

# METHODS OF SOLID WASTE DISPOSAL

by: Adnan Aqeel\*

\* Assistant Professor – Sana'a University, Yemen; email: ben\_aqeel\_2005@yahoo.com

## 1. INTRODUCTION

A waste is any solid, liquid, or contained gaseous material that is discarded by being disposed of, burned or incinerated, or recycled. There are some exceptions for recycled materials. The waste can be a by-product of a laboratory operation or process or a commercial reagent or product that is no longer wanted or needed[1].

Waste disposal facilities are necessary if society is to function smoothly . *Facility* means all contiguous land and structures, other appurtenances, and improvements on the land used for the disposal of solid waste [2]. However, no one wants to live near a waste disposal site, sanitary landfill, since such site obviously will create serious sitting problems in long-term even if the local geologic and hydrologic environment is favorable .

Some waste disposal site, such as Fresh Kills Landfill which is located on a 1500-hectare site on Staten Island, New York, accepts tens of tons of municipal and commercial wastes forming a pile of refuse of several tens of meters above sea level up to an elevation of 150-200 meters above sea level . At a point of time, the facility or the landfill will be completely filled, unable to accept further waste, and thus another landfill site will be required to occupy the waste.

Today , many large cities are seriously considering alternatives to landfills for disposal of urban waste. This is a necessity ; the distance from collection to disposal sites has growing concern for the safety of people living in close proximity to large landfills that may pollute the surrounding environment [3].

All types of societies produce waste, but industrialization and urbanization have caused an ever-increasing effluence that has greatly compounded the problem of waste management .Although tremendous quantities of liquid and solid waste from different sources are being collected and recycled , treated or disposed, new and innovative programs remain necessary to avoid what might be called a waste crisis. It seems that all waste will not be recycled creating a concept known as *sequential land use* which means urban housing, school, hospitals, and other such construction should not be placed over old waste disposal sites [3]

For discussion purposes , it is advantageous to break the management, treatment, and disposal of waste into several categories as following: solid-waste disposal, hazardous chemical waste management, radioactive waste management, ocean dumping, septic-tank sewage disposal, and wastewater treatment [3].

## 2. BACKGROUND

*Solid waste* means any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities, but does not include solid or dissolved materials in domestic sewage, or solid or dissolved material in irrigation return flows or industrial discharges which are point sources subject to permits under section 402 of the

Federal Water Pollution Control Act, as amended (86 Stat. 880), or source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923).

In the United States alone, each person generates, on the average, more than 1.5 kilograms of garbage every day. Accordingly, Every five years, each an American person generates a mass of waste equal to the mass of the Statue of Liberty!. If this amount of waste is added to industrial, agricultural, and mineral wastes, four billions tons of solid waste would be produced only in the United States each year [4] . This increasing volume of municipal solid waste reflects the dramatic population growth which was 76 million in 1900 and 225 million in 1981 [5].

*In terms of environment, disposal* means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid or hazardous waste into or on any land or water so that such waste or any constituent thereof may enter the environment, or be emitted into the air or discharged into any waters including ground waters.

Disposal of solid waste is primarily an urban problem . In the United States alone, urban areas produce about 640 million kilograms of solid waste each day . That amount of waste is sufficient to cover more than 1.6 square kilometers of land every day to a depth of 3 meters [3]. The majority of these solid waste are papers as illustrated in Fig.1.

The common sources and types of solid waste are listed below:

- Garbage : home and commercial
- Rubbish : paper , tree branches , etc.
- Demolition Waste : Lumber , Pipes, and masonry
- Construction waste : Lumber ,masonry, and pipes and other materials .
- Light Industrial waste : Cinders , metal scarps (quoted from Keller,1988 ) .
- Street refuse : sweepings, dirt, leaves, etc. [6]

