UNEP

Developing Integrated Solid Waste Management Plan

Training Manual

Volume 1:
Waste Characterization and Quantification with Projections for Future

United Nations Environment Programme

Disclaimer

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Compiled by

UNEP
Division of Technology, Industry and Economics
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Preface

Rapid increase in volume and types of solid and hazardous waste as a result of continuous economic growth, urbanization and industrialization, is becoming a burgeoning problem for national and local governments to ensure effective and sustainable management of waste. It is estimated that in 2006 the total amount of ***municipal solid waste*** **(M SW)** generated globally reached 2.02 billion tones, representing a 7% annual increase since 2003 (Global Waste Management Market Report 2007). It is further estimated that between 2007 and 2011, global generation of municipal waste will rise by 37.3%, equivalent to roughly 8% increase per year. Based on incomplete reports from its participants, The Basel Convention estimated that about 318 and 338 million tons of ***hazardous and other waste*** were generated in 2000 and 2001 respectively. ***Healthcare waste*** is classified as a sub-category of hazardous wastes in many countries. As per WHO estimations, the total health-care waste per person per year in most low-income countries, is anywhere from 0.5 kg to 3 kg. There is no estimate about *global industrial wastes generation*. The US EPA estimates that, American industrial facilities generate and dispose off approximately 7.6 billion tons of non-hazardous industrial solid waste each year. The EU estimated that its 25 member states produce 700 million tons of ***agricultural waste*** annually. **Waste Electrical and Electronic Equipment (WEEE) o r** ***E-waste*** is also one of the fastest growing waste streams and it equals to 1% of total solid waste on an average in developing countries. It is expected to grow to 2% by 2010.

Although considerable efforts are being made by many Governments and other entities in tackling waste-related problems, there are still major gaps to be filled in this area. The World Bank estimates that in developing countries, it is common for municipalities to spend 20-50 percent of their available budget on solid waste management (open dumping with open burning is the norm), even though 30-60 percent of all the urban solid wastes remain uncollected and less than 50 percent of the population is served. . In low-income countries, collection alone drains up 80-90 percent of municipal solid waste management budget. In mid-income countries, collection costs 50-80 percent of total budget. In high-income countries, collection only accounts for less than 10 percent of the budget, which allows large funds to be allocated to waste treatment facilities. Upfront community participation in these advanced countries reduces the collection cost and facilitates waste recycling and recovery.

Hence, developing countries face uphill challenges to properly manage their waste with most efforts being made to reduce the final volumes and to generate sufficient funds for waste management. If most of the waste could be diverted for material and resource recovery, then a substantial reduction in final volumes of waste could be achieved and the recovered material and resources could be utilized to generate revenue to fund waste management. This forms the premise for **Integrated Solid Waste Management (ISWM) system based on 3R (reduce, reuse and recycle) principle.** ISWM system has been pilot tested in a few locations (Wuxi, PR China; Pune, India; Maseru, Lesotho) and has been well received by local authorities. It has been shown that with appropriate segregation and recycling system significant quantity of waste can be diverted from landfills and converted into resource.

Developing and implementing ISWM requi res comprehensive data on present an d anticipated w aste situations, sup portive poli cy framew orks, knowledge and capacity to develop plans/systems, proper use of enviro nmentally sound technol ogies, and appropriate financial instruments to support its implementation.

Many national governments, therefore, have approached UNEP, [as reflected in the decision taken by the UNEP Governing Council/Global Ministerial Environment Forum during its 25th Session in February 2009 (UNEP/GC.25/CW/L.3)] to get further support for their national and local efforts in implementation of the Integrated Solid Waste Management (ISWM) programme.

In response to this decision and in line with the Bali Strategic Plan for Capacity Building and Technology Transfer, UNEP has developed a programme on integrated solid waste management. This programme includes support for capacity building and technology transfer for ISWM through a number of actions:

1. Guidelines to develop ISWM System: The four sets of guidelines on ISWM covering waste characterization and quantification, assessment of current waste management system, target setting and identification of stakeholders' issues of concern for ISWM, and how to develop ISWM Plan.
2. Pilot projects on ISWM and emerging waste streams including E-waste, waste agricultural biomass, waste plastics and so on
3. Regional and sub-regional training for policy makers and experts on ISWM and emerging waste streams
4. Interactive advisory support on ISWM and emerging waste streams

This document is the *first* of the four sets of the guidelines on ISWM. It focuses on collection and analysis of data to generate baseline on waste characterization and quantification with projections in the future. This first step is vital to develop ISWM Plan.

This document can also be of interest to other interested parties/organisations that aim at supporting decision-makers. They may be:

- consultants working on urban services, recycling, or waste management;
- representatives or staff of other local stakeholders including community groups, NGOs, and the private sector;
- entrepreneurs wishing to expand or strengthen their solid waste portfolios;
- academicians and scholars in urban environmental management;
- the press, especially when seeking background materials;
- donors interested in supporting future waste management activities;
- local experts interested in using or replicating the results.

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ACRONYMS

AHP	Analytical Hierarchy Process
ASL	Automated Side Loaders
APC	Air Pollution Control
BEI CHP & RS	The bei cellulose hydrolysis process and reactor system
BMT	Biological and Mechanical Treatment
BMW	Bio-Medical Waste
BOT	Build-operate-transfer
C&D	Construction and Demolition
CDM	Clean Development Mechanism
CD-ROM	Compact Disc Read-Only Memory
CIWMB	California Integrated Waste Management Board
C.L	Confidence Level
CO2	Carbon Dioxide
CRT	Cathode Ray Tube
CRV	California Redemption Value
CV	Calorific Value
DEPA	Danish Environmental Projection Agency
DKK	Danish Krone
DPSIR	Driving force - Pressure - State - Impact - Response
DTIE	Division of Technology, Industry and Economics
EIA	Environmental Impact Assessment
EMC	Environmental Management Centre
EnRA	Environmental Risk Assessment
EPA	United States Environmental Protection Agency
EPR	Extended Producer Responsibility
ESTs	Environmentally Sound Technologies
E-Waste	Electronic Waste
EWC	European Waste Catalogue
FOB	Free on Board
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GPS	Global Positioning System
HCl	Hydrogen Chloride
HDPE	High Density Polyethylene
HW	Hazardous Waste
IETC	International Environmental Technology Centre
ISWM	Integrated Solid Waste Management
ISWMP	Integrated Solid Waste Management Plan
IT	Information Technology
IWPM	Integrated Waste Management Plan
KPIs	Key Performance Indicators
LPB	Liquid Paper Board
LR	Landfill Rate
LWAC	Landfill Waste Acceptance Criteria
MB	Megabytes

MBT	Mechanical and Biological Treatment
MC	Moisture Content
MCDM	Multi Criteria Decision Making
MEAs	Multilateral Environmental Agreements
MF	Multi Family residence
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NGOs	Non-governmental Organizations
NIMBY	Not-in-my-backyard
O&M	Operations and Maintenance
ODS	Ozone Depleting Substances
OECD	Organisation for Economic Co-operation and Development
PAYT	Pay as You Throw
PE	Polyethylene
PET	Polyethylene Terephthalate
PIC	Project Implementation Committee
PMC	Pune Municipal Corporation
PP	Polypropylene
PPE	Personal Protective Equipment
PRC	People’s Republic of China
PS	Polystyrene
PS	Private Sector
PSP	Private Sector Participation
PVC	Polyvinyl Chloride
RAM	Random Access Memory
RDF	Refuse Derived Fuel
RPPC	Rigid Plastic Packaging Containers
SAT	Sustainability Assessment of Technologies
SF	Single Family residence
SP	Strategic Planning
SWAP	Solid Waste Analysis Protocol
SWM	Solid Waste Management
SWOT	Strengths, Weaknesses, Opportunities and Threats
3R	Reduce, Reuse and Recycle
UNEP	United Nations Environment Programme
USD	The United States Dollar
WCV	Waste Collection Vehicle
WGF	Waste Generation Factors
WND	Wuxi New District, People’s Republic of China
WTE	Waste-to-Energy
WWTP	Wastewater Treatment Plant

1. Data on Solid Waste

1.1. Overview

These guidelines are written to collect the information on the overall solid waste and waste streams including how much of which type of waste is disposed by each generator type or sector and the kind of demographic and socio-economic characters and technology influencing the current and future solid waste generation trends.

1.2. Importance

The data on current and future trends of various solid waste streams is the basic requirement to develop the Integrated Solid Waste Management (ISWM) Plan. In this regard, data on different waste streams will be analyzed to develop the current and projected scenario for:

- Developing an integrated solid waste management plan;
- Generating comprehensive information on the quantity and type of recyclable and recoverable materials/energy to prioritize the recovery opportunities;
- Developing baseline for continued long-term measurement of system performance;
- Generating information on the different sub-streams of waste to design, implement and monitor an effective and efficient system for collection, transportation, recycling, treatment, recovery and disposal of various streams of solid waste and;
- Providing comparison of waste composition and waste diversion accomplishments for continuing improvements in integrated solid waste management.

