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CONFERENCE

Waste Management

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DEVELOPMENT OF SOLID AND LIQUID WASTE DATA COLLECTION PROGRAMME

G. E. Ho
Lecturer in Environmental Engineering,
Murdoch University, W.A.
Quantitative data such as the type, quantity, and bulk density as received and after in situ compaction, are required for the proper management of a landfill site. Without quantitative data we cannot determine for example whether too much cover material is used, with the resultant shortening of the life of the landfill site. Such data are also required for planning of the use of the existing site, and also for the acquisition of future sites or the use of alternative waste treatment processes. An estimate of the growth of the rate of waste generation is also required for planning purposes. The estimate should be based on data collected over a period of time supplemented by information on anticipated changes in factors such as housing and other building development in the area served by the landfill site.

It may be argued that information is already available on the per-capita waste generation in major cities in the world (e.g. refs. 1 to 4) and also in a number of cities in Australia (e.g. refs. 5 to 10). The per-capita waste generation has been found, however, to vary from city to city. This is not surprising, since it is expected that waste generation is affected by the standard of living of the population, the type of housing, development activities, and many other factors that may be peculiar to the locality. On-site surveys are therefore required to obtain data for particular localities, and the recognition of the importance of such surveys is indicated by the increasing number of survey results being reported in the literature (e.g. ref. 2,4).

The aim of this paper is to present methods for data collection required for the proper and effective management of landfill sites. The methods range from a simple survey involving field weighing and vehicle count, to a comprehensive survey that takes into account the physical and chemical composition of the waste. It has to be borne in mind that the method selected should depend upon the objective to be achieved. If the objective of the survey is the estimation of the life of a landfill site then a simple field weighing survey is what is required, on the other hand if incineration is to be considered as an alternative waste treatment process then a more comprehensive survey needs to be carried out to include at least the calorific value of the waste and the properties of ash formed.

Data collection programmes

1. Field weighing programme

A scale/weighing machine is required for this survey to weigh vehicles as they enter and leave the site. From the weighing survey we can
obtain the weight of waste delivered to the site.

Before we consider the analysis of the results of the weighing survey let us consider the large amount of information that can be gathered by the operator of a site even without the aid of a weighing scale. By using a note book and a pen he can enter the following information for each vehicle entering the site:

(i) type of waste (domestic refuse, garden wastes, commercial and industrial wastes, building and demolition rubble, or filling materials)

(ii) type of vehicle, and whether it is council operated, contractor operated or private vehicles

(iii) area or blocks from which the waste originates/is collected
   (the locality may be divided into areas/blocks based on type of housing for example)

(iv) an estimate of the volume of the waste (a ruler may be required); dimensions (length, width and depth can be recorded and volume calculated afterwards).

The data collection can be made systematic and more efficient by the use of a prepared table with columns and headings such as shown in Table 1. It can be seen that the amount of information that can be obtained is quite considerable considering the facility that is required to obtain it. Such a survey in fact constitutes a field volume survey.

The total volume of waste (m$^3$) received per day can be established. Combining this with the population of the area served by the landfill site, the volume of waste generation as received at the site per head of population per day can be calculated (m$^3$/person/day). By recording the times the vehicles enter and leave the site, an estimate can be made of the number of vehicles present at any particular time during the day and the average time spent by the vehicles so that sufficient space can be provided for that purpose without creating congestion at the site.

From the point of view of landfill site management, however, the volume survey is not adequate. It lacks the information on the weight of the waste, which is necessary for the calculation of the volume of landfill site required per day. The volume of the waste decreases as it is compacted at the landfill site. The final bulk density of the waste after compaction and left to settle for a
<table>
<thead>
<tr>
<th>Time</th>
<th>Type of waste</th>
<th>Type of vehicle</th>
<th>Origin of waste</th>
<th>Volume of waste</th>
<th>Weight of Vehicle</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>In</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**FIELD VOLUME SURVEY**
reasonable period of time (say two years) is, however, known reasonably well (approximately 500 kg/m\(^3\)). The weighing survey is carried out in the same manner as for the volume survey, but in addition the weights of the vehicles as they enter and leave the site are entered into the table which now has two additional entries (Table 1.). The total weight of waste brought to the site can then be estimated, and the landfill space requirement can be established. The survey needs to be conducted over a period of one week (including the weekend) to obtain a representative picture of the daily variation of waste brought to the site, and four times a year to cover any seasonal variations (spring, summer, autumn and winter) in waste generation.

A periodic level survey needs to be carried out on the covered refuse to ascertain the bulk density of the compacted waste. The level surveys can be conducted at the same time as the seasonal field weighing surveys. The costs of conducting a one week field weighing survey consists of:

(a) the cost of employing a person to carry out the survey at the site for one week
(b) the cost of hiring a suitable weighing scale, and
(c) the cost of analysing the data.

The results of the survey can be presented in a table form, summarizing the daily rate of waste received and other information (Table 2.).

The benefits from the field weighing survey in terms of the effective operation of the site and the possibility of forward planning with a certain degree of certainty outweigh the survey cost that is involved.