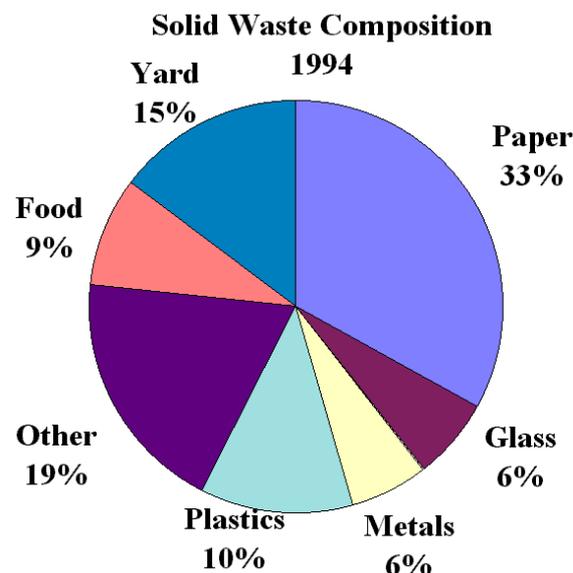


Figure 1: The composition of solid waste in the United States as in 1994 [7]

### 3. METHODS OF WASTE DISPOSAL

The common methods of solid-waste disposal , summarized from a U.S. Geological Survey report, include on-site disposal, composting, incineration, open dumps, and sanitary landfills. A brief description for each of these methods is below.

#### 3.1. On- Site Solid Waste Disposal

By far the most common on-site disposal method in urban areas is the mechanical grinding of kitchen food waste. Garbage disposal devices are installed in the waste-water pipe system from a kitchen sink, and the garbage is ground and flushed into the sewer system. This effectively reduces the amount of handling and quickly removes food waste, but final disposal is transferred to the sewage treatment plant where solids such as sewage sludge still must be disposed of. Another method is small-scale incineration. This method is common in institutions and apartment houses. It requires constant attention and periodic maintenance to insure proper operation . In addition, the ash and other residue must be removed periodically and transported to a final disposal site [3].

#### 3.2. Composting of Solid Waste

Composting is a biochemical process in which organic materials decomposes to a humus like material. It is rapid, partial decomposition of moist, solid , organic waste by aerobic organisms. This process is generally carried out in the controlled environment of mechanical digesters. A major drawback of composting is the necessity to separate the organic material from the other waste. Therefore, it is probably economically advantageous only when organic material is collected separately from other waste as illustrated in Fig. 2 [3].

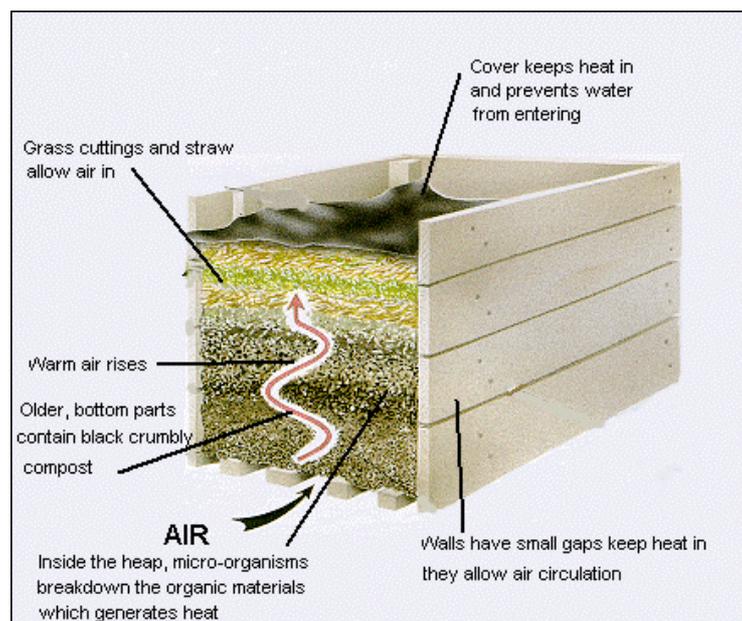


Figure 2: Mechanism of composting method [8]

### 3.3. Incineration

Incineration is the reduction of combustible waste to inert residue by burning at high temperatures, 900°-1000° C. Such temperature is sufficient to consume all combustible material, leaving only ash and non-combustibles. Incineration effectively reduces the volume of waste that must be disposed of by 75 to 95 percent as illustrated in Figs. 3&4 [3]. At moderate temperatures, incineration may produce a variety of toxic gases, depending on what is burned [4]. Advantages of incineration at the municipal level are twofold. First, it can effectively convert a large volume of combustible waste to much smaller volume of ash to be disposed of at a landfill; and second, combustible waste can be used to supplement other fuels in generating electrical power. Disadvantages are that it requires high capital outlay, high maintenance cost, and additional handling to remove materials that are not burnt, and it can cause air pollution [3]. Table 2 shows some air pollution quantities resulted from the incineration of solid waste.