1.3. Roadmap

It is very important to *set the boundaries and plan the data collection and analysis procedures before hand*. The data collection and analysis may follow the following roadmap:

- **Setting the boundaries:** This includes the clear definition and demarcation of geo-political and administrative boundaries, various waste streams based on the sectors and/or waste generators *(Chapter 2)* and;
- **Setting the procedures for data collection, analysis and presentation:** This includes determining number samples, to identify sites and timing for sample collection, to select methods for analyzing the samples, and to choose methodology for analysis and presentation of the data *(Chapter 3).*

The guidelines, procedures and format for data collection, analysis and presentation of various waste streams are provided in the following chapters:

- **Municipal solid waste (residential and commercial):** *(Chapter 4)*
- **Construction and demolition waste:** *(Chapter 5)*
- **Industrial solid waste (non-hazardous):** *(Chapter 6)*
- **Hazardous Waste (Industrial, healthcare, laboratory waste and C&D):** *(Chapter 7)*

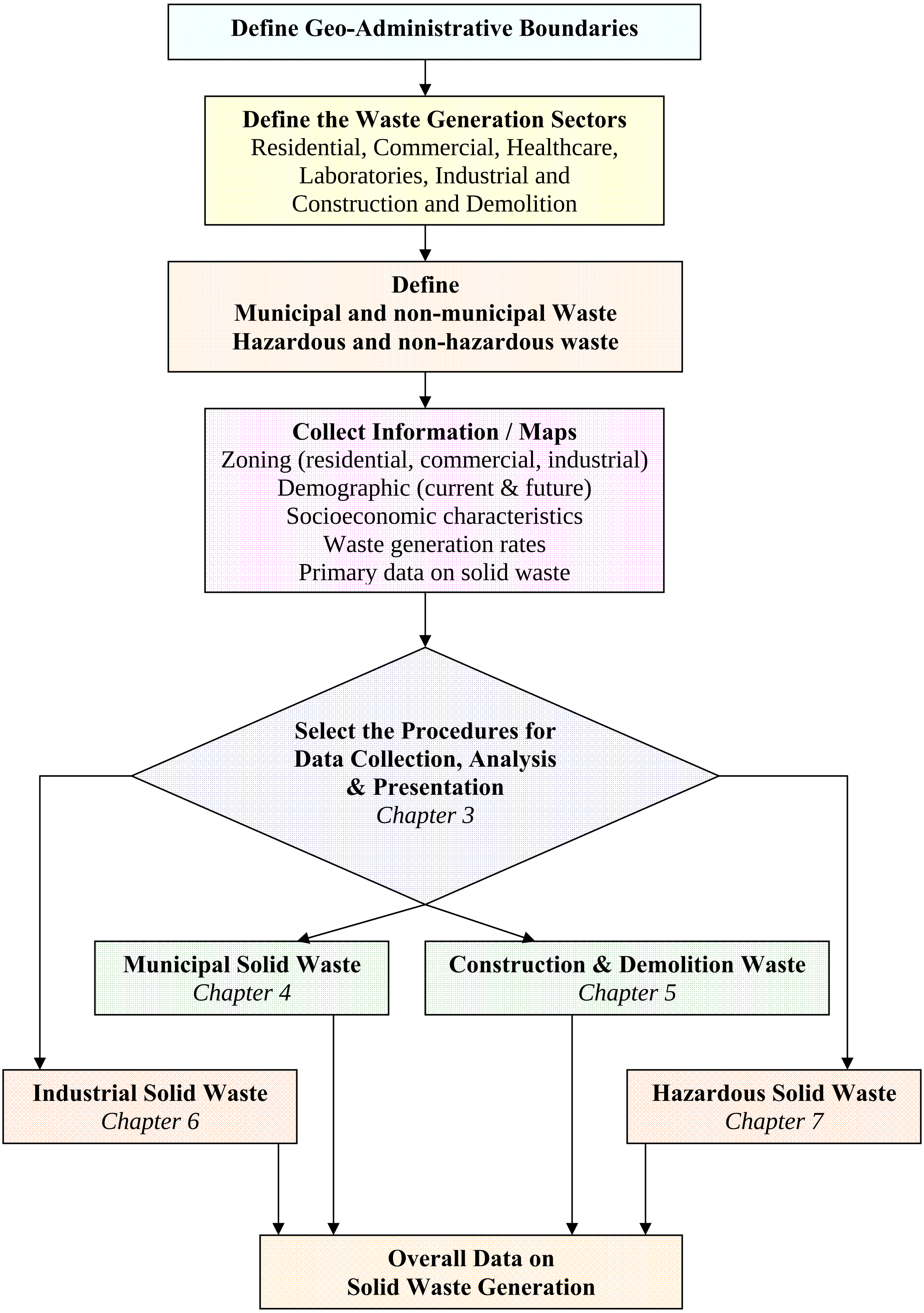

Figure.1.1: Flowchart for Data Collection & Analysis

2. Setting the Boundaries

The first step for data collection is to clearly set the boundaries in terms of geographical and administrative coverage and in terms of different sectors and waste generators with respect to various waste streams.

2.1. Geo-Demographical & Administrative

- **Geographical Size of the Area and Zoning**

A map is required from local authorities that identify the geographical and administrative boundaries with geographical area and land zone planning.

- **Population size and Growth**

Time series data of the population and future projections along with the distribution of population among various zones is required. Total number of single and multi-family buildings and the average size of their inhabitants is also required.

- **Socio-Economic Patterns**

The information on socio-economic patterns is required to assess their influence over the current and future solid waste generation levels and trends.

- **Size and Number of Industries and Commercial Undertakings**

The information on the size and number of industries and other commercial undertakings, according to their type or clusters as per industrial classification (an example of industrial classification is shown in chapter 6), is required to formulate the data collection strategies, as various type or clusters may generate specific types of hazardous and non-hazardous waste.

- **Administrative Boundaries and Responsibilities**

The information on the administrative roles of various departments and their jurisdiction will be required as baseline information for the institutional arrangements. This information will also cover the responsibilities of various sectors (government, industry, community) in collection, transportation, treatment, recycling and disposal of different types of waste streams. This would further help to estimate the type and quantity of solid waste generated at its origin, transported to disposal site, and recycled.

2.2. Waste Streams

- **Municipal Waste**

Depending on the administrative boundaries, municipal waste may cover only residential and commercial non-hazardous waste, and may also include industrial and agricultural non-hazardous waste. This has to be defined based on the existing regulations and practices within the specified geographic location. Usually, the municipality - responsible for the collection and disposal of municipal waste - collects residential waste while other sectors (commercial, industrial, and agriculture), if they are allowed to dispose their waste at municipal facilities, make their own arrangements to transport their waste to the municipal disposal sites (landfill and incineration plants) and pay disposal charges.

- **Residential Waste**

Residential waste generated by households living either in single-family houses or multi-family buildings may contain organic waste (for example, from the kitchen and gardens), recyclable waste (for example, plastics, paper, cans, etc.), non-recyclable waste (that has no recycling value), and hazardous waste (batteries, some oils, etc.). Usually, the municipality is responsible for collection and disposal of such waste, thus it is treated as municipal waste. In some countries, the collection and transportation of waste from multi-family buildings could be the responsibility of the residents and in some; there are regulations on segregation at source for recyclable waste like hazardous waste has to be disposed off separately. Information on these regulations may also help to prepare a list of sub-categories of the waste for quantification and characterization of waste streams.

- **Commercial Waste**

In many places, non-hazardous commercial waste generated by the businesses is considered as municipal waste; however, waste generators through private sector usually arrange its collection. The local authorities may provide the details of the types of commercial wastes to be considered as municipal waste. They may also indicate the existing procedure for the segregation of recyclable waste and collection of the disposal waste from commercial sector. The hazardous waste from commercial sector could be the sole responsibility of the generator. This information would help to list out different waste streams for quantification and characterization.

- **Other Wastes (RPPC, Glass Containers, etc.)**

In some countries, some of the municipal wastes are sub-categorized separately. For example rigid plastic packaging containers (RPPC), glass containers, and so on. These wastes are usually not mixed up with the normal municipal waste. The authorities may identify if there are special procedure for any special type of municipal waste.

- **Construction and Demolition (C&D) Waste**

In some countries, construction and demolition waste is considered as municipal waste; however, the generator is responsible for its transportation to municipal landfill site. In many cases, the local authorities charge extra fees for the disposal of this waste. This waste could be substantial in volume; thus, may create challenges for municipal disposal facilities. However, this waste contains high proportion of recycling materials, and if there are appropriate regulations, then most of this waste could be recycled and this will release the pressure on the municipal disposal facilities. There may be some hazardous substances in C&D waste and those should be disposed off separately.

- **Industrial waste**

Industrial waste is categorized as hazardous waste and non-hazardous waste. Usually, industrial waste is not considered as municipal waste; however, in some places, non-hazardous waste is disposed off at municipal disposal facilities. In this case, the industries make arrangements for the transportation of the waste to the disposal facility and they may pay disposal charges. The municipality should clearly identify its role in industrial waste management as per the regulations and current practices. This would help towards quantification and characterization of different types of industrial wastes with respect to hazardous and non-hazardous, and municipal and non-municipal wastes.

- **Hazardous Waste (Industrial, Healthcare and Laboratory, and C&D)**

Hazardous waste is generated by different sectors including industries, healthcare facilities, laboratories, construction and demolitions, sludge and urban agriculture. Some hazardous waste is also generated by residential sector; however, the data on residential hazardous waste is usually collected under municipal waste. For hazardous waste, the data could be collected based on the classification of hazardous waste which is based on the content of hazardous substances. Considering the nature and the complications in testing the waste for the presence of the hazardous substances, the data for such wastes is directly collected from the generator instead of going for the procedure of collection and analysis of the waste samples.

