Waste Characteristics (physical)

Physical characteristics

Information and data on the physical characteristics of solid wastes are important for the selection and operation of equipment and for the analysis and design of disposal facilities. The required information and data include the following:

(i) **Density:** Density of waste, i.e., its mass per unit volume (kg/m^3), is a critical factor in the design of a SWM system, e.g., the design of sanitary landfills, storage, types of collection and transport vehicles, etc. To explain, an efficient operation of a landfill demands compaction of wastes to optimum density. Any normal compaction equipment can achieve reduction in volume of wastes by 75%, which increases an initial density of 100 kg/m^3 to 400 kg/m^3. In other words, a waste collection vehicle can haul four times the weight of waste in its compacted state than when it is uncompacted. A high initial density of waste precludes the achievement of a high compaction ratio and the compaction ratio achieved is no greater than 1.5:1. Significant changes in density occur spontaneously as the waste moves from source to disposal, due to scavenging, handling, wetting and drying by the weather, vibration in the collection vehicle and decomposition. Note that:

- the effect of increasing the moisture content of the waste is detrimental in the sense that dry density decreases at higher moisture levels;
- soil-cover plays an important role in containing the waste;
- there is an upper limit to the density, and the conservative estimate of in-place density for waste in a sanitary landfill is about 600 kg/m^3.

(ii) **Moisture content:** Moisture content is defined as the ratio of the weight of water (wet weight - dry weight) to the total weight of the wet waste. Moisture increases the weight of solid wastes, and thereby, the cost of collection and transport. In addition, moisture content is a critical determinant in the economic feasibility of waste treatment by incineration, because wet waste consumes energy for evaporation of water and in raising the temperature of water vapour. In the main, wastes should be insulated from rainfall or other extraneous water. We can calculate the moisture percentage, using the formula given below:

$$Moisture\ content\ (\%) = \frac{Wet\ weight\ -\ Dry\ weight}{Wet\ weight} \times 100$$

A typical range of moisture content is 20 to 40%, representing the extremes of wastes in an arid climate and in the wet season of a region of high precipitation. However, values greater than 40% are not uncommon.

(iii) **Size:** Measurement of size distribution of particles in waste stream is important because of its significance in the design of mechanical separators and shredders. Generally, the results of size distribution analysis are expressed in the manner used for soil particle analysis. That is to say, they are expressed as a plot of particle size (mm) against percentage, less than a given value.

The physical properties that are essential to analyse wastes disposed at landfills are:

I. Field capacity: The field capacity of MSW is the total amount of moisture which can be retained in a waste sample subject to gravitational pull. It is a critical measure because water in excess of field capacity will form leachate, and leachate can be a major problem in landfills. Field capacity varies with the degree of applied pressure and the state of decomposition of the wastes.

II. Permeability of compacted wastes: The hydraulic conductivity of compacted wastes is an important physical property because it governs the movement of liquids and gases in a landfill. Permeability depends on the other properties of the solid material include pore size distribution, surface area and porosity.

Porosity: It represents the amount of voids per unit overall volume of material. The porosity of MSW varies typically from 0.40 to 0.67 depending on the compaction and composition of the waste.

Porosity of solid waste n= e/ (1+e)

Where e is void ratio of solid waste

III. Compressibility of MSW: Degree of physical changes of the suspended solids or filter cake when subjected to pressure.

$\Delta HT = \Delta Hi + \Delta Hc + \Delta H\alpha$ [ΔHT= total settlement; ΔHi=immediate settlement; ΔHc = consolidation settlement; $\Delta H\alpha$ = secondary compression or creep.]

$C'\alpha = \Delta H / [H0 \times (\text{Log}(t2/t1))] = C\alpha / (1+e0)$

[*Cα, C'α* = Secondary compression index and Modified secondary Compression index; and t1, t2= Starting and ending time of secondary settlement respectively.]

The variation and trends in quantity, composition, and other characteristics of urban waste are not confined to the national level. Indeed, they persist even at the community level. The persistence is due to the fact that the characteristics of the waste stream are affected by an array of factors. Ranking high among these factors are degree of industrialisation, extent and nature of socioeconomic development, and the climate.

Despite the obvious fact that a thorough understanding of the characteristics of the waste is requisite to making rational decisions in solid waste management, it remains a prevalent practice to pay little heed to conducting a comprehensive and accurate survey of quantity and composition. Instead, reliance is had on some inaccurate method, especially the traffic count. Although traffic counts, if coupled with estimates of volume, may give an indication of the quantities being disposed; strictly speaking, they serve to ascertain solely that which is implied by the term -- namely, the number of vehicles entering the disposal site.

Rigorous, scientifically performed studies of waste quantities and characteristics are required to proper design, operate, and monitor solid waste management systems.

This chapter is concerned primarily with describing important waste characterisation parameters, and methods of determining them, so that designers can have a firm foundation to plan and implement waste management systems. The parameters and methods of determination are described in the following sections.

Quantities and composition

Quantity and composition surveys have an essential role in determining the dimensions of the key elements in solid waste management. A list of such elements would certainly include method and type of storage, type and frequency of collection, crew size, method of disposal, and degree of resource recovery. The utility of the surveys extends not only to the evaluation of present conditions, but also to the prediction of future trends. Consequently, frequent and ongoing surveys are the mainstays of a successful solid waste management program.