(2) Composition and analysis programme

If waste treatment processes other than disposal by the sanitary landfill method are to be considered, and also if the potential for materials salvage is to be fully assessed, then the composition of the waste needs to be determined. An analysis of the waste on its own provides useful information on the nature of the waste, and an analysis over a period will give the trend in the changing nature of the waste. An analysis of refuse in the U.K. over a period of 3 decades, for example, shows the increase in the content of packaging waste (paper, plastic, and metal and glass containers) over that
<table>
<thead>
<tr>
<th>Waste type</th>
<th>Rate (tonnes/day)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic refuse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garden wastes (incl. parks/streets)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building &amp; demolition rubble</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filling materials</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average bulk density as received \( \text{kg/m}^3 \)
Per capita waste \( \text{kg/person/day} \)
Percentage of waste collected by council \%
Average daily vehicle count
period, with a corresponding decrease in the bulk density of the refuse.

In the U.K. the analysis of domestic waste has been standardized for many years by the Institute of Public Cleansing. The method of analysis has been well described elsewhere (11, 12); and is quite applicable to Australian conditions. Other methods are very similar in their classification of the components of the waste. The method consists of collecting and weighing of not less than one tonne of the waste to ensure that a representative sample is obtained. The sample is then screened to separate out materials passing through a ½ in. mesh riddle and 1-3/4 in. mesh riddle. Materials retained by the larger mesh are sorted into vegetable and putrescible materials, paper, metal, rag, glass, plastics and unclassified debris not classified above (wood, leather, stones, crockery etc.).

The additional equipment required to carry out the composition analysis as described above is a mechanical screen (with ½ in and 1-3/4 in. mesh), with jigging action, and a more sensitive weighing scale than for the vehicle weighing programme, a 1 cu.m. container for measuring volumes and containers to store the various waste classifications.

The results of the survey are recorded on standard forms, such as shown in Table 3. The results can be related to the source area of waste, type of housing and other variables that may affect the composition of the waste. Future changes in one or more of the above factors can then be taken into account in its effect to the nature of the waste, besides the rate of waste generation obtained from the weighing survey.

As can be seen the additional information that is obtained is worth the extra effort of obtaining it. The survey is best carried out at the same time as the field weighing survey. Daily sample can be analysed over the 7 day period to obtain an idea of the statistical variation in the composition.

(3) Comprehensive analysis programme

A comprehensive analysis of the waste involves a physical, chemical and microbiological examination of the waste to obtain the physical properties, chemical composition and fermentability and other biological characteristics of the waste. At first sight it appears
Table 3. The Institute of Public Cleansing Qualitative and Quantitative Seasonal Analysis of House Refuse.

<table>
<thead>
<tr>
<th>Town</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of houses</td>
<td>Date sample collected</td>
</tr>
<tr>
<td>Date of previous collection from same district</td>
<td></td>
</tr>
<tr>
<td>Date sample analysed</td>
<td></td>
</tr>
<tr>
<td>Total rainfall - week prior to test week of test</td>
<td></td>
</tr>
<tr>
<td>Average temp. - week prior to test week of test</td>
<td></td>
</tr>
<tr>
<td>Weight of sample</td>
<td></td>
</tr>
<tr>
<td>No. of premises from which collected</td>
<td></td>
</tr>
<tr>
<td>Average weight of refuse per house</td>
<td></td>
</tr>
<tr>
<td>Type of property from which sample collected (i.e. blocks of flats with or without solid fuel heating, residential houses, (private or council, etc.))</td>
<td></td>
</tr>
</tbody>
</table>

Analysis of Refuse

<table>
<thead>
<tr>
<th></th>
<th>kg</th>
<th>% by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Fine dust and small cinder (under 1/2 in.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Cinder content (between 1/2 x 1-3/4 in.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Vegetable and Putrescible content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Paper Content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Metal Content (ferrous and non-ferrous)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) Rag content (inc. bagging and all textiles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) Glass content (bottles, jars and cullet)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(h) Unclassified debris (not classified above)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Plastics and Polythene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Difference between collected and analytical weight

Total weight collected

Density of refuse kg/m³

Density of fine dust and small cinder kg/m³

Type of vehicle used in collecting sample (whether compression device or not). Note whether separate collection of waste paper or salvage made at time of collection, and if so record the amount to be added.
that a detailed analysis of the waste has only an academic value. But this is not so, since the moisture content and calorific value of the waste is required when considering the design of an incineration plant, and the organic chlorine content will determine the amount of the corrosive hydrochloric gas emitted with the combustion gases. The optimum operation of a composting process requires knowledge of the organic carbon content of the waste, the carbon nitrogen ratio and the pH of the waste. The heavy metal concentrations of the compost need also to be determined to see whether the compost is suitable for agricultural land application.

