UNIT 1 INTRODUCTION TO WASTE LANDFILL

Structure

1.1 INTRODUCTION

The purpose of this module is to learn about municipal solid waste land filling, components of a landfill, the processes which take place in a landfill, and basic landfill design. The majority of municipal solid wastes globally are placed in landfills. In developed countries, well-designed sanitary landfills are used which typically include bottom liners, leachate collection systems, leachate treatment, gas collection, gas treatment, final covers, and air and water monitoring systems. The modern landfill has evolved over the past 40 years from a long history of open dumps. Open dumps are still common in developing countries and potentially lead to adverse environmental impacts and threaten human health. Most countries have protective regulations in place that prescribe the design and operation of landfills, although they are not always enforced. Though it is considered most cost-effective means of waste disposal, but poor management practices specially in developing countries like India are the major causes of environmental pollution. Within the landfill, a complex sequence of chemical, physical, and biological processes occur that lead to waste degradation. These processes are naturally occurring but can be enhanced by controlling landfill internal conditions. Landfills also generate a toxic soup known as leachate, formed when waste is subjected to biological and physiochemical transformation. Leachate is highly toxic and causes land and groundwater pollution. The degradation processes of landfill lead to the emission of biogas and to the leaching of material from the landfill. Toxic gas emissions from landfills also pose a serious threat to the environment as well as on human health. Some studies have shown that toxic gases released from landfill sites are even responsible for lung and heart diseases in humans. Gas and leachate must be effectively managed to protect the environment. This module will provide the reader in depth understanding of landfills and their role in managing of municipal solid waste.

Objectives

After studying this unit, you should be able to:

- Develop a general familiarity with landfill topics and issues

- Describe the main components of a modern landfill
- Explain the landfill waste degradation process and the reactions involved

1.2 LANDFILLING

Landfill is the oldest and most common form of waste disposal although the systematic burial of the waste with daily, intermediate and final covers only began in the 1940s. In the past, refuse was simply left in piles or thrown into pits; in archeology this is known as a midden. Some landfill sites are also used for waste management purposes, such as temporary storage, consolidation and transfer, or for various stages of processing waste material, such as sorting, treatment, or recycling. Unless they are stabilized, landfills may undergo severe shaking or soil liquefaction of the ground during an earthquake. Once solid waste is transported off-site it is normally taken to a landfill site. Here the waste is placed in a large excavation (pit or trench) in the ground, which is back-filled with excavated soil each day waste is tipped. Ideally, about 0.5 m of soil should cover the deposited refuse at the end of each day to prevent animals from digging up the waste and flies from breeding. The location of landfill sites should be decided upon through consultation with the local authorities and the affected population. Sites should preferably be fenced, and at least one kilometer downwind of the nearest dwellings. A sanitary disposal method can be managed effectively but requires a reasonably large area.

1.2.1 History of Landfills

Landfills have existed for over 5,000 years. Archaeological evidence of landfills dates back to 3000 BC in Crete, where waste was deposited in pits that were subsequently covered up with earth when full. A municipal landfill operated on the outskirts of Athens at least 2,500 years ago; residents were required to transport waste to the site, which was outside of the city gates, sparing the walled city from the stench of the open-air system. In the US and Europe, waste was primarily disposed of by dumping within cities until the 1800s when the link was identified between poor environmental conditions and disease. In the UK, the Public Health Act 1875 required householders to store their rubbish in dustbins and made local authorities responsible for the removal and disposal of waste, which led to the development of the modern landfill. It is worth noting that although the term landfill implies filling a hole with waste (landfilling), it is also used to refer to sites constructed by disposing of waste on the ground and covering it (land raising), such sites have often been used for land reclamation, i.e. raising land above the river or coastal floodplains. By the beginning of the twentieth century in the United States, a regular system of garbage collection was in use in a majority of cities. By the 1920s, wetlands began to be used to dispose of garbage. An example is the Back Bay area of Boston, now a prestigious residential area, Back Bay was once a wetland that was pressed into use as a landfill. In 1937, a landfill that opened in Fresno, California, first utilized compacting of waste and daily application of a covering layer of soil. This more sanitary disposal of garbage, as opposed to the open-air and haphazard dumping of trash in dumps, became even more publicly acceptable during World War II (1939–1945), with images of troops burying their garbage. By the end of the war, more than 100 cities in the United States had established “sanitary landfills.” In 1948, the Fresh Kills landfill was opened on New York’s Staten Island. Before it was closed due to environmental concerns in 2001, the landfill grew to occupy 2,200 acres (890 hectares); at one time it was the largest landfill in the world. At the site’s peak, five barges transported

almost 3,300 tons (3,000 metric tons) of garbage to the site every day. By 2001, the mound of garbage that had been produced was higher than the Statue of Liberty. By the mid-1950s, the booming U.S. economy had increased the allure for disposable goods, as a demonstration of people's affluence. As a result, the amount of solid waste and the need for disposal sites, increased markedly.