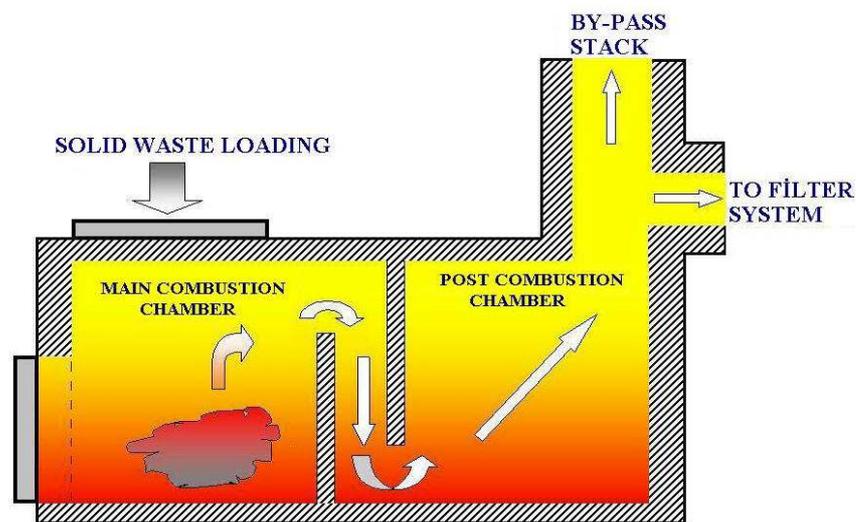


Figure 3: A Sketch showing an incineration system for solid waste disposal [9]

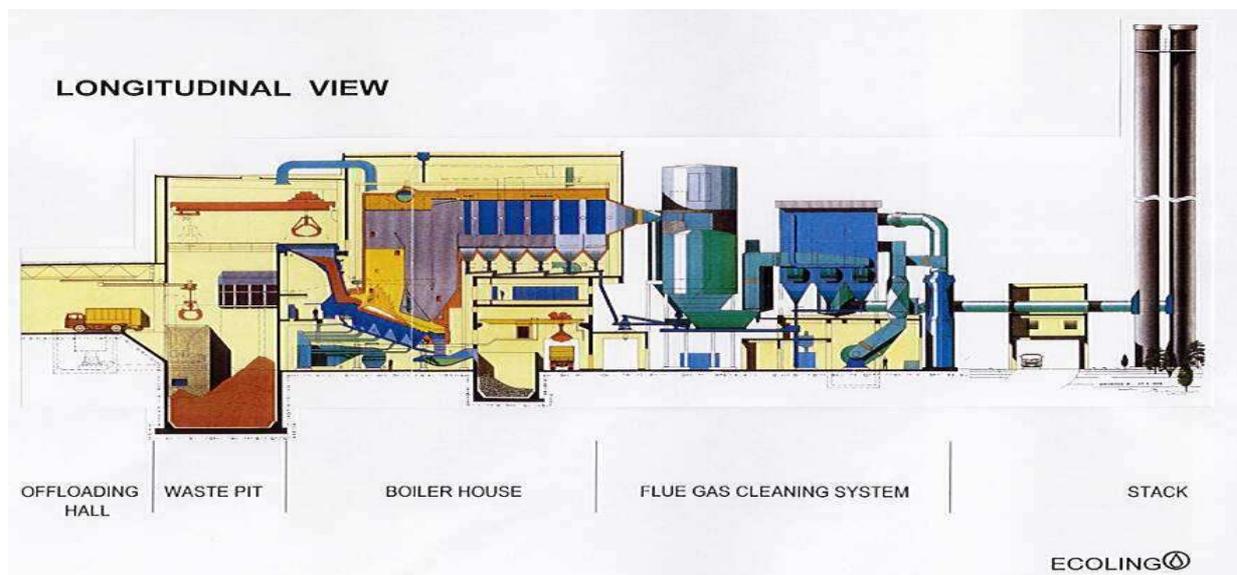


Figure 4: A full mechanism of solid waste incineration in a plant [10]

Table 2. The pollutant materials resulted from incineration method [11]