The comprehensive analysis is obviously more involved and requires a lot of instruments for carrying out the analysis. The determination of moisture content requires an oven, the calorific value determination requires a bomb calorimeter; chemical composition determination requires analytical instruments and an accurate analytical balance. Many of the methods used are based on established methods that have been used for analysing the composition of raw materials and finished products. The weight of sample required for analysis is usually very small, of the order of a few grams, and it is important to obtain a fully representative sample. This is done by pulverising the crude waste (100 - 200 kg), mixing it intensively and dividing it into a hundred equal parts. The latter are sampled for analysis. A list of standardised methods has been compiled by the International Reference Centre for Waste Management of the World Health Organization (13). The W.H.O. compilation includes methods for the determination of moisture content, calorific value, total carbon, nitrogen and phosphorus contents, sodium, potassium, calcium, magnesium, chlorine concentrations, pH, fungi growth rate (chaetomium test), compostability, and seedling test.

Liquid Wastes

The above programmes refer specifically to solid wastes. A survey of liquid waste is, however, also very important to the proper management of a liquid waste disposal site, which may be adjacent to a solid waste landfill site or the liquid waste may be dumped onto solid waste in a landfill site. The concept behind the survey programmes for solid waste is applicable to liquid waste. Volume survey is generally sufficient for liquid wastes, since the density of the liquid is very close to the density
of water. Information on the type of waste (domestic, commercial, industrial) and others such as the type of processing industry from which waste is generated can also be collected during the survey. A 7 day survey is considered sufficient per year provided that wastes that are brought infrequently (e.g. once per six months) are taken into consideration. Information on the strength of the waste in terms of its solids content, biological oxygen demand, is required to determine whether a liquid waste pond has a sufficient capacity to decompose the wastes relying on micro-organism activity. Information on the presence of toxic chemicals such as cyanide, acids, alkalis, solvents, heavy metals, etc. in the waste ought to be required from the waste generator, so that they may be treated separately. Cyanides for example will kill the micro-organisms that decompose the waste. Also if cyanide waste is mixed with acid waste, hydrogen cyanide gas is evolved and can be very dangerous.

Methods for analysing liquid wastes are very well established. (14).

Most of the methods require elaborate analytical instrumentation.

Discussion

Solid waste has up to now been disposed of by the landfill technique and management of the site has been very minimal. This situation cannot go on any longer as the availability of landfill sites close to the place of waste generation is becoming scarce, and as the demand for better environmental control is increasing. Data collection is an important prerequisite to the proper management of a landfill site, and for planning future requirement for the treatment and disposal of solid waste. The implementation of the field weighing programme described here is within the capability of local authorities that operate landfill sites. Additional useful information can be obtained by carrying out the composition and analysis programme.

The methods described above are specifically discussed in terms of their application to the wastes as received at the landfill sites. If desired programmes can be carried out to find out the characteristics of the waste as produced at the source (e.g. domestic refuse by householders), their relation to types of housing, social strata, etc. (e.g. ref. 15).

The comprehensive analysis programme is useful if incinerator or composting is considered as alternative treatment processes. Nothing has been said about tests to indicate what happens when the waste is
baled (compressibility, amount of leachate produced etc.) or pulverised. These can, however, generally be inferred from the composition analysis.

Other aspects of data collection programmes which have not been discussed are the data required for the assessment of the effect of solid waste disposal on the environment: the effect of leachate from the site to the quality of underground water, whether the sand/soil can purify the leachate before it reaches the water table, and if so, how much depth is required between the water table and the bottom of the landfill site, the production of methane gas from the completed site, etc.

There is also a need to obtain data on waste generated by the community that is not disposed of at local authorities landfill sites. Such a survey needs to be carried out to ascertain the total waste generated for the proper planning of land use for disposal purposes. Eventually there will be a competition between demands for landfill sites by private operators and local authorities. The total survey is especially important for liquid wastes, since the proportion of liquid wastes received at designated local authorities disposal sites are only a small portion of the total liquid waste generated. Large quantities of liquid wastes containing toxic materials are still disposed of by soaking into the ground, and no data are available to ascertain whether the soil can filter and cope with the wastes before the filtrate enters ground water.

These latter aspects require a considerable amount of effort, and coordination by a coordinating authority is required. It is here that institutes which have an interest in waste management with the associated facilities and expertise can help in the effort.

Conclusions
A Field weighing survey provides data for the effective and proper management of landfill disposal sites. The facilities required for the survey are minimal and the survey is within the capability of operators of landfill sites to carry out.

Composition analysis in terms of paper content, vegetable and putrescible, rag, glass, etc. requires more effort but gives useful additional information for other aspects of management: planning, consideration of alternative treatment processes prior to disposal.

Comprehensive composition analysis and total regional waste generation surveys are required for regional planning to make optimum use of available waste disposal sites.
References


2. Results of waste generation and composition in the U.K. are periodically reported in 'Solid Wastes', the monthly journal of the Institute of Solid Waste Management (U.K.).


4. Results of waste generation and composition in the U.S. are reported in annual U.S. Environmental Protection Agency publication: 'Solid Waste Management - Available information materials'.


13. 'Methods of Sampling and Analysis of Solid Wastes' EAWAG, Dubendorf (Switzerland), 1970.