2.3. Formats for Information Required

At a particular city, the information on the boundaries could be collected by utilizing the following format:

I. Maps from local authorities identifying the geographical and administrative boundaries.
II. Maps with geographical ages and land-use/zoning plans.
III. Population size and growth: Time-series data with future projections, distribution of population among various zones, number of single-family and multi-family buildings and average size of inhabitants.
IV. Size and number of industries and commercial undertakings as per national or local classification.
V. Regulations and demarcation of various waste streams including municipal, non municipal, hazardous, non-hazardous, industrial, healthcare and laboratory, construction and demolition, and sludge.
VI. List of material types with reference to various waste streams.
VII. List of hazardous wastes under hazardous waste classification.
VIII. Primary data on solid waste, if already available.

References:

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Sky Valley Associates (2003), *2002 Oregon Solid Waste Characterization and Composition*. Department of Environmental Quality, Oregon, USA http://www.deq.state.or.us/wmc/solwaste/wcrep/ReportWC02Full.pdf (6 April 2006)

CASCADIA Consulting Group (2003), *Guidelines for Waste Characterization Studies in the State of Washington*. Washington State Department of Ecology

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3. Data Collection, Analysis and Presentation

Once the information on the demarcation of various waste sectors and waste streams is available, the next step would be to set the procedures for data collection, analysis and presentation. For data collection the first step would be the finalization of list of materials available in solid waste generated by various sectors. The second step would be the identification of number of samples, timing of samples, methods to cover seasonal variations, sites for collection of samples and methodologies for sample analysis and data generation. For data analysis, the important considerations would be to produce the results, which are representative with high confidence levels with minimum costs, and the future projections incorporating population and socio-economic growth, and technological development. For data presentation, the useful aspects would be to provide overall current and future picture (graphically and in tables) and its sub-categorization with respect to various waste streams and list of materials covering recyclable and non-recyclable materials. The data presentation may also include future projections.

However, for designing a waste quantification and characterization study, including measurement and sample analysis, it may be noted that these studies are costly, time consuming and little complicated. Therefore, these studies may be minimized to the level, where sufficient data could be made available to take appropriate decisions and to formulate integrated solid waste management plan.

3.1. Procedures for Collection of Samples

1. **List of Material Types**

After the demarcation of various waste streams, it is important to decide on the list of material types, which might be available in various waste streams. A narrow down list of materials would be required. For reference, a list of materials from California Integrated Waste Management Board's Uniform Waste Disposal Characterization Method is shown in Annexure-I.

2. **Number of Samples**

The number of samples depends primarily on the cost versus its utility. For higher statistical accuracy and confidence level, the number of samples will be more. There are statistical procedures to calculate the number of samples at each confidence level. Usually for solid waste data, the confidence level (C.L) is set at 80% or 90% (Cacadia 2003). Following table gives the idea of variation in the number of samples to achieve confidence levels of 95%, 90%, 80% and 70% respectively (Recycle Worlds 1994).

Table 3.1: Number of Samples for Waste Composition

Materials	C.L 95%		C.L 90%		C.L 80%		C.L 70%	
	Residential	Commercial	Residential	Commercial	Residential	Commercial	Residential	Commercial
Newsprint	224-2397	698-3563	58-600	170-991	16-150	48-223	9-58	21-101
Cardboard	899-1955	533-997	225-499	134-250	58-123	35-64	27-66	17-30
Aluminium	275-1437	754-4399	70-350	191-1100	19-92	60-275	10-42	23-123
Ferrous	194-554	552-3411	50-139	138-953	14-37	36-214	8-18	17-97
Glass	145-619	596-2002	39-155	149-501	19-61	39-126	6-19	19-58
Plastic	261-1100	422-783	67-275	107-195	18-70	28-61	10-32	14-24
Organic	12-47	26-92	5-14	8-25	3-5	4-8	3-4	3-5

The difference in number of samples for residential and commercial waste is due to the level of variation in waste between these two sectors. For residential waste the variation for types of materials across the samples is usually low; therefore, fewer samples would be required to establish the same confidence level in comparison with assessment of commercial waste. For example, California Integrated Waste Management Board (CIWB) asks for 40 samples for residential waste, 50 for non-residential wastes, 25 for sub-population with similar businesses and 40 for sub-population with different businesses per year.

The number of samples is also influenced by level of variation of materials in the samples. For example, if a certain type of material contained in the sample is in lower percentages with respect to other materials (e.g. aluminium), higher number of samples will be required to confirm the quantity of that material in comparison with the higher percentage material (e.g. food).

The number of samples also depends on the methodology for sample analysis. For example, more samples would be required to achieve same confidence level if the samples are being analyzed through visualization, in comparison to analysis based on hand sorting.

3. **Timing for Sample Collection**

To get a representative data, the timing of sample collection could be a vital factor. Waste disposal patterns, with respect to types of materials, often vary according to the time of day or week. Therefore, based on the economic viability, the study should include plans either (1) to collect data that covers the *entire* period of disposal, or (2) to collect data that may be assembled later in a way that *represents* the entire period.

Nevertheless, the local knowledge can play an important role to identify and plan for appropriate timings for data collection for various waste streams or for different types of materials. In some countries, there are regulations for disposing of certain types of wastes at certain timings (for example, residential waste - early in the morning or late in the night) and at certain days of the week (for example, recyclables - once a week). In other cases, a pilot survey can also help to determine the variations either across the different timings of the day or the different days of the week.

4. **Seasonal Variations**

To account for seasonal variations, the local knowledge may help to identify the possible seasonal changes in the waste streams. For example, the availability of certain type of agricultural or industrial products in a certain season may increase the waste generation for that material. Similarly, at some places the seasonal buildings may also affect the construction waste streams. This identification would be useful to plan the data collection activities, as it will be very costly and time consuming to collect data during all the seasons for all type of waste streams.

5. **Selection of Sites**

The samples may be taken either directly from generators or at the primary collection point (piles/heaps). The samples may also be collected from waste collection vehicles or at a disposal facility. The decision in this regard depends on the trade-off between efforts and the requirements for data. If the data has to be very accurate with respect to waste generators, then samples should be collected at the primary stage of waste generation. Furthermore, the timing of sample collection would differ based on the decision for its site for collection. For selection of sites, it is important to ensure that samples are randomly selected across the different sites for unbiased statistical analysis. To facilitate random selection of samples, "random numbers table" may be generated based on the virtual numbering of the sites.

6. **Methods for Sample Analysis**

An appropriate methodology would be required to analyze the samples. There are a few common methods, adopted to analyze the samples at generation point, from vehicles transporting waste and at the disposal point. The data may slightly vary from one method to another. For example, for higher confidence level, extensive samples may be collected at generation point and could be analyzed by hand sorting. These methods also differ in terms of cost and efforts. Therefore, depending on the information requirements, one, or a combination of the methods could be adopted to collect the information. These methods can be divided into two categories – first is for measuring the amount of waste or quantification of waste and the second, for characterization of waste. This could be further divided into characterization through visualization and characterization through hand sorting.

3.2. Quantification of Waste

1. **By Measurements at the Point of Generation:**

This method of quantifying waste involves visiting or contacting waste generators (e.g., businesses, apartment buildings, etc.) and determining through measurement or observation, the amount of waste disposed during a given time period. Since waste generation is highly variable from place to place, or from one time to another, it is advisable to collect many data points in order to develop a reliable estimate of the *average* amount of waste disposed by that class of waste generator. Typically, estimates of generation are correlated with another variable that describes the generator, such as, number of employees, number of acres, etc. This correlation permits estimates of waste quantities to be "scaled up" to a level larger than the individual generator – e.g., to the countywide or state-wide level.

2. **By Examination of Records at the Point of Generation:**
   Some businesses and institutions maintain records that reflect the amount of waste disposed over time. This information often can be found in invoices from the waste hauler or from the log sheet. Typically, the amount of waste is expressed in terms of *volume* rather than weight, so a volume-to-weight conversion factor may be necessary in order to quantify the weight of waste.

3. **Through Use of a Vehicle Survey:**
   This method quantifies the waste that arrives at a disposal facility according to waste sector. Since disposal facilities often do not classify disposed waste according to the same *waste sectors* that are used in municipal solid waste planning or waste characterization studies, it is sometimes necessary to use statistically valid surveying techniques to determine the portion of a facility's disposed tonnage that corresponds to each sector. The portions that are revealed through the vehicle survey are then applied to a known total amount of waste that is disposed at the facility during a given time period.

4. **By Examination of Records at the Disposal Facility:**
   Most disposal facilities keep transaction records that reflect the tonnage brought for disposal. In cases where the facility classifies waste according to the same sectors that are considered in the waste characterization study, facility records can provide thorough and reliable data to show the portion of a facility's disposed tonnage that corresponds to each sector. The portions that are revealed in the records are then applied to a known total amount of waste that is disposed at the facility during a given time period.

3.3. Characterization of Waste

3.3.1 Hand sorting of Samples

- **From Generators:** This study method produces waste composition data that can be correlated to specific types of waste generators, such as specific categories of business or industry, multi-family buildings, or single-family residences in specific neighbourhoods. Waste samples are obtained at the location where they were generated – e.g., from the dumpsters or disposal areas of the business or building in question.
- **At Disposal Facility:** This method produces the most accurate waste characterization data, and it is especially suitable for waste that is typically composed of many small pieces of numerous materials. Generally, an entire vehicle-load of waste is identified for sampling, but only a portion of the load is pulled out for actual sorting. This method is nearly essential for thorough characterization of residential or commercial waste. It is less useful in characterizing waste that typically consists of large pieces of material, such as some loads of construction and demolition waste. Because the method is employed at the disposal facility, it is of little use in correlating waste composition with specific types of waste generators, such as particular types of business.

