that if they are left where they are generated or dumped somewhere in the midst of or near population there is risk of disease and ill hygienic condition as well as economic loss of land area. In nomadic society the waste was left where it was produced and the population used to move away. But with permanent settlement being the order of the day and urbanization requiring every inch of available land for residential and economic purposes both the risks to health and locking of land can not be tolerated and hence the removal of solid waste at a safe distance and in a safe way becomes imperative. The management of MSW in this context has assumed greater significance as well as the part of economic activity.

However, there are several constraints that work around MSW. These constraints apparently can be listed as public health protection, cost restriction, environmental compatibility and recovery of resources from wastes.

The solid waste particularly from food source and putrescible material, is capable of attracting rats and flies. Such vermins are capable of disease causing bacteria. This makes solid waste a significant health hazard and management functions concentrate on this object of removing disease causing waste material from environs of population.

The cost evaluation of removing solid waste takes several factors into account. The management has to identify such technologies as dumping waste in a gravel pit, hauling it to sea, volatilizing it in atmosphere or incinerating. There is yet another technique of removing and creating a landfill. All the techniques may have a current cost but also a cost which will incur in future. The economic evaluation must consider both and attempt to bring the combined cost to minimum. The cost of design, construction and operation of handling, transporting and dumping equipment must be minimum at present and in future as well.

It is important to see that any consequence of waste disposal method does not cause damage to environment. The earlier technique of burning the waste and converting it into innocuous and less voluminous ashes has to be abandoned in favour of adding no harmful gases to the environment. The cost of removal of ash may pose a far less expenditure in transportation. The environmental pollution cannot be allowed for its incompatibility with the people. Almost since 1970 the burning of all disposable solid waste has been abandoned.

Any management strategy in respect of solid waste must keep the objective of recovering usable material as well as energy from the waste. The landfills have been used to recover fuel gases. Their geographical locations, mixing with moisture, exposure to sun, depth to which filled and distance from populated areas are sundry factors which need consideration under this disposal programme. The plastic, metals and paper products can be recycled, and thus a great deal of energy can be saved. However, such a scheme will require sorting of components of waste. The best and efficient way to separate them will be at source itself. The MSW is one of most entangled waste whereas industrial solid waste can be very conveniently separated at the source itself. That is the reason why these two types require two different strategies. Educated and enlightened housewives can support the separation strategies at the source of domestic waste. The institutions which produce large volumes of waste can also help in separation or sorting at the source and thus boost the recycling strategy.

9.3.1 Environmental Concerns

The greatest concern of solid waste management, today, is related to environment. The awareness about environment has grown on scientific, social, political and legal grounds. In all spheres of life very strong desire for sustainable development seems to have taken roots. Sustainable development is understood to meet the needs of present without

compromising the ability of future generations to meet their needs. This development requires more value from goods and services produced by industry with consumption of material and energy with less emission and waste. If the waste is large it is simply squandering of earth's resources and all should join hands in avoiding such squandering. In immediate past much of useful material has been put as waste in the landfills and less of it is now available from its natural source. This practice has already triggered mining of landfills and future is full of such opportunities. Yet such management of natural resources can hardly be called efficient. The strong demand of technology and management now is to reduce or minimise the wastage. While landfills assume the role of future source of material and energy in form of fuel gas. Such gases start emitting at low rate from the beginning. Despite the fact that landfill gases have global warming potential when dispersed widely in atmosphere, they can have immediate explosive effect in local area. The landfills can pollute groundwater from the leachate generated in the landfill sites.

With rising population and their needs there is multiplying effect on industrial and economic activities. The environment and natural resources can be saved by way of reducing waste and handling the inevitable waste in such ways that resources and energy can be recovered and disposed waste does not cause any adverse effect on the environment.

9.3.2 Management Strategies

It has been recognized in general that the control of waste so that it is less and its disposal so that it does not prove hazardous is the responsibility of waste generators. It so happens that almost all citizens are involved in waste generation whereas the industries and local and state governments are involved in their disposal. Failure on the part of any one section can cause great damage to waste management. For keeping an overall control on waste the government has to formulate rules and regulations or legislate acts so that all citizens can be equally held responsible for not being careful.

The regulations have *end-of-the pipe* nature by defining the permissible limits of emissions both in respect of waste from an activity or in disposing off the waste. Waste disposal processes like incineration or landfilling are controlled by such regulations in terms of their effects.