Surveys either of quantity or of composition must take into consideration scavenging and illegal dumping.

Composition

A full knowledge of the composition of the wastes is an essential element in: 1) the selection of the type of storage and transport most appropriate to a given situation, 2) the determination of the potential for resource recovery, 3) the choice of a suitable method of disposal, and 4) the determination of the environmental impact exerted by the wastes if they are improperly managed.

A reasonably realistic estimate of the composition of a community's waste output requires an analytical period of two weeks' duration, repeated two to four times per year. During the two weeks, samples are taken from the collection vehicles at the disposal site. All types of municipal wastes should be sampled, i.e., residential, commercial (offices and markets), and light industrial. The ratio of the number of samples of each type of waste to the total number of samples should be the same as that of the quantities of each type to the total quantity disposed. For example, if the output of residential waste is ten times greater than the combined commercial and light industrial wastes, then the number of samples of residential wastes should be ten times that of the other two combined.

Regarding sample size, the minimum weight per sample should be on the order of 100 kg. If the sample size is too small, the possibility of obtaining a representative sample is lessened. On the other hand, accuracy is not improved sufficiently to warrant taking samples greater than 100 kg in size [1].

To reduce the magnitude of errors arising from moisture change and from decomposition, analysis of the samples should be begun within two to three hours after collection.

Other characteristics

In addition to analysing for composition, it is recommended that the sampling program include provisions for determining moisture content, bulk density, and particle size distribution. The measurement of these three properties is especially recommended if no prior scientific waste characterisation study has been performed locally. These particular characteristics have a substantial influence on determining: 1) wastes that will be difficult to manage, 2) proper and best methods for storing, collecting, processing, and disposing of the wastes and 3) marketability of potentially recoverable materials. In addition to the moisture content, particle size, and bulk density, a knowledge of several other properties of solid waste are also required for properly planning, designing, and operation waste management programs. Among such other properties are chemical/thermal and mechanical analyses.

Moisture Content

The moisture content is determined as follows: The sample is weighed as received ("wet weight"). It is then allowed to stand until it is air-dry, i.e., its moisture content is in equilibrium with that of the ambient air. The percent moisture content is then obtained through the following formula:

$$\text{Moisture Content (\%)} = \frac{W_W - W_D}{W_W} \times 100$$

where:

- W_W = wet weight of sample, and
- W_D = dry weight of sample.

BULK density

The bulk density can be measured by filling a container of known volume with wastes and then weighing the loaded container, (The container should be constantly shaken during filling.) The bulk density is calculated by dividing the net weight of the refuse (weight of loaded container minus weight of empty container) by its volume. The result is expressed as kg/m^3.

SIZE distribution

Size distribution may be determined with the use of a set of manually manipulated screens. The screens should have square openings, particularly those with large openings, and the sizes of the openings included in the set should be 100, 50, and 25 cm. The screens, particularly those with large openings, can be easily made with lumber and wire.

Representative waste from the sample is placed on the largest of the screens (100 cm). The screen is shaken until particles of refuse no longer pass through the openings. Material remaining on the screen (oversize) is collected and weighed. The material that has passed through the screen (undersize) is placed on the screen with the 50-cm openings, which is shaken as in the preceding step. The process is repeated until all three screens have been used. The fractions that are sized are weighed, and the weight values are used to plot a size distribution curve. Typically, the size distribution is plotted as cumulative percent passing versus screen size.

CHEMICAL/thermal properties

Determination of chemical/thermal properties of solid wastes or its components would be necessary in order to ascertain the most appropriate type of treatment. These analyses must be conducted by a reliable laboratory. The authors generally rely on either governmental laboratories or universities to perform the work. Typical analyses include moisture and ash contents; calorific value; and the concentrations of carbon, nitrogen, hydrogen, oxygen, and some heavy metals if there are reasons to suspect that they may be present.

MECHANICAL properties

Despite the fact that the proper design of processing plants as well as final disposal facilities should include a thorough understanding of the properties of refuse and its components, this requirement has, up until recently, been ignored. Perhaps this can be explained by the absence of

reliable information readily available in the literature. This problem is particularly more pronounced in economically developing countries. Mechanical properties are especially important in the design of sanitary landfills and ancillary systems. This section presents the results of analyses carried out using raw (fresh) MSW, fractions of MSW, as well as landfilled MSW generated in industrialised countries in Western Europe. Due to the sharp differences in the composition and characteristics between these wastes and those from economically developing countries, it is recommended that the data presented in these sections be used simply as references and modified to suit the conditions of the particular location.

SUMMARY

This Unit began with a discussion on the significance of collecting information and data on wastes, and in that context discussed some aspects of waste stream assessment that would help in the planning and design of waste management activities. Following this discussion, we explained waste generation and composition and pointed out that solid wastes generated vary in composition and characteristics depending on the source of generation (domestic, industries, agriculture, institution or commercial sectors) and factors such as geographic location, seasonal variation, collection frequency, public attitude, etc. Then, we discussed how the information on the physical and chemical characteristics of wastes would help decide the various elements of waste management and disposal options. Subsequently, we discussed the consequences of improper disposal of solid waste on public health and the environment (e.g., air, water, visual, noise and odour pollution, explosion hazards, etc).

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