3.3.2 Visual characterization of Samples

- **From Generators:** This method of waste characterization is ideal for wastes that are nearly homogeneous, such as mill tailings, agricultural chaff, sawdust, etc. Hand sorting is not necessary to characterize these wastes.
- **From Vehicles:** This method is ideally suited for waste that is taken to a disposal facility and that arrives in loads that are fairly homogenous individually (even if loads are markedly different from one another). Waste loads from various construction, demolition, and landscaping activities are often suitable for visual characterization, because an individual load often contains just a few materials. The usual approach in visual characterization is to estimate the composition of the entire load and to correlate the visual estimate with the net weight of the load.

3.4. Methods for Data Analysis

3.4.1 Calculations for Measuring Quantity

- **Quantifying a Waste Sector on Vehicle Surveys:**

If the annual tonnage of all waste disposed at the facility is known, then the analyst should use the vehicle survey to determine the portion of annual disposal corresponding to the waste sectors being studied. For a given waste sector, *S*, the sector tonnage can be calculated from the tonnage, *q*, found on individual vehicles.

$$\text{Sector (tons)} = \frac{\sum Q\text{, S, survey period}}{\sum Q\text{ all, survey period}} \times \sum Q\text{ all, annual}$$

If the annual tonnage of all waste disposed at the facility is not known, then the analyst should extrapolate sector tons directly from the corresponding tons that were counted during the vehicle survey.

$$\text{Sector (tons)} = \sum Q\text{, S, survey period} \times \frac{\text{Operating days in year}}{\text{Days in survey period}}$$

Appropriate adjustments should be made for the differences between weekdays and weekends and for any other known shifts in waste disposal patterns across days, weeks, or seasons.

- **Quantifying a Waste Sector on Measurement at the Point of Generation:**

The process of quantifying waste for an industry sector involves several steps, starting with the individual measurements of waste taken at the generators that were visited. The general procedure, applicable in most instances, is described below. It should be followed separately for each *size group* that is being studied within a larger commercial group or industry group.

First, extrapolate the volume of waste disposed using each waste container (or pile or process, etc.) at each generator that was visited.

$$\text{Volume}_{\text{container, annual}} = \text{Volume}_{\text{container, measured}} \times \frac{\text{Generation time}_{\text{annual}}}{\text{Generation time}_{\text{measured}}}$$

Second, add together the extrapolated volume of waste disposed in all containers that handle waste belonging to the same waste stream at the location.

$$\text{Volume}_{\text{site, annual}} = \sum \text{Volume}_{\text{container, annual}}$$

Third, calculate the density of the waste at the generator location, based on data from the waste sample.

$$\text{Density}_{\text{site}} = \frac{\text{Weight}_{\text{sample}}}{\text{Volume}_{\text{sample}}}$$

Fourth, apply the location-specific density figure to calculate the tons of waste disposed annually by the generator.

$$\text{Tons}_{\text{site, annual}} = \text{Volume}_{\text{sample}} \text{ X Density}_{\text{site}}$$

Fifth, calculate a "scale-up factor" for waste generation by the industry and size group. For many commercial sectors, the appropriate scale-up factor is according to the number of employees. For most agricultural sectors, it is according to number of crop acres or number of animals. The example shown below involves calculating *tons per employee*, or TPE for a given size group in the industry. It draws upon data reflecting the disposed tons and employment only at the locations that were visited as part of the study.

$$\text{TPE}_{\text{annual, size group}} = \frac{\sum_{\text{visited sites}} \text{Tons}_{\text{site, annual, size group}}}{\sum_{\text{visited sites}} \text{Employees}_{\text{site, annual, size group}}}$$

Sixth, calculate the tons disposed from the entire size group in the industry being studied. The example below draws upon data reflecting the total number of employees in the larger population (e.g. countywide, state-wide, etc.) of industry members in the appropriate size group.

$$Q_{\text{site, annual}} = \text{TPE}_{\text{annual, size group}} \text{ X Industry - wide employment in size group}$$

Seventh, add the results for the size groups to calculate total tons disposed by the industry.

$$Q_{\text{industry}} = \sum Q_{\text{size group}}$$

- **Quantifying based on Waste Generation Factors:**

For calculating and projecting waste quantities, especially from service and industrial sector, waste generation factors (WGF) should be determined. Then it will be easy to extrapolate the waste generation rates for the industries and services. WGF depends on size of operation, waste management practices and the process technology. Therefore, the information for this sector should not only have number according to the industrial classification, but also the size of production and process technology with respect to non-hazardous and hazardous waste generation. WGF can be defined as:

$$\text{WGF} = \frac{\text{Quantity of waste generated (tons per year)}}{\text{Quantity of product produced (tons per year)}}$$

3.4.2 Calculations for Composition

The composition of the waste corresponding to a sector of the waste stream is calculated using the method described below. The method should be applied separately to each waste sector being studied and to each size group or distinct waste stream within an industry group. (The next section of this chapter describes how results for individual sectors or size groups can be combined to describe the composition of larger segments of the waste stream.)

- **Calculating the Mean Estimate:**

For a given material, *j*, in all of the relevant samples, *i*, calculate the ratio, *r*, of the material weight, *m*, to the total sample weight, *w*.

$$r_j = \frac{\sum_i m_{i,j}}{\sum_i w_{i,j}}$$

The calculation should be repeated for each material.

- **Calculating the Error Range:**

For each mean estimate, r_j, calculated as described above, the confidence interval (error range) surrounding the mean estimate is calculated as follows. First, calculate the variance, Vr_j, of the mean estimate.

$$Vr_j = \frac{1}{n} \times \frac{1}{\bar{w}^2} \times \frac{\sum_i (m_{i,j} - r_j w_i)^2}{n-1}$$

Where n is the number of samples, and mean sample weight $\bar{w} = \frac{\sum_i w_i}{n}$

Confidence level is $\pm (t \times \sqrt{V_{i,j}})$, where t depends on the number of samples, n, and the desired confidence level. The value of t can be estimated from t-static (Appendix)

- **Volume to Weight Conversion Factors & Net Weight of Waste:**

Combining the composition estimates for two or more segments of the waste stream require the use of a *weighted averages* method. The result for each segment of the waste stream is weighted according to the relative size of that segment in the larger waste stream that is being studied. Annexure-II provides the volume-to-weight conversion factors from Guidelines for Waste Characterization Studies in the State of Washington.

- **Calculating the Weighting Factors when Combining Waste Sectors:**

A specific weighting factor should be calculated for each sector or segment of the waste stream being studied. The weighting factor, P_G, for each segment or size group, *G*, within the waste stream is calculated as follows:

$$P_G = \frac{t_{G,\ annual}}{T_{allsectors,\ annual}}$$

A weighting factor should be calculated for every waste sector, and thus the sum of all the values of P_G should equal to one.

- **Calculating the Mean Estimate for Combining Waste Sectors:**

The mean estimate for a given material, *j*, in a combination of segments (1, 2, 3...) of the waste stream is found as follows.

$$r_{j,\ combined} = (p_1^2 \text{ X } V_{rj1}) + (p_2^2 \text{ X } V_{rj2}) + (p_3^2 \text{ X } V_{rj3}) + \ldots.$$

Confidence level is $\pm (t \text{ X } \sqrt{V_{j,\ combined}})$.

Variables:

S	tonnage associated with a sector during a particular time period
Q	quantity of waste encountered in the study
TPE	tons per employee
j	designation of a particular material
i	designation of a particular sample
r	ratio of material weight to total sample weight, for an individual sample
m	weight of a material in an individual sample
w	total weight of an individual sample
V	the variance associated with the estimate for a material's percent in a group of samples
n	number of samples in the group
p	a weighting factor given to a segment of the waste stream, where the sum of all the values of p is 1
G	designation of a size subgroup within a segment of the waste stream – usually used for generator samples

3.5. Determining Waste Composition

3.5.1 Moisture Content

Moisture content is a very important factor that influences the decisions for converting organic waste into compost and biogas, using solid waste as a fuel, and designing landfills or incineration plants. Currently there are various types of moisture meters available to check the moisture content. However, the traditional test could also be done on certain types of materials. The moisture content shall be measured by heating the sample at 105^o C in an oven until the weight loss stabilizes. The weight of the sample before and after gives the moisture content. The different fractions of the waste stream shall have their moisture content measured separately.

Representative samples shall be selected from the sorted fractions depending on the waste materials. Solid plastics do not need to be dried to find the moisture content, but bottles need to be emptied before weighing whereas plastic films do need to be dried to find moisture content. The moisture content measurement has to be carried out on the same day of the sample collection to avoid drying out.

3.5.2 Calorific Value

The energy value of the waste components depends on its calorific value, which is influenced by the moisture content and hydrogen content of the wastes. The formula for determining the calorific value of waste components is:

$$CV_{raw} = ((1 - MC) \text{ X } (CV_{upper} - (2241^* \text{ X } 9) \text{ X } H)) - 2441 \text{ X } MC$$

Where:

CV = calorific value ('raw' is real 'as delivered' value, 'upper' is value for dried material) in kJ/kg
MC = % moisture content (by weight)
H = % Hydrogen content (from literature)
* vaporization enthalpy of water (2441 kJ/kg at 25^oC)

To determine the calorific value of waste stream the following steps to be carried out:

- Sample to be sorted and analyzed into the fractions;
- CV_{upper} is applied from know data (literature);
- CV_{upper} is analyzed for unknown fractions;
- % Hydrogen is applied from know data (literature);
- Moisture of fractions is determined; and
- Calculate value for CV_{raw}.