There are several hierarchies of options of waste management that have been proposed though no legal or other binding has been placed upon a particular order. All or some of them may be selected in order that suits local needs the best. However, less waste generation will always remain the most important hierarchy. The other hierarchies are *reuse, recycling, composting, energy recovery, incineration without energy recovery and landfill*. It is difficult to say which option is best. It will depend upon material in the waste. Yet it may be mentioned that management of solid waste is in crisis. There are several manifestations of this crisis. Some of them are dwindling landfill capacity and public opposition to siting of landfill, groundwater contamination and again public opposition to incineration. The increasing cost of handling of solid waste is further augmented by its increasing volume. Natural cause of all these manifestations is indiscriminate use of material from natural sources. The cost of solid waste handling is the down stream cost of material and its peculiarity must be noted that it is same for costly and not so costly material. The intrinsic cost of the material depends upon its extraction and availability in nature. The cost of extraction does not normally include the value of scenic vistas, clean air, groundwater or habitats of variety of life forms which are damaged due to extraction of material from earth. If right perspective of environment is kept in mind then the extraction of material from ground will be the last resort in material flow cycle.

The maximum use may be extracted from the material through recovery and re-entry into the manufacturing loop. This is an attitude to develop upon the ideology of sustainability. A forest not cut, a mine pit not opened or an oil well not tapped will leave environment proportionally clean and will also leave the natural resources for future generation.

It is important to note that recycling of paper will leave many trees uncut. A study in USA has shown that recycling of paper to the extent of 40% will leave 175 million trees uncut in next 10 years. Yet another study in the USA indicates that about a billion ton of mining processing waste is generated in extracting material. This waste damages water in 730 km² of lakes and 19000 km length of rivers. There are some metals which produce much greater volume and weight of waste than the metals themselves. As an example it is noted that for every ton of lead extracted 33 tons of waste is left. Recycling of used lead and minimizing its use will greatly help the reduction of solid waste.

The risk minimisation during recovery or recycling may be effected by bringing chemical changes during the process. It is imperative that any process used for recovering material or energy from the waste will cost more if harmful ingredients are likely to be added to the environ. For example cadmium based pigments in plastic products will present great difficulty in incineration in which cadmium may either pass into air or remain in ash. In both situation it is dangerous and cost of waste disposal can be brought down if cadmium based pigments are avoided.

At this time in most developed countries recycle efforts mainly concentrate on newsprint, cardboard, glass, steel, aluminium, tin cans and some plastics. About 17% of waste is recycled in these countries.

Composting is resorted to in case of yard or garden waste mixed with other organic substances. Composting results in volume reduction by about 50% but produces CO₂ and water. The composting product normally sold as organic manure is not readily acceptable in the market because the chemical composition of final product is variable.

The decisions on the technology to be used and also upon siting of facilities is a managerial decision. The decision is based upon available technology and market condition. The most convenient method that has been used very widely is landfilling but the awareness about environment which has developed among people, government, politicians and social workers does not allow landfilling to continue in the vicinity of populace. Recycling incineration and composting reduce the size of landfills.

9.4 SOLID WASTE MANAGEMENT SCENARION IN URBAN INDIA

India has a poor solid waste management system and this waste, in whatever way, is mainly managed in developed urban areas. While urbanization has been increasing at 3.6% rate annually the infra-structure in cities of population of 1 lakh and above has not kept pace with their increasing population. The waste generation in cities of population of 1 lakh to 5 lakh is at the rate of 200 to 500 gm per person per day. The higher rates are found in still larger cities. By the year 2000 the Indian cities were generating solid waste around 40 million tones per year. In India the waste typically consists of compostable material in the range of 30 to 57% while inert material in the range of 40 to 54%. The recyclables form a small part from 5 to 10% only.

The Indian scenario in respect of waste has been found to be very miserable by a committee appointed by Supreme Court in 1999. It was reported by the committee that domestic, commercial, bio-medical and industrial wastes are thrown on streets, footpaths, and into drains and water bodies. There is no segregation or sorting out of recyclable materials.

Primary collection system does not exist in most cities. Thus the waste is collected from the streets. In some place street bins are provided but they are insufficient in number and inefficient in function.

Some cities have provisions of large masonry or metallic bins where waste is stored from primary collection. Yet these bins are not emptied everyday and waste is found more around the bins than inside. Street cleaning is also not done daily. Sunday and public holidays are not meant for cleaning.

All sorts of vehicle like bullock carts, tractors, three wheelers and trucks can be seen to carry waste on roads of cities. Only big metros have modern hydraulic loading trucks. In most cases the loading in vehicles is manual. There is no synchronization between primary collection and bulk storage of waste. This results in multiple manual handling.