Pollutant	With controlling	Without controlling
Hydrogen chloride	75 mg/m <sup>3</sup>	430 ppm <sub>dv</sub> *
Carbon monoxide	57 mg/m <sup>3</sup>	150ppm <sub>dv</sub>
Dioxins and furans	0.5 ng/m <sup>3</sup>	250 ng/m <sup>3</sup>
Particulate matter	20 mg/m <sup>3</sup>	6,300 mg/m <sup>3</sup>
Sulfur dioxide	260 mg/m <sup>3</sup>	400 mg/m <sup>3</sup>
Oxides of nitrogen	400 mg/m <sup>3</sup>	260 mg/m <sup>3</sup>
Polyaromatic hydrocarbons	5 µg/m <sup>3</sup>	70 µg/m <sup>3</sup>
Polychlorinated biphenyls	1 µg/m <sup>3</sup>	3 µg/m <sup>3</sup>
Pentachlorophenol	1 µg/m <sup>3</sup>	2.7 µg/m <sup>3</sup>
Lead	50 µg/m <sup>3</sup>	34,000 µg/m <sup>3</sup>
Cadmium	100 µg/m <sup>3</sup>	1,500 µg/m <sup>3</sup>
Mercury	200 µg/m <sup>3</sup>	320 µg/m <sup>3</sup>
Arsenic	1 µg/m <sup>3</sup>	130 µg/m <sup>3</sup>
chromium	10 µg/m <sup>3</sup>	2,000 µg/m <sup>3</sup>

\* ppm<sub>dv</sub> = part per million dry volume

### 3.4. Open dumps

Open dumps (Figs 5&6) are the oldest and the most common way of disposing of solid waste . In many cases, these dumps are located wherever land is available, without regard to safety, health hazards, and aesthetic degradation . The waste is often piled as high as equipment and land allow. In some instances, the refuse is ignited and allowed to be burnt . In others, the refuse is periodically leveled and compacted [3]. Open dumps are unsightly, unsanitary, and smelly. Therefore, they surely attract rats, insects, and other pests. Moreover, surface water percolating through the trash can dissolve out, or leach, harmful chemicals that are then carried away from the dump site by runoff. Toxic gasses can be emitted from open dumps causing serious health problems to lives. In addition, trash may be scattered by wind or water over surrounding areas. In sum, open dumps are an unsatisfactory means of solid-waste disposal [4 & 12] .



Figure 5: Open dumps are aesthetic degradation [13]



Figure 6: Open dump is a good place for rats, insects, and unpleasant lives [14]

### 3.5. Sanitary Landfill

A sanitary landfill, as defined by the American Society of Civil Engineering, is a method of solid waste disposal that functions without creating a nuisance or hazard to public health or safety. The sanitary landfill as we know it today emerged in the late 1930s. Engineering principles are essentially used to confine the waste to smallest practical area, reduce it to the smallest practical volume, and cover it with a layer of compacted soil at the end of each day of operation, or more frequently if necessary. This covering of the waste with compacted soils makes the sanitary landfill "sanitary". The compacted layer effectively denies continued access to the waste by insects, rodents, and other animals. It also isolates the refuse from the air, thus minimizing the amount of surface water entering into and gas escaping from the wastes.

Two types are used: area landfill type which is constructed on relatively flat sites (Fig. 7); and depression landfill type which is in natural or artificial gullies or pits (Fig. 8). The depth of landfills vary about 2 to 13 meters [3& 12].