Default higher calorific values and hydrogen contents for solid waste are shown in Table 3.2. The moisture content, as shown in the table, is for illustration purposes only and should be determined for each waste component. Moisture content varies by location (climatic variation) and by season and leads to a directly proportional change in the CV_{raw}.

Solid waste is usually a mixture of various waste components and some of those may not be eligible for using them as fuel. This table is provided for reference purposes and each country may have regulations on some of the wastes which may not be considered as eligible. Therefore, this table should be revised for practical purposes in each country or city.

3.5.3 Chemical Composition

For organic and inorganic waste, the information on chemical composition is quite important to design recycling, including composting, energy recovery and disposal. The important elements are carbon, hydrogen, oxygen, nitrogen, sulphur, and ash. The local or national institutes may have typical data for various types of wastes on dry-basis for these elements. That data may be utilized to calculate the composition for the collected waste.

Table 3.2: Moisture Content, Hydrogen Content and Calorific Values for MSW

Material in MSW	Moisture[1]	Hydrogen content	CV upper kJ/kg	CV raw kJ/kg
Eligible Components				
Kitchen Organics – vegetable	80.9%	6.2%	19,800	1,540
Kitchen Organics – meat	52.9%	9.4%	11,900	3,340
Municipal Garden Organics	46.5%	6%	16,800	7,140
Paper composite	12%	7.5%	21,450	17,130
Mixed Paper	29.7%	5.8%	15,150	9,030
Liquid Paper Board	4.5%	7.5%	21,450	12,520[2]
Newspaper	7.2%	6.1%	17,330	14.660
Magazines	5%	5.1%	13,500	11,640
Cardboard	6.7%	5.9%	18,670	16,050
Disposable Nappies	55%	6.4%	22,900	4,190[2]
Wood(timber)[3]	19%	6%	20,630	15,070
Non-Eligible Components				
Textiles[4]	26.8%	6.4%	16,780	10,600
Liquid Paper Board	4.5%	7.5%	21,450	6,360
Disposable Nappies	55%	6.4%	22,900	4,140
Compounds (radios etc)	10%	5.1%	12,000	9.570
Mixed Plastics	10%	10%	39,000	32,880
Plastic composite	<1%	10%	37,100	34,900
Plastic Film	<1%	10%	40,000	37,800
Polystyrene (PS)	<1%	8.4%	40,000	38,150
Polyethylene (PE)	<1%	14.2	45,000	41,880
Polyvinyl chloride (PVC)	<1%	5.6%	25,000	23,770
Polyethylene terephthalate (PET)	<1%	6%	25,000	23,680
Polypropylene (PP)	<1%	14%	44,000	40,920
Rubber	18.7%	8.7%	23,100	16,770

Note 1 – Caution: Moisture content changes seasonally, regionally and due to rainfall.
Note 2 – For these mixed materials the CV has been adjusted to 15% plastic (LPB), 10% plastic (Disposable Nappies) and split into eligible and non-eligible components.
Note 3 – Excludes green organics and wood waste from forestry or land clearing operations.
Note 4 – Textiles may be eligible if from known source of natural fibre.
Source: Office of the Renewable Energy Regulator, Austria (March 2001)

3.6. Working Example

Let us take an example of a small city X. The data collection and analysis has to be done to quantify and characterize residential solid waste. Based on the historical data or pilot surveys, the major waste components are identified as food wastes, paper, cardboard, plastics, textiles, rubber, leather, yard wastes, wood, glass, metals, dirt and ash. To collect the data, for quantification and characterization of current solid waste, the number of samples should be determined based on two factors.

Firstly, the confidence level required and that depends on the utility of the data. In case, if we have to establish recycling units, then we may need higher confidence level, but if this is to develop an overall scenario then we may go for lower confidence level. Based on Table 3.1, we may choose 70% confidence levels.

Secondly, it depends on the methodology for analysis of the samples. We have to develop an overall scenario, and not the detailed scenario for each residential area, so we adopt hand sorting at disposal facility, if all the waste is being collected and transported to the disposal facility. We take samples directly from the vehicles at disposal facility and during different times of the day. We assume that there are no seasonal variations in residential solid waste. From Table 3.1, for 70% confidence level, the sample number for cardboard is highest on the lower-end. So we choose number samples as 27.

Based on the random numbers, we start collecting the samples from the vehicles arriving at the disposal facility. We also check the records at the disposal facility to know the annual tonnage at the disposal facility. If the annual tonnage is not available, then we can extrapolate the tonnage, based on the vehicles surveyed. However, if the waste from different sectors, for example residential or commercial, is being transported in separate vehicles, then we can directly calculate the daily average.

A. Quantity

We distribute the 27 samples over the nine days with 3 samples per day. For sample collection, we measure tonnage of all the samples (vehicles) which may turn out as shown in Table 3.3. There are 20 trips per day for residential waste and we select 3 vehicles randomly. Based on these 3 samples, weight of solid waste could be calculated and based on the 9 days, we can calculate daily average tonnage of residential waste (Table 3.3).

However, if the same vehicles are bringing mixed waste from more than one sector, then we can first take the proportion of residential waste for each sample with a crosscheck at samples collected at generation or primary disposal point.

B. Characterization

The samples have to be sorted out and different materials needed to be separated out. Then the measurement of each type of available material could be done either by weighing it or by applying volume-to-weight conversion factors. An example of these conversion factors is given in Annexure II, but these should be locally established factors.

After measuring all the materials, we can calculate the ratio of each component with respect to the total weight of the sample. Based on the average ratios from all the samples, these ratios could be used to calculate the distribution of major wastes in the overall residential waste. We prepare Table 3.4 based on the data for the collected waste by weight and its moisture content; or based on the laboratory tests; or based on moisture meter readings. The dry weight could be calculated by subtracting moisture content from the wet weight.

For example, weight of raw food waste is 4.1 tons and moisture content is 70%. The dry weight would be 4.1-(4.1X0.7) =1.23 tons.

Table 3.3: Quantity of Residential Waste for City X

Daily Samples				Aggregated Data		
Day	**Samples**	**Tonnage per sample**		**Day**	**Tonnage per 3 samples**	**Total (Daily)**
1	1	2		1	7	46.7
1	2	2		2	7	46.7
1	3	3		3	7	46.7
2	4	4		4	6	40.0
2	5	2		5	7	46.7
2	6	1		6	7	46.7
3	7	2		7	6	40.0
3	8	2		8	6	40.0
3	9	3		9	8	53.3
4	10	2			61	406.7
4	11	3			Average (Daily)	45.2
4	12	1				
5	13	2				
5	14	2				
5	15	3				
6	16	3				
6	17	2				
6	18	2				
7	19	1				
7	20	2				
7	21	3				
8	22	2				
8	23	3				
8	24	1				
9	25	2				
9	26	4				
9	27	2				

Table 3.4: Raw Weight and Moisture Content of collected MSW in City X

Component	Raw Weight (tons)	Moisture Content, MC (%)	Dry Weight (tons)
Food Wastes	4.1	70.0	1.2
Paper	15.4	5.9	14.5
Cardboard	2.7	5.0	2.6
Plastics	3.2	1.4	3.2
Textiles	0.9	10.0	0.8
Rubber	0.2	0.0	0.2
Leather	0.2	20.0	0.2
Yard wastes	8.4	64.9	2.9
Wood	0.9	20.0	0.7
Inorganic	9.1	3.0	8.8
Total	45.2		35.1

Table 3.5: Typical Data for Dry Waste in City X

Component	Percent by weight (dry basis)					
	Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	Ash
Food wastes	48.0	6.4	37.6	2.6	0.4	5.0
Paper	43.5	6.0	44.0	0.3	0.2	6.0
Cardboard	44.0	5.9	44.6	0.3	0.2	5.0
Plastics	60.0	7.2	22.8			10.0
Textiles	55.0	6.6	31.2	4.6	0.2	2.5
Rubber	78.0	10.0		2.0		10.0
Leather	60.0	8.0	11.6	10.0	0.4	10.0
Yard wastes	47.8	6.0	38.0	3.4	0.3	4.5
Wood	49.5	6.0	42.7	0.2	0.1	1.5
Glass	0.5	0.1	0.4	0.1		98.9
Metals	4.5	0.6	4.3	0.1		90.5

Based on Table 3.4 and Table 3.5, we can calculate the composition of various types of solid wastes. Fore example:

Food Waste: Dry weight = 4.08 – (4.08 X 0.7) = 1.2 ton; C = 1.2 X 0.48 = 0.6 ton

Table 3.6 shows the composition for all the waste components

Table 3.6: Waste Composition for City X

Component	Wet Weight	Dry Weight	Composition					
Tons		tons	C	H	O	N	S	Ash
Food Waste	4.1	1.2	0.6	0.1	0.5	0.0	0.0	0.1
Paper	15.4	14.5	6.3	0.9	6.4	0.0	0.0	0.9
Cardboard	2.7	2.6	1.1	0.2	1.2	0.0	0.0	0.1
Plastic	3.2	3.1	1.9	0.2	0.7	0.0	0.0	0.3
Textiles	0.9	0.8	0.4	0.1	0.3	0.0	0.0	0.0
Rubber	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0
Leather	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0
Yard Wastes	8.4	2.9	1.4	0.2	1.1	0.1	0.0	0.1
Wood	0.9	0.7	0.4	0.0	0.3	0.0	0.0	0.0
TOTAL	36.1	26.4	12.4	1.6	10.4	0.2	0.1	1.6