Only in a few big cities part of waste is composted. The waste is very commonly dumped in crude manner in open ground in most of the places. The local governments which are responsible for waste disposal seem to have developed no scientific outlook towards this problem. Even if deposited in open, as is the practice, the waste may be made safe environmentally by covering with an inert material but unfortunately it is not done in most of cities. Since the suitability of ground for dumping is not ascertained a very imminent risk of groundwater pollution exists. Further the growth of vermins, rodent, flies occurs creating conditions which are disease causing.

The immediate needs of creating professional administration of waste disposal and involving community through general education are recognizable. The steps are to be taken by the government. The problem of mismanaged waste is faced by 65% of the population of cities of population more than 1 lakh. The committee appointed by Supreme Court has gone into the depth of the problem and has made far reaching recommendations for waste disposal.

9.4.1 Proposal for Solid Waste Management

In the first place throwing of wastes in the street is required to be banned. The waste should be stored in place of generation preferably in two bins. One bin is to be reserved for food or biodegradable waste while the other for recyclable waste. This arrangement must be made compulsory for all residential and commercial complexes where additionally community bins may be erected or installed.

It should be the responsibility of the local government or an agency appointed by the government to collect the wastes from doorstep. Vehicular carriers – manual or motorized – may be deployed for such collection and public awareness for cooperation may have to be created. The local government or its appointed agency may decide if hazardous waste is generated at any place and then make special arrangement for its handling. The arrangement for sweeping of street without any break during the week should be adopted. The public places frequented by people must be provided with bins visible marks. No bins on street sides should be permitted.

Multiple handling of waste should be avoided. The specially designed trucks for transferring waste from small vehicles should be used and system must be synchronized. Such systems do exist in developed countries and trucks normally have compactors to reduce the volume. A study of such system will help.

It is strongly proposed that in our country compostible waste should be converted into organic fertilizer so that organics will be returned to soil. Also associated with separation of recyclable waste, only a small part of total waste will be required to be disposed off in landfills. Entrepreneurship in composting will provide a boost to economy and government must make programmes on the same scale as they have done for small industries. The help of NGOs may also be solicited. Certain alternative technologies suggested and used in many developed countries like incineration, burning in furnaces for power generation or palletizing into fuel pellets appear to be costly in Indian conditions. They must be examined extensively before making selection. Bio-medical waste, slaughter house waste and industrial waste need to be handled differently and they are not the part of general MSW. The guidelines for disposal of these categories of waste are obtained from pollution Control Boards.

Cooperation of public is of great importance, however, those found guilty of erring and not following the rules may be required to pay fines. Necessary provisions in the law may have to be added and local government given the powers to impose such fines.

9.5 AN INTEGRATED APPROACH TO SOLID WASTE MANAGEMENT

We have attempted to define waste and categorized it into various types. We have also identified the sources from which solid waste is generated. The further discussion brought out the importance of disposing off waste in a manner that will have following characteristics.

- (a) The economic cost of waste disposal is to be minimal.
- (b) The method of waste disposal should be acceptable to people.
- (c) The waste disposal must not further create burden on environment like producing greenhouse gases or polluting groundwater.
- (d) The energy and/or material may be extracted from the waste, i.e. recycling of recyclable waste or incineration.
- (e) Compostible waste must be composted to produce organic fertilizer and reduce the volume of waste.
- (f) The legislations if existing in respect of waste must be enforced and if not existing must be passed by the government for the sake of health of people and clean environment.
- (g) The people in general must be educated in respect of waste and their cooperation must be sought.

The Indian scenario having a dismal picture on waste disposal front was described and need for managing the waste in a proper manner was also stressed. However, Indians still do not produce as much waste per capita as Americans or Europeans do.

With several methods of waste disposal described here the questions can be raised. Will the recycling which will have natural resources for future generation be eco-friendly or economic? Should incineration be discarded for producing greenhouse gases whereas many industrial processes and automobiles continue to do the same in much greater proportion? Should landfilling be not looked at as a method of storing material for a long time to be extracted by future generation or only its negative aspects be highlighted? Why should the waste be sorted out despite the fact that it will add greatly to the cost of disposal? There are many such question that may arise when one is required to make choice from several available strategies. The answer is simple that no one strategy will be able to solve the problem to greatest satisfaction and hence the idea of integrated waste management is introduced.

The objective of integrated waste management will be to achieve environmental and economic sustainability. It has also become clear that no single method of waste disposal can achieve both the objectives. A range of options is to be examined. The use of different options like composting or recovery will also depend upon the collection and subsequent sorting system. This means that any waste management system is made up of inter-related processes which need to be integrated. In the approach of integrated system the focus from comparison of individual systems (like comparing incineration with landfill) is shifted to synthesizing the waste management system, which can deal with whole waste streams. The comparison is then made between synthesised systems.