By the late 1950s, management of landfills was becoming more regulated. For example, the American Society for Civil Engineers published a guide to sanitary landfilling in 1959. The guide specified that garbage be compacted prior to addition to a landfill to reduce its volume and so increase the usable lifetime of the facility, and that each day's addition of trash be covered with a layer of soil to minimize odor and attraction of pests such as rodents. In 1965, the federal Solid Waste Disposal Act was passed. Following its creation in 1970 by President Richard M. Nixon, the EPA assumed responsibility for the regulation of existing landfills and approval of new facilities. In 1979, open landfills were banned in the United States by the EPA, and legally enforceable standards for landfill construction and operation were enacted. In 1953, a joint committee of the USPHS and the American Public Works Association (APWA) published recommended guidelines for refuse collection and disposal practices for a small community. The sanitary landfill recommendations reflect how dramatic the change from open-burning dumps to sanitary landfills would be. Key concepts and recommendations include:

- Design and operations of Landfills.
- Necessary training of operators.
- End use to be part of the plan and design.
- No open burning.
- No swine feeding.
- The working face should be kept narrow and covered promptly.
- Surface drainage should be managed to prevent ponding and erosion.
- Compaction should be done in thin layers (2 ft. of loose refuse).
- Control of insects, rodents, and blowing paper should be practiced.
- Scavenging is not recommended.
- An alternate operating area should be set aside for bad-weather operations.

In 1961 the USPHS developed a set of recommended standards for sanitary landfill operations. These standards evolved from the 1953 guidelines and indicate the evolution of sanitary landfill concepts and consist of the following main points.

- Refuse should not come in contact with surface water or groundwater.
- A registered engineer should design sanitary landfills.
- No open burning.
- No domestic animals at the site.
- Access should be limited.
- All refuse should be weighed.
- Telephone/radio communications should be provided.

- The working face should be kept small.
- The refuse should be spread and compacted in 2-ft. layers.
- Compacted 8-ft. lifts are preferred.
- At least 6 in. of daily cover consisting of compacted soil should be applied.
- No scavenging at the working face.
- Surface water should be managed to keep it out of the landfill.
- The final cover and the closed site should be managed after closure.

No mention is made of monitoring. These recommended standards were never published in final form by the USPHS. They, however, served as the basis for the USPHS promotion of the sanitary landfill with state agencies and in their training programs.

1.2.2 Landfill Sites in India

- **Deonar Dumping Ground, Mumbai:** Deonar dumping ground of Mumbai is the largest dumping ground of India where waste has reached up to the height of 164 ft. Dumping sites are Mulund Waste Gound and Kanjurmarg Dumping Site.
- **Landfill Sites in Delhi:** Ghazipur Landfill site is the biggest contributors of air pollution in Delhi, grown tall up to 65 metres over the past few years and one of the largest dumping site for Delhi. Other dumping sites are Bhalswa Landfill and Okhla Landfill.
- **Kodungaiyur Dump yard, Chennai:** Kodungaiyur Dump yard is the largest dump yard in Chennai and said to be toxic site for residents of Kodungaiyur and Perungudi.
- **Dhapa Wasteland, Kolkata:** Dhapa Wasteland and dumping ground of Kolkata is spread over 60 acres of land and they are also searching for new garbage dumping ground for the city.
- **Mavallipura Landfill Site Bangalore:** Mavallipura Landfill at Bangalore was a village now a landfill site at the outskirt and house 500 tonnes of waste.
- **Uruli Devachi and Phursungi, Pune:** Uruli Devachi and Phursungi villages were used as landfill site in Pune, Issue with waste is indeed a serious problem for Punekars.
- **Jawahar Nagar Dump Yard Hyderabad:** Jawahar Nagar dump yard is spread over 135 acres of land and dumped by the garbage collected from the city of Hyderabad.

