DSPMU UNIVERSITY, RANCHI.
DEPARTMENT OF GEOLOGY

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SOLID WASTE DISPOSAL GEOLOGY IN PLANNING AND SITING OF LANDFILLS

Solid waste management affects every person in the world. Poorly managed waste is contaminating the world's oceans, clogging drains and causing flooding, transmitting diseases, increasing respiratory problems, harming animals that consume waste unknowingly, and affecting economic development. Unmanaged and improperly managed waste from decades of economic growth requires urgent action at all levels of society.

Industrial and domestic waste disposal is an increasing problem throughout the world, particularly in the industrialised nations, as both domestic and industrial waste production multiplies. The politics and economics of waste disposal and the pollution problems created by waste are of such fundamental importance that the management of waste is now a major issue in most industrialised nations, particularly in the densely populated urbanised nations.

Major Sources of Solid Waste

Waste category	Source
Residential	Food wastes, plastics, paper, glass, leather, cardboard, metals, yard wastes, ashes, tires, batteries, old mattresses
Industrial	Packaging wastes, ashes, chemicals, cans, plastics, metal parts
Commercial	Thin and thick plastics, food wastes, metals, paper, glass, wood, cardboard materials
Institutional	Wood, paper, metals, cardboard materials, electronics
Construction and Demolition	Steel materials, concrete, wood, plastics, rubber, copper wires, dirt and glass.
Agriculture	Agricultural wastes, spoiled food, pesticide containers
Biomedical	Syringes, bandages, used gloves, catheter, urine bags, drugs, paper, plastics, food wastes, sanitary napkins and diapers, chemicals.
E-Waste	Electronic items like used TVs, transistors, tape recorders, computer cabinets, mother boards, CDs, cassettes, mouse, wires, cords, switches., chargers.

Magnitude of waste generated

By 2050, the world is expected to increase waste generation by 70 percent, from 2.01 billion tonnes of waste in 2016 to 3.40 billion tonnes of waste annually. Individuals and governments make decisions about consumption and waste management that affect the daily health, productivity, and cleanliness of communities, yet it is often overlooked, particularly in low-income countries. While more than one-third of waste in high-income countries is recovered through recycling and composting, only 4 percent of waste in low-income countries is recycled. It is estimated that 1.6 billion tonnes of carbon-dioxide-equivalent were generated from the treatment and disposal of waste in 2016 – representing about 5 percent of global emissions.

In India, about 960 million tonnes of solid waste is being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Of this ~350 million tonnes are organic wastes from agricultural sources; ~290 million tonnes are inorganic waste of industrial and mining sectors and ~4.5 million tonnes are hazardous in nature (Pappu, A., et al., 2007).

Sanitary landfill

A **landfill** is a carefully designed structure built into or on top of the ground, in which trash is separated from the area around it.

Why are landfills important?

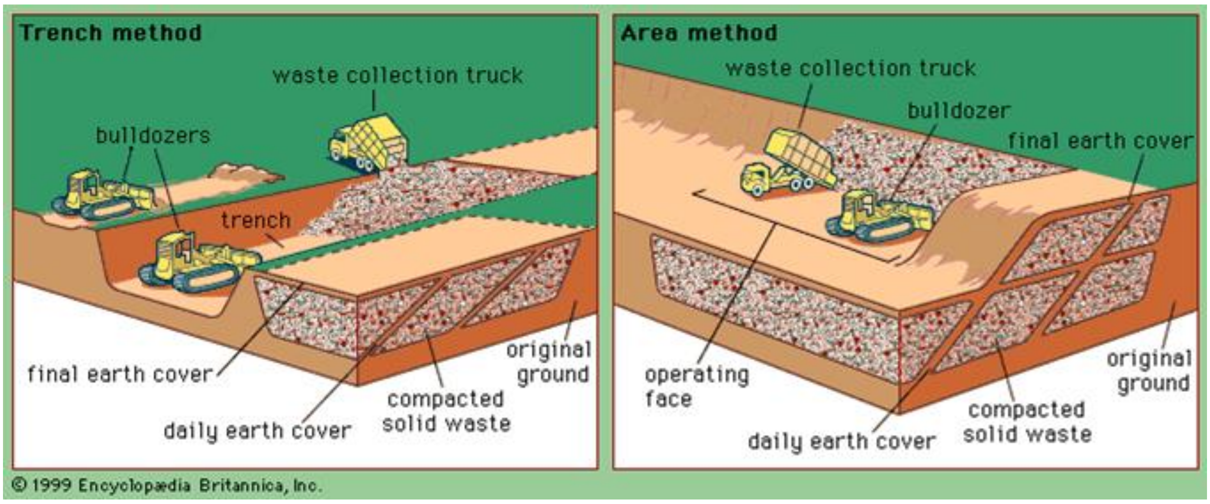
Landfills contain garbage and serve to prevent contamination between the waste and the surrounding environment, especially groundwater. **Landfilling** is the term used to describe the process by which solid waste is placed in the landfill. Landfilling is one of the major solid waste disposal methods practiced worldwide. 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.