Note: C, H, O, N, S is carbon, hydrogen, oxygen, nitrogen and sulphur respectively

C. Calorific Values

$$CV_{raw} = ((1 - MC) \times (CV_{upper} - (2241^* \times 9) \times H)) – 2441 \times MC$$

Where:

CV = calorific value ('raw' is real 'as delivered' value, 'upper' is value for dried material) in kJ/kg
CV upper is taken from the literature

MC = % moisture content (Table 3.4)

H = % Hydrogen content (Table 3.5)

* Vaporization enthalpy of water (2441 kJ/kg at 25^{o}C)

Table 3.7: Calorific Values for Waste Components in City X

Component	CV raw	CV upper	Hydrogen (H)	Moisture Content (MC)
Kj/kg		Kj/kg	(%)	(%)
Food	3809	19800	6.4	70
Paper	14905	17330	6	6
Cardboard	16383	18670	5.9	5
Plastics	37020	39000	7.2	1
Textiles	13553	16780	6.6	10
Rubber	41803	44000	10	0
Yard Wastes	3832	16800	6	65
Wood	14961	20630	6	20

Note: CV is calorific value; 'raw' is real 'as delivered' value of the collected waste while 'upper' is value for dried material from literature

3.7. Data Presentation

The data could be presented in various layers and in various formats (tables and graphs). Depending on the scope of the data, various details should be provided in tabular as well as in graphical formats. For example, if the data is required for integrated solid waste management covering all the sectors showing future projections, then various tables and graphs may be generated. Following is the hypothetical example for City X:

3.7.1 Tabular Presentation:

Table 3.8: Solid Waste Generation in City X (167tpd non-hazardous & 33tpd hazardous)

Sector Estimated	Ratio (%age)	Estimated tonnage (per day)	
		Non-Hazardous	Hazardous
Residential	22.6	45.2	0.0
Commercial	17.4	34.8	0.0
Construction & Demolition	9.0	16.0	1.0
Healthcare	0.5	1.0	1.0
Industrial	50.0	70.0	30.0
Sludge	0.5	0.0	1.0

Table 3.9: Residential Waste in City X

Component	Wet Weight	Dry Weight	Composition							
Kg		Kg	MC	CV	C	H	O	N	S	Ash
Food Waste	4.1	1.2	70	3809	0.6	0.1	0.5	0.0	0.0	0.1
Paper	15.4	14.5	6	14905	6.3	0.9	6.4	0.0	0.0	0.9
Cardboard	2.7	2.6	5	16383	1.1	0.2	1.2	0.0	0.0	0.1
Plastic	3.2	3.1	1	37020	1.9	0.2	0.7	0.0	0.0	0.3
Textiles	0.9	0.8	10	13553	0.4	0.1	0.3	0.0	0.0	0.0
Rubber	0.2	0.2	0	41803	0.2	0.0	0.0	0.0	0.0	0.0
Leather	0.2	0.2	20		0.1	0.0	0.0	0.0	0.0	0.0
Yard Wastes	8.4	2.9	65	3832	1.4	0.2	1.1	0.1	0.0	0.1
Wood	0.9	0.7	20	14961	0.4	0.0	0.3	0.0	0.0	0.0
Glass	4.0	4.0								
Metals	5.1	5.1								

Note: MC, CV, C, H, O, N, S are moisture content, calorific value, carbon, hydrogen, oxygen, nitrogen and sulphur respectively.

Similar tables may be produced for other sectors. Thereafter, similar waste components from different sectors could be grouped for different purposes, including overall available amount of certain components for recycling, or for final disposal.

Table 3.10: Aggregated Data on Waste Components

Components	Residential	Commercial	Construction	Industrial	Health Care	Total
Food Waste	4.1	5.2	0.0	2.0	0.3	11.6
Paper	15.4	5.0	0.2	7.0	0.1	27.7
Cardboard	2.7	3.0	1.0	9.0	0.0	15.7
Plastic	3.2	3.3	1.0	10.0	0.1	17.6
Textiles	0.9	1.2	0.0	5.0	0.2	7.3
Rubber	0.2	1.0	1.0	5.0	0.1	7.3
Leather	0.2	1.0	1.0	5.0	0.1	7.3
Yard Wastes	8.4	4.0	1.0	5.0	0.1	18.5
Wood	0.9	2.0	4.0	5.0	0.0	11.9
Glass	4.0	4.0	2.0	7.0	0.0	17.0
Metals	5.1	5.1	3.0	10.0	0.0	23.2
Hazardous	0.0	0.0	1.0	30.0	1.0	32.0
Total	45.2	34.8	15.2	100.0	2.0	197.2

The data on details of sub-components can also be tabulated if the decisions are required to be taken on those sub categories of the materials presented in solid waste. For example, there are various categories for plastics (please refer to list of the materials in Annexure I).

These data tables can also be produced for time-series data showing overall trends or showing trends in each sector or for each type of material. Based on that data, future projections can be provided with a few different possible scenarios. For example, the following table shows hypothetical time series data for City X.

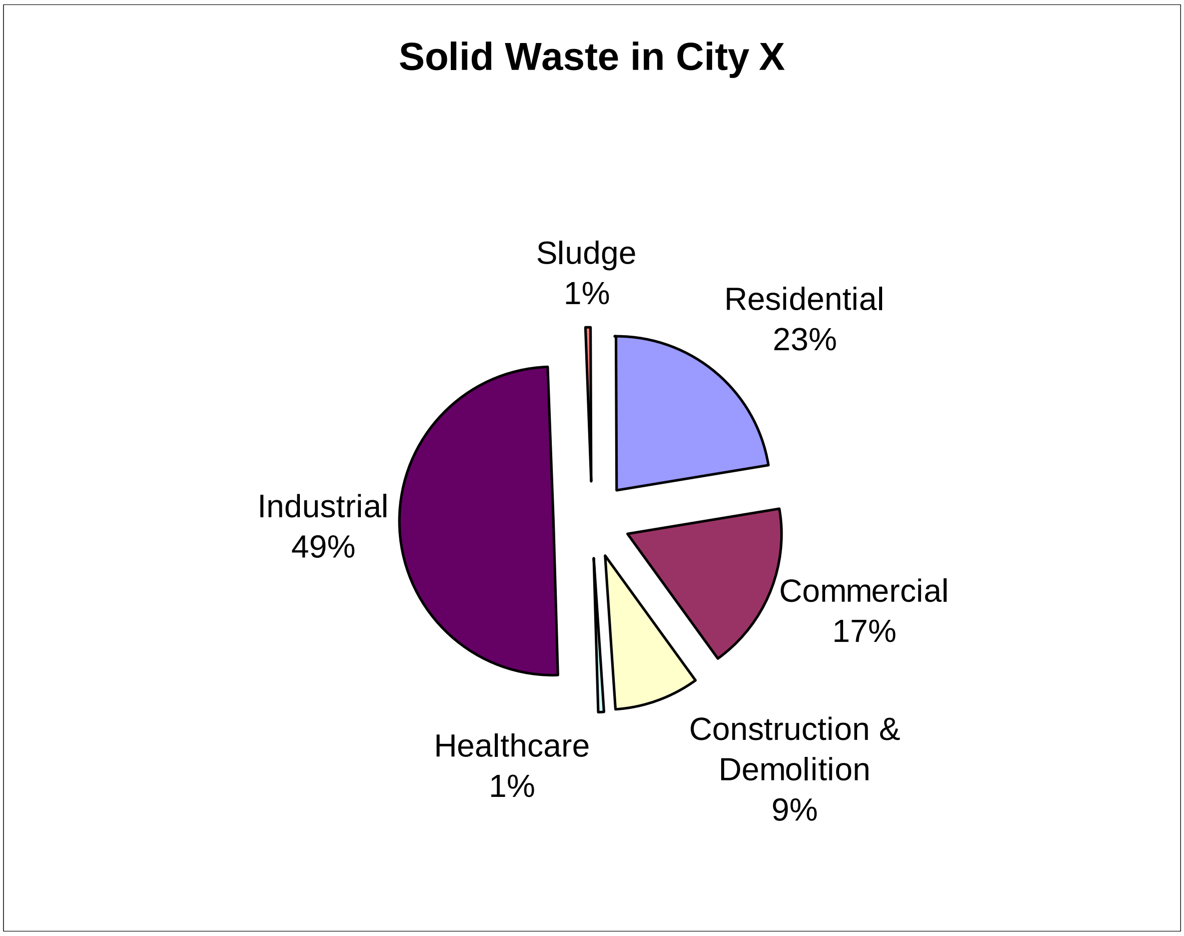
Table 3.11: Time Series Data and Projections (1991-2010) for Residential Waste in City X