- **Pirana Landfill, Ahmedabad:** Pirana Landfill in Ahmedabad is the producer of smoke, toxic fumes and foul smell, one of the most unsafe and unstable landfill of India.
- **Bhandewadi Dumping Site Nagpur:** Bhandewadi dump yard of Nagpur is dangerous for the residents, as it was spreads the fire to vicinity of Bhandewadi area.
- **Vellalore Garbage Yard, Coimbatore:** Vellalore dump yard is a big garbage site with no easy access of vehicles and pathways and gangways, also the landfill site had one of the largest fire at Coimbatore outskirts.

1.2.3 Advantages of Landfills

There are many advantages of landfills.

a) Burying can produce energy and can be obtained by the conversion of landfill gas.
b) The waste products of landfills can be used as direct fuel for combustion or indirectly they can be processed into another fuel.
c) Landfill is a specific location for waste deposition that can be monitored. On completion of the landfill it can be reclaimed and it can be used as parks or farming land.
d) In properly designed landfills the waste can be processed and all recyclable materials can be used before closing.
e) Organic material can also be separated from a properly designed landfill which can be used for compost or production of natural gas. The landfills that are properly managed can capture the natural gas or methane that is produced by the underground decomposing material.

1.2.4 Disadvantages of Landfills

Landfills that are poorly designed or operated share more problems that are faced at the uncontrolled dumping areas.

a) The areas surrounding the landfills become heavily polluted.
b) Landfill can pollute air, water and also the soil.
c) In a poorly developed landfill it is difficult to keep the dangerous chemicals from leaching out into the surrounding area. Dangerous chemicals can seep into the ground water system.
d) Many insects and rodents are attracted to landfills and can result in dangerous diseases. It can cause diseases and illness in the communities living around the landfill.

1.3 GENERAL PRINCIPLE OF LANDFILLING

The purpose of landfilling is to bury/ alter the chemical composition of the waste so that they do not pose any threat to environment/public health. Landfills are usually made up of cells in which a discrete volume of waste is kept isolated from adjacent waste cells by a suitable barrier.

a) solid waste is placed in a suitably selected and prepared (lined) landfill site in a carefully prescribed manner.
b) the waste material is spread out and compacted with appropriate heavy machinery.
c) the waste is covered each day with a layer of compacted soil.

d) most important feature of modern sanitary landfill design is the technology used to prevent GW pollution.

1.3.1 Layout of Landfill

In planning the layout of a landfill site, the location of the following must be determined and is shown in Figure 1.1.

a. Access roads
b. Equipment shelters
c. Scales, if used
d. Office space
e. Location of convenience transfer station, if used
f. Storage and/or disposal sites for special wastes
g. Identification of areas to be used for waste processing (e.g., composting)
h. Definition of the landfill areas and areas for stockpiling cover material
i. Drainage facilities
j. Location of landfill gas management facilities
k. Location of leachate treatment facilities, if required
l. Location of monitoring wells
m. Placement of barrier berms or structures to limit sight lines into the landfill
n. Plantings