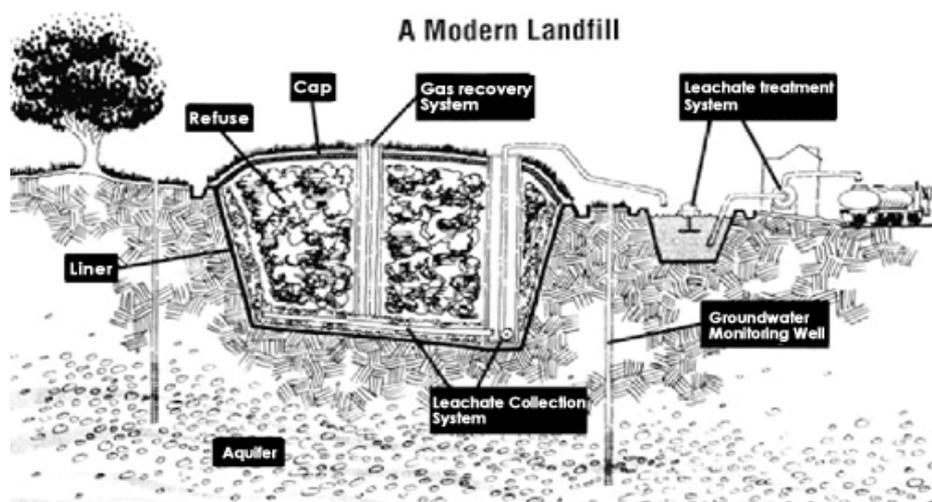


Figure 7: Modern open area landfill type [15]

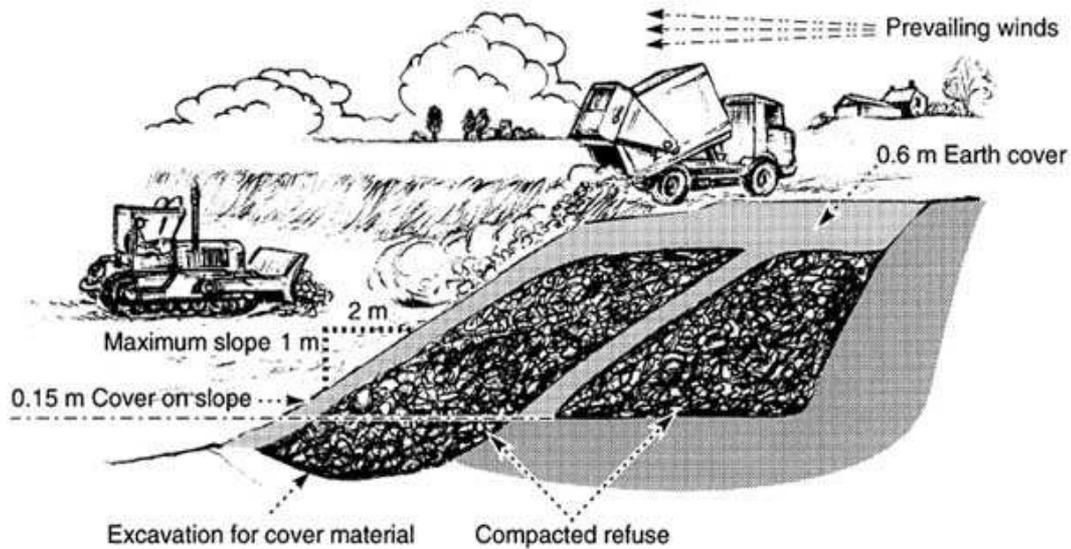


Figure 8: Depression sanitary landfill type and its compacted cover dimensions [16]

Normally, refuse is deposited, compacted, and covered by a minimum of 15 centimeters of compacted soil at the end of each day (Figures 7 and 8). The finishing cover is at least 50 centimeters of compacted impermeable soil, clay, designed to minimize infiltration of surface water (Figures 7 &8). Subsidence can be expected for years following completion of landfill; therefore, any subsequent development that cannot accommodate potential subsidence should be avoided [3].

#### Advantages of sanitary landfill

- Most economic method of solid waste disposal where land is available.
- Initial investment is low compared with other methods .
- The operation can being within a short time period .
- All types of wastes can be deposited, eliminating separate collection.
- Completed sites may be used for other purposes (Fig. 9) [5].

#### Disadvantages of sanitary landfill

- In densely populated areas, suitable land may not be available at economic hauling distances.
- Daily maintenance is required as well as constant monitoring.
- Methane and other gases may be produced and create a nuisance and hazard to public health and environment [5]. for example, gas generated in an Ohio landfill migrated several hundred meters through a sandy soil to a housing area , where one home exploded and several others had to be evacuated [3].
- Unless properly engineered, leachate may be a continuing problems for years [5]. *Leachate* means liquid that has passed through or emerged from solid waste and contains soluble, suspended or miscible materials removed from such wastes. The main associated problem with leaching is contamination of groundwater (Figure 10).

For instance, two landfills dating from the 1930s and 1940s in long Island, New York, have produced leachate plumes that are several hundred meters wide and have migrated several kilometers from the disposal site [3] .