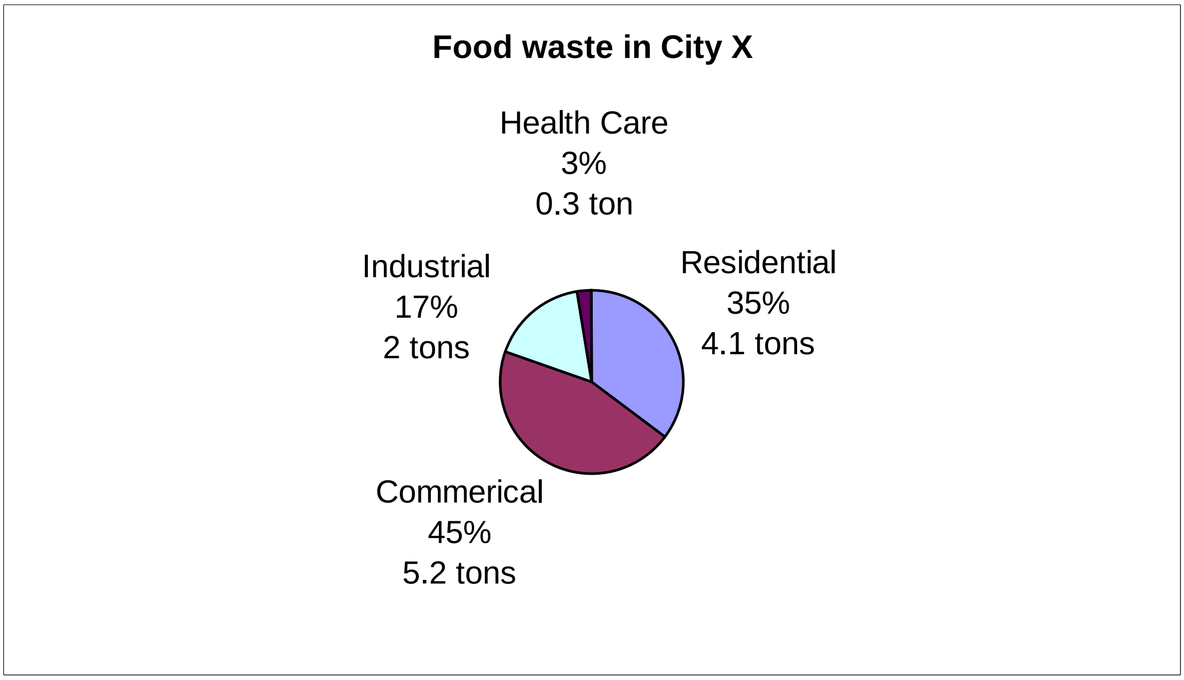
Year	Residential			Year	Residential		
	Organic	**Inorganic**	**Total**		**Organic**	**Inorganic**	**Total**
1991	20.0	15.0	35.0	2001	14.0	28.0	42.0
1992	19.0	16.0	35.0	2002	14.0	29.0	43.0
1993	18.0	17.0	35.0	2003	13.8	30.0	43.8
1994	17.0	20.0	37.0	2004	13.6	31.0	44.6
1995	17.0	22.0	39.0	2005	13.4	31.8	45.2
1996	16.0	23.0	39.0	*2006*	*13.4*	*33.0*	*46.4*
1997	15.0	24.0	39.0	*2007*	*12.9*	*34.2*	*47.1*
1998	15.0	25.0	40.0	*2008*	*12.5*	*35.4*	*47.9*
1999	14.5	26.5	41.0	*2009*	*12.0*	*36.6*	*48.6*
2000	14.5	27.5	42.0	*2010*	*11.6*	*37.8*	*49.4*

Note: organic waste covers food waste and yard waste which can be converted into compost

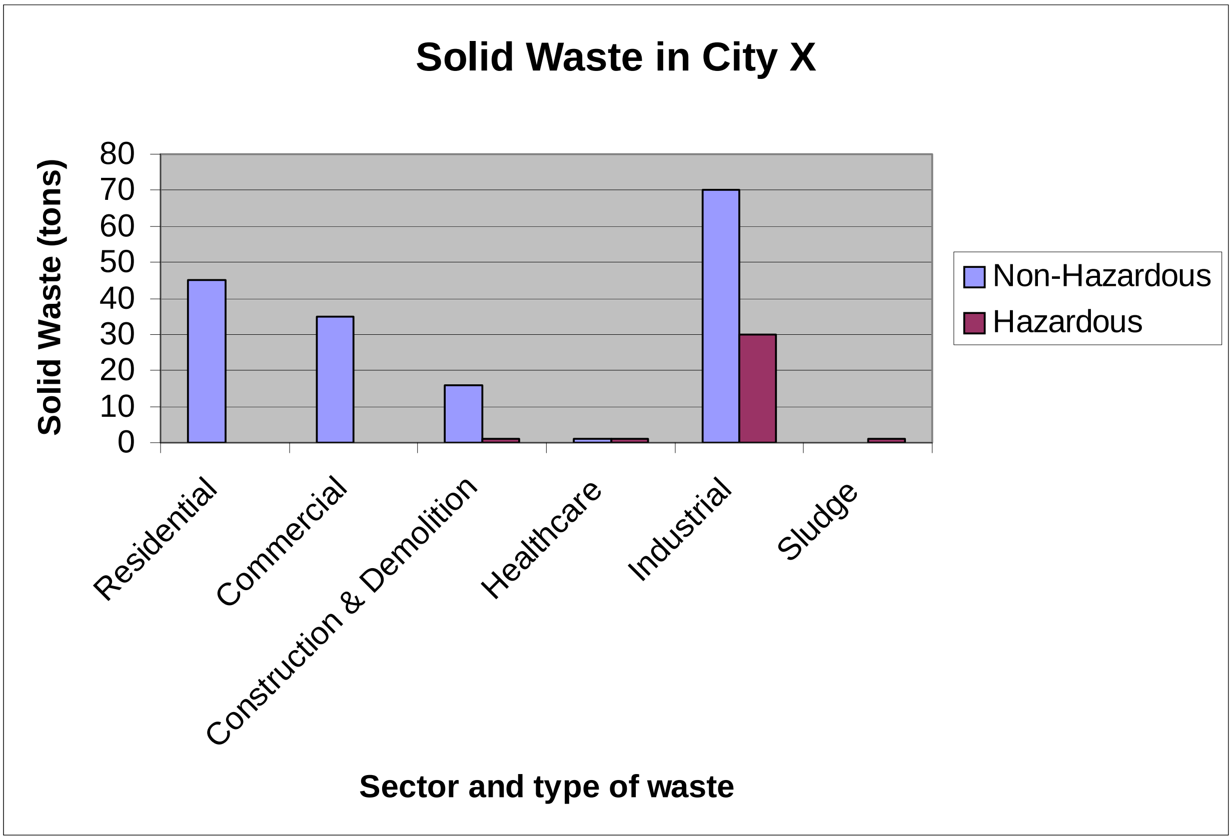
3.7.2 Graphical Presentation:

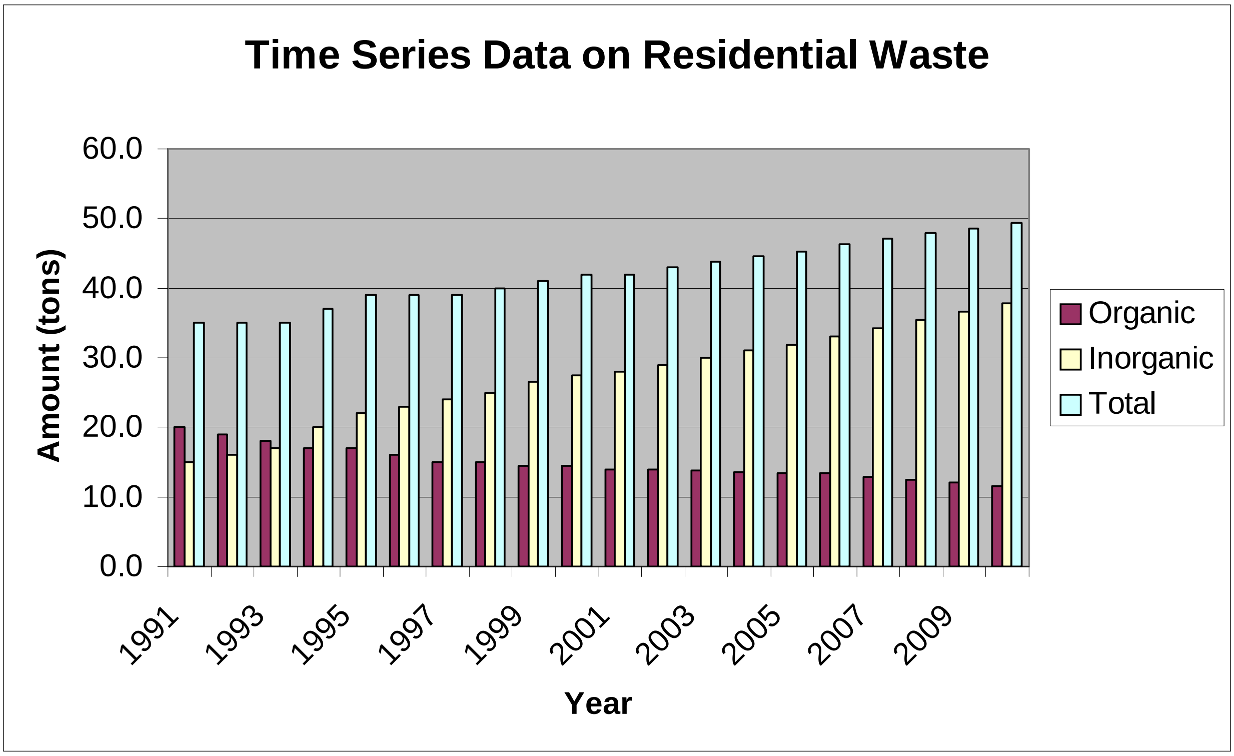
It is important to produce graphs, based on the tabulated data, as they provide quick and better understanding. For example, a pie chart can provide a quick glimpse of the share of each sector in overall solid waste. Similarly, pie charts are also good to show the proportion of each type of material presented in solid waste.