Sanitary landfills are sites where waste is isolated from the environment until it is safe. It is considered when it has completely degraded biologically, chemically and physically. In high-income countries, the level of isolation achieved may be high. However, such an expensive high level of isolation may not be technically necessary to protect public health. Four basic conditions should be met before a site can be regarded as a sanitary landfill (see following.) The ways of doing this should be adapted to local conditions. The immediate goal is to meet, to the best extent possible, the four stated basic sanitary landfill conditions, with a longer term goal to meet them eventually in full.

As a minimum, four basic conditions should be met by any site design and operation before it can be regarded as a sanitary landfill:

- Full or partial hydrogeological isolation: if a site cannot be located on land which naturally contains leachate security, additional lining materials should be brought to the site to reduce leakage from the base of the site (leachate) and help reduce contamination of groundwater and surrounding soil. If a liner - soil or synthetic - is provided without a system of leachate collection, all leachate will eventually reach the surrounding environment. Leachate collection and treatment must be stressed as a basic requirement.
- Formal engineering preparations: designs should be developed from local geological and hydrogeological investigations. A waste disposal plan and a final restoration plan should also be developed.
- Permanent control: trained staff should be based at the landfill to supervise site preparation and construction, the depositing of waste and the regular operation and maintenance.
- Planned waste emplacement and covering: waste should be spread in layers and compacted. A small working area which is covered daily helps make the waste less accessible to pests and vermin.

Landfilling methods/types



1) **Trench Method** (Below Ground Level)-

- Used where adequate cover material is available at site and the water table is well below the surface.
- Waste are placed in trench and compacted in thin layers.
- After layer's compacted height reaches design height, cover material is placed over the compacted layer.
- Same trench is then continued and filled similarly.
- Good in areas where there is relatively little waste.

2) **Area Method** (Above Ground level)

- Used on flat ground or terrain is unsuitable for the excavation of trenches.
- Before actual land filling, an earthen levee is constructed against which wastes are placed in thin layers and compacted.
- Thickness of layer reaches a height of 200 to 300 cm.Cover material of 15 to 30 cm thickness is placed after each layer.
- A completed lift including the cover is called a cell.
- This method is used to dispose of large amounts of solid waste.

Geological Controls on Waste Disposal Site Selection

From a geological standpoint, sites suitable for landfill projects are subject to stringent criteria in order to ensure that pollution effects, particularly groundwater contamination, are minimised. Factors which determine suitability of tip sites from a geological/hydrogeological standpoint are :-

1. **Bedrock Lithology -** rock type, grainsize characteristics, texture, homogeneity, bedding characteristics, etc.
2. **Quaternary Geology -** character, thickness and homogeneity of unconsolidated drift.
3. **Hydrological Properties -** of both bedrock and drift, ie. porosity, permeability, hydraulic conductivity, attenuation potential etc.
4. **Geological Structure -** attitude of bedding, folding, faulting, jointing, including discontinuities on all scales.

5. **Hydrogeology -** groundwater levels, distibution of aquifers and aquicludes, groundwater flow patterns etc.
6. **Surface Runoff Patterns -** size and discharge of streams running through the site - controlled by the topography of the site
7. **Topography -** inclination of sloping sites, shelter from wind.

Optimal natural waste disposal sites should have a thick cover of low permeability drift such as boulder clay overlying low permeability bedrock, and a thick unsaturated zone (Daly, 1983,1987). Secondary permeability in the bedrock should be low, ie. the bedrock should be relatively free of discontinuities, particularly fractures and cleavage. In addition, the attenuating potential of the drift, and to a lesser extent the bedrock must be high. Sites with such optimal characteristics are probably fairly common, but their ability to protect groundwater will be diminished in areas of high rainfall, where leachate may be washed more rapidly down through the overburden. Nevertheless, such sites should be sought as they offer the best natural protection to groundwater, and together with appropriate waste management techniques, they can considerably curtail the pollution potential of leachate infiltrating the ground. Furthermore, in the long term, identification of such sites may be extremely cost effective (Daly,1987), as they can substantially reduce the waste management overheads compared to sites which offer no natural groundwater protection. In short, it is argued, that a combination of careful selection of a hydrogeologically suitable site and prudent site management practices can offer the best protection to groundwater from contamination by tip sites.