Figure 9: A completed landfill site which may be used for recreation [17]

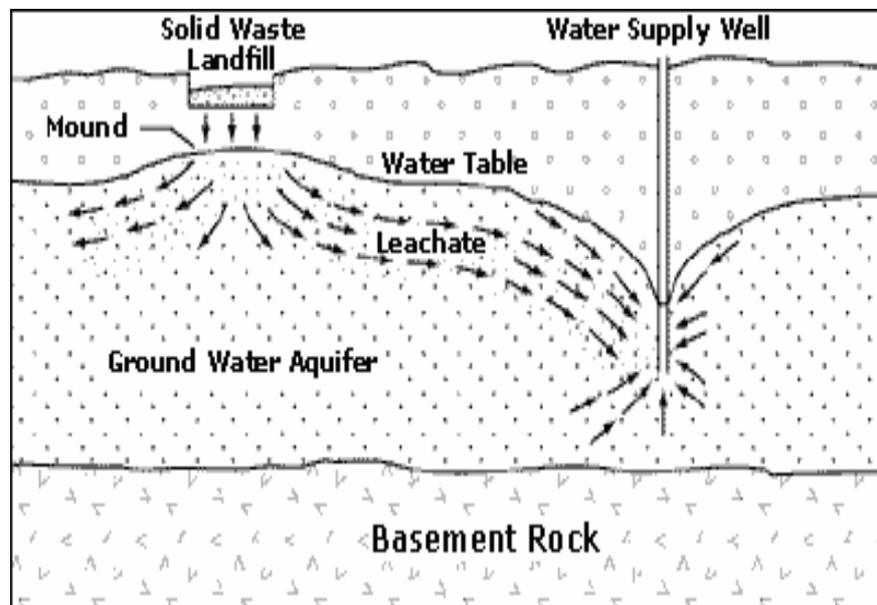


Figure 10: Resulted leachate from a solid waste disposal site contaminates a ground water well [18]

### 3.6 Recycling

Recycling is defined as the series of activities, including collection, separation, and processing, by which products or other materials are recovered from the solid waste stream for use in the form of raw materials in the manufacture of new products other than fuel for producing heat or power by combustion [19].

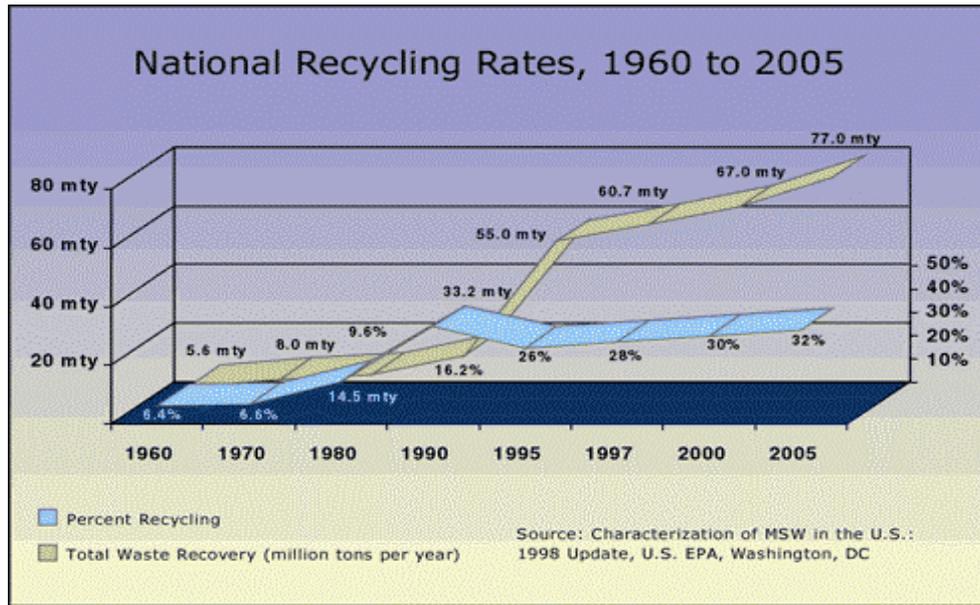


Figure 11: National recycling rates in the U.S. since 1960 until 2005 [7]

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