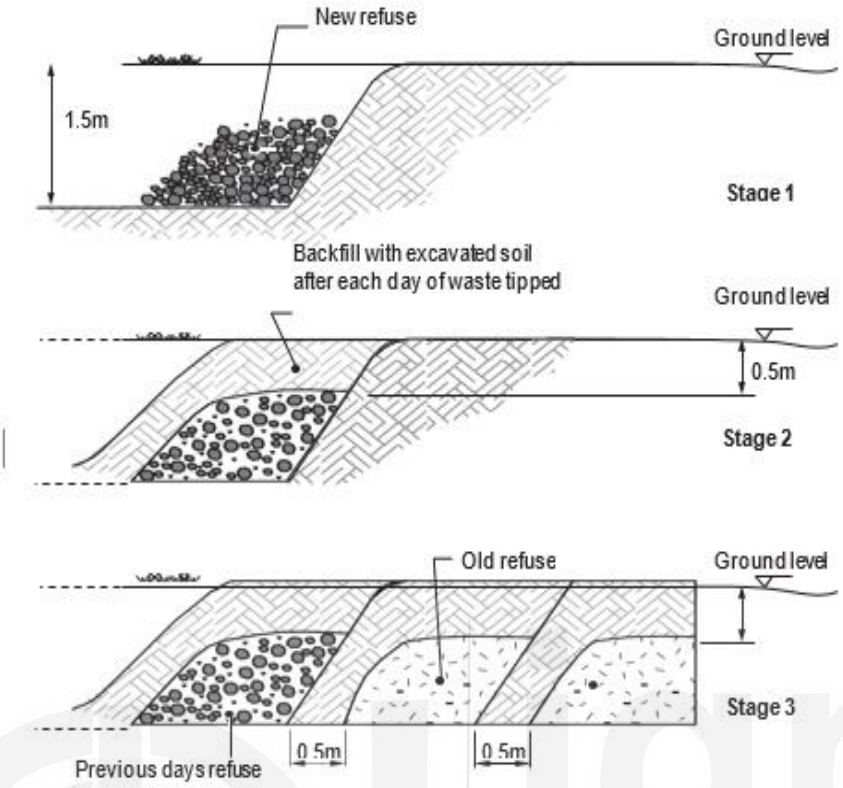

Figure 1.1: .Layout of Landfills

1.3.2 Reactions Occurring in Landfills

Solid wastes placed in a sanitary landfill undergo a number of simultaneous and interrelated biological, chemical and physical changes. The most important biological reactions occurring in landfills are those related to the conversion of the organic material in MSW, leading to the evolution of landfill gases and leachate. Important chemical reactions that occur within the landfill include dissolution and suspension of landfill materials and biological conversion products in the liquid percolating through the waste, evaporation and vaporization of chemical compounds and water into the evolving landfill gas, sorption of volatile and semi volatile organic compounds into the landfilled material, dehalogenation and decomposition of organic compounds, and oxidation-reduction reactions affecting metals and the solubility of metal salts. Among the more important physical changes in landfills is the settlement caused by consolidation and decomposition of landfilled material.

1.3.3 Microbial Degradation of Refuse in Landfills

Except for the first few days after refuse or solid waste placement, microbial decomposition in landfills proceeds under anoxic conditions. Hydrolytic and fermentative microbial processes solubilize waste components, producing organic acids, alcohols, ammonia, and carbon dioxide as major products. These processes are vigorous and rapidly initiated as the moisture content increases in the landfill. After several months, methanogenesis is initiated with methane and carbon dioxide produced as by-products. Two concepts are important to establish - (1) active methanogenesis substantially reduces leachate organic strength (by decomposing organic acids and alcohols) and increases pH; and (2) vigorous methanogenesis does not always occur in landfills because the landfill environment is much less than

optimum for the methane bacteria. The liquid resulting the microbial degradation as a by-product is also a part of the resulting leachate.

1.4 ENVIRONMENTAL IMPACT OF SOLID WASTE DISPOSAL ON LAND

When solid waste is disposed off on land in open dumps or in improperly designed landfills (e.g. in low lying areas), it causes the following impact on the environment.

- ground water contamination by the leachate generated by the waste dump
- surface water contamination by the run-off from the waste dump
- bad odour, pests, rodents and wind-blown litter in and around the waste dump
- generation of inflammable gas (e.g. methane) within the waste dump
- bird menace above the waste dump which affects flight of aircraft
- fires within the waste dump
- erosion and stability problems relating to slopes of the waste dump
- epidemics through stray animals
- acidity to surrounding soil and
- release of green house gas

SAQ 1

a) Write short notes on history of solid waste landfills.
b) Write a note on microbial degradation of refuse in landfills

1.5 SUMMARY

Landfill is the oldest and most common form of waste disposal although the systematic burial of the waste with daily, intermediate and final covers only began in the 1940s. In the past, refuse was simply left in piles or thrown into pits; in archeology this is known as a midden. Some landfill sites are also used for waste management purposes, such as temporary storage, consolidation and transfer, or for various stages of processing waste material, such as sorting, treatment, or recycling. When solid waste is disposed off on land in open dumps or in improperly designed landfills (e.g. in low lying areas), it causes the following impact on the environment.

1.6 KEY WORDS

Midden: In the past, refuse was simply left in piles or thrown into pits; in archeology this is known as a midden.

Methanogenesis: Process that initiates in solid waste landfill after several months with generation of methane and carbon dioxide as by-products.

Leachate: The liquid resulting as a by-product due to the microbial degradation is known as leachate.

1.7 ANSWERS TO SAQ

a) Refer section 1.2.1
b) Refer section 1.3.3