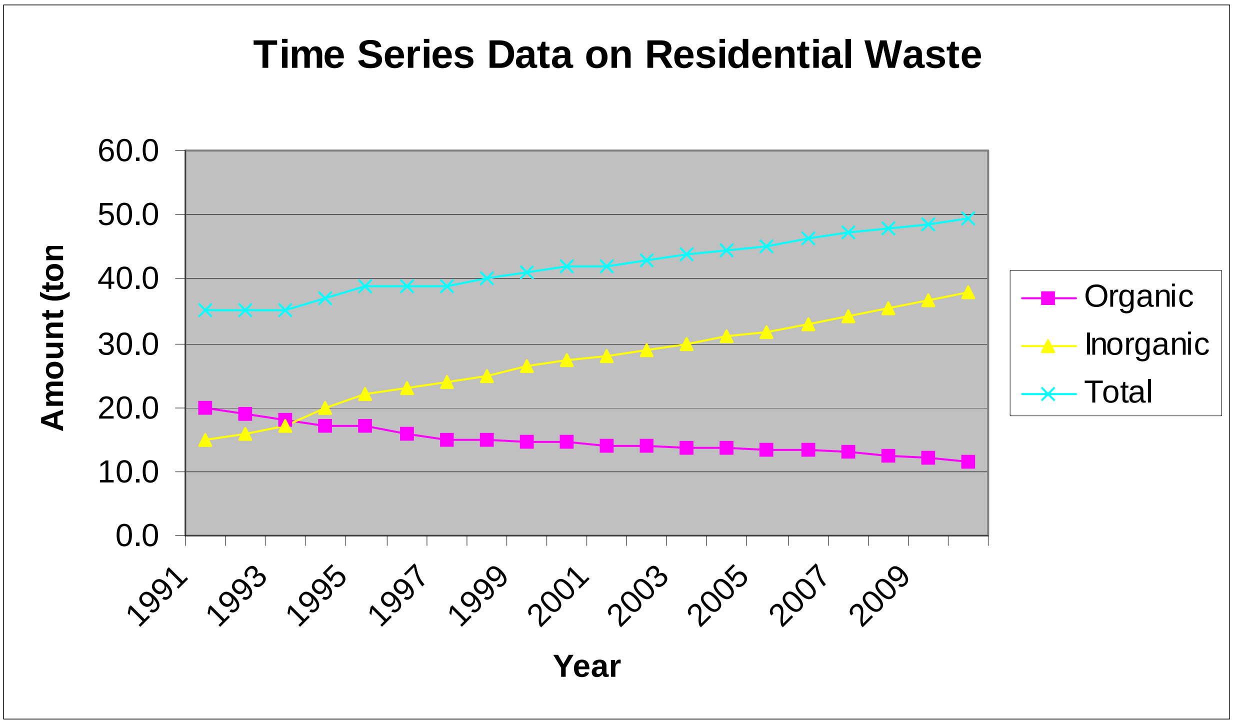




Bar, column and line charts are usually recommended for comparing the values rather than the ratios. These are also useful tool for time series data with future projections.







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4. Municipal Solid Waste

Prior to carrying out data collection and analysis for municipal solid waste, the following information is available based on the previous steps:

1. Geographical and administrative boundaries are defined and land use maps are ready with information on residential, commercial, industrial and other zones.
2. The decisions taken on geographical coverage and type of waste that is considered as municipal solid waste. Usually, residential and non-hazardous commercial waste is considered as municipal waste. However, if there are other sectors or types of wastes - to be considered as municipal solid waste - then those should be included in the survey.
3. The primary information on the waste transfer stations, transportation and final disposal would be required to design the survey and to identify the sites for the collection of samples.

4.1. Designing Survey for Municipal Solid Waste

The survey for municipal solid waste should be aimed to gather accurate data with minimum efforts, time and money. The survey may be designed through the following process:

1. Based on the geographical and administrative map, prepare a list of districts/counties with basic information

District / County	A	B	C	D
Zoning	Residential	Residential & Commercial	Industrial	Residential
Counties / Streets	A1, A2, A3…	B1, B2, B3…	C1, C2, C3…	D1, D2, D3…

Note: A,B,C,D will be replaced with the real district/county names and subsequently A1,A2,.. will be replaced with the street names within each district or county

2. Separate lists of the primary waste collection and final disposal facilities for each district/county should be prepared and allocate a number to each waste collection site and waste disposal facility. In case, if the data has to be collected at a disposal facility, then identify the number of trips by waste collection vehicles and check if they bring waste from a single sector (e.g. residential) or from all the sectors under municipal waste and if they transport waste from a single county/district. There should be separate numbering for the vehicles transporting waste from a single sector. Furthermore, if the same vehicle makes more than one trip per day, then that vehicle will be allocated number equal to the number of trips.

District/County	A (A1)	A (A3)	B (B2)	B (B4)	C (C1)	C (C3)	D (D2)
Collection site	1, 2, 3	4, 5, 6, 7	8, 9	10, 11	12, 13	14, 15	16, 17, 18
Disposal site & vehicles	I 1, 2, 3,4	5, 6, 7, 8	9, 10	II 11, 12	13, 14	III 15, 16	17, 18, 19, 20

Note: A,B,C,D will be replaced with the real district/county names and subsequently A1,A2,.. will be replaced with the street names within each district or county, and each primary collection site at generation or each collection vehicle at disposal site will be allocated one number (1,2,3..) for random selection of sites for collection of samples.

3. Calculate the number of samples based on the information provided in chapter 3. Thereafter, randomly select the numbers (corresponding to waste sites or vehicles). For example, if the number of samples is decided as 20 and it is also decided to collect samples from generators or collection points as well as from disposal facility (from vehicles). However, there may be a balance between samples collected at the generation point and those collected at the disposal point. In this case, 10 samples may be collected each at generation and disposal site. The selection of sites may look like this

Sample No.	1	2	3	4	5	6	7	8	9	10
Collection site	2	3	5	7	8	11	12	15	17	18
Disposal site	1	2	6	8	12	13	15	17	18	20

4. The details should be chalked out for sample collection and sorting, including time-table, team members and sample sorting procedures: hand sorting or visualization and weighing

Sample No.	1	2	3	4	5	6	7	8	9	10
Collection site Date/Time Team Equipment Method										
Disposal site Time Team Equipment Method										

5. The data should be recorded for each sample. Following table is for reference purposes and the list of materials could be expanded. Similarly the composition indicators may also be reduced or increased.

Sample No.1; Location: Street A1, District A
Sample Type: Waste Container for primary collection
Sample Type: Mixed / Segregated (recyclable, organic/food, non-recyclable)
Volume: 2 m^3; Weight: 45.1 Kg

Component	**Wet Weight**	**Dry Weight**	**Composition**							
k	**g**	**kg**	**MC**	**CV**	**C**	**H**	**O**	**N**	**S**	**Ash**
Food Waste	4.1	1.2	70	3809	0.6	0.1	0.5	0.0	0.0	0.1
Paper	15.4	14.5	6	14905	6.3	0.9	6.4	0.0	0.0	0.9
Cardboard	2.7	2.6	5	16383	1.1	0.2	1.2	0.0	0.0	0.1
Plastic	3.2	3.1	1	37020	1.9	0.2	0.7	0.0	0.0	0.3
Textiles	0.9	0.8	10	13553	0.4	0.1	0.3	0.0	0.0	0.0
Rubber	0.2	0.2	0	41803	0.2	0.0	0.0	0.0	0.0	0.0
Leather	0.2	0.2	20		0.1	0.0	0.0	0.0	0.0	0.0
Yard Wastes	8.4	2.9	65	3832	1.4	0.2	1.1	0.1	0.0	0.1
Wood	0.9	0.7	20	14961	0.4	0.0	0.3	0.0	0.0	0.0
Glass	4.0	4.0								
Metals	5.1	5.1								

Note: MC, CV, C, H, O, N, S are moisture content, calorific value, carbon, hydrogen, oxygen, nitrogen and sulphur respectively.

6. Simultaneously information should be collected from the generators on their direct reuse, recycling and disposal of waste other than dumping at the waste collection points or waste disposal facilities

District A County / Street	A1	A2	A3	A4	A5	A6	A7
Population, No. of houses Single family & Multi-family	2000 100 30	1000 20					
Number & type of commercial undertakings	Fruit Mart 5 shops	Services 5 Banks 4 Office					

Note: A1, A2, will be replaced with names of streets or areas within a district

Street A1	SF	SF	SF	SF	MF	MF	Shop
Type and amount of waste for reuse and recycling	2 Plastic jar 1 newspaper	2 newspapers					
Ballpark estimates for %age of waste being reused or recycled at source	5%	4%					

Note: SF is single-family residence and MF is multi-family residence (e.g. apartment buildings)

7. Similar type of sample collection and analysis would be done at disposal sites, where waste collection vehicles would be analyzed as samples in the similar fashion. The total weight of samples (vehicles) could be measured at weighing bridges at disposal facility for loaded and empty vehicles.
8. Based on the data from all the samples, municipal waste could be quantified and characterized as per the guidelines provided in Chapter 3.

4.2. Residential Hazardous Waste

There may be some hazardous waste from residential sources, the most common being containers of various types of paint, batteries, fluids for vehicles and equipment, used oil and others. A separate data sheet should be prepared if households segregate hazardous waste at source. However, if it is evident from analysis of samples, that hazardous waste is mixed within these samples then this should also be listed in the sample analysis forms.

Hazardous Waste	District A	District B	District C	Total
Batteries				
Containers of auto oil /fluid				
Containers of pesticides				
Containers of paint				

Note: A,B,C will be replaced with district names

5. Construction and Demolition Waste