It may be pointed out here that a great deal of efforts has been made into schemes concentrating attention on individual technologies like recycling, or composting. Such efforts have been found to be less efficient economically or environmentally ineffective or both. It is further to note that the waste management functions do not come directly under the jurisdiction of one authority. The leading functions are collection, transportation, landfilling, recycling and incineration. Different authorities like local government, its agencies, private companies and contractors may contribute partly or

totally in each of above functions. Then there are compliance authorities which over-view functions individually and separately. The coordination among these agencies is essentially required in a holistic approach and such coordination among diverse authorities and agencies is very difficult. Thus implementation of integrated waste management is full of difficulties.

To conclude, while designing a waste management system one can seek following characteristics.

Marketability

Marketability of products of recycling, composting and energy. Naturally these products from waste have to compete with products from conventional sources which normally have their prices determined by other forces.

Flexibility

Flexibility of the system is the response to the need for change and such a response should be positive. Again the need for change can arise from many different quarters.

Scale

Scale of operation should be large. It has been estimated that comfortable number of household for profitable schemes would be 500,000. This is a very large number even for big cities.

SAQ 1

- (a) Describe different types of wastes.
- (b) What are different sources of wastes?
- (c) How can waste be used?
- (d) What is municipal solid waste? Describe different categories of MSW.
- (e) How is environment related to waste?
- (f) How is solid waste disposed off?
- (g) What is the solid waste scenario in Indian cities?
- (h) What is integrated solid waste management?

9.6 SUMMARY

Waste is valueless material left after a process is complete and product made. The product also becomes waste when it has served its purpose. The first type of waste is often generated in industry while second type predominates domestic and commercial establishments. The waste material could be in all three states of solid, liquid and gas. The solid does not flow or diffuse hence becomes a heap and obstructs movement, dirties surrounding and hosts vermins, flies and other disease causing bacteria. This is more true for municipal solid waste or MSW which comprises food remains paper, glass and metals. MSW is much smaller than industrial waste but becomes a major problem for its multiple sources and mixed nature. Garden or yard waste mainly consisting of leaves and twigs from trees and bulky furniture also become the part of MSW. Construction and demolition waste, though most of it is removed by constructor still adds to MSW. Dead animals and in some cities the abandoned cars also become part of MSW. Thus MSW has a vast variety and is difficult to dispose off. Industries, besides producing specialized industrial waste also contribute their share to MSW and some of agricultural wastes are also added.

The principle of waste management is to add value to wasted material and reuse. The extraction of useful material or recycling of waste requires tedious and costly process of separation or sorting and then use of energy to extract useful material. Such process may provide some sustainability to development by not using natural resources and leaving them for posterity. Yet another method may be to extract energy by incinerating waste though such a process may release pollutants in the atmosphere. The organics or putrescible part may be composted to extract organic fertilizer and reduce the volume to less than half. All sorts of MSW or remains from recycling and incineration may have to be buried in the landfills which may cause groundwater pollution and may produce landfill combustible gases. Such gases may be causing greenhouse effects and may catch fire accidentally. However, the landfills can become mining sites and sources of fuels in future.

However, a concept of integrated waste management whereby all technologies may be considered and used is being proposed now. With difficulties like different authorities controlling different aspects of solid waste management, such holistic approach seems difficult.

9.7 KEY WORDS

Waste	: A valueless material remaining from a process, product or service.
Solid Waste	: A waste which does not flow or diffuse in air.
MSW	: Municipal solid waste is produced from domestic and commercial sources. Its disposal is not the responsibility of producer but local government.
Compostible	: The waste which can be converted into manure.
Recyclable	: The waste which can be converted into useful material.
Incineration	: The process of burning a combustible waste to produce thermal energy. It is done in specially designed incinerators.
Hazardous Waste	: Mainly part of industrial waste. That waste which may explode, catch fire, react chemically or released toxic material. Radioactive material is also hazardous.
Angle of Repose	: Angle made by solid waste with horizontal when it stands in a heap or pile.
Agricultural Waste	: Residues from crops.
Solid Waste Management	: Disposing off solid waste without prospects of pollution or hazards.
Landfill	: A piece of ground where waste is dumped. It could be a flat stretch, naturally available depression or abandoned mine.
Bins	: Vessels of metal, plastic or masonry to collect waste.
Integrated	: An approach in which all waste disposal methods are given equal weightage and consideration.
Sustainability	: Producing goods and services from natural resources with a view to conserve them for future.

9.8 ANSWERS TO SAQs

Types of Wastes and
Waste Generation

Please refer preceding text for answers to all the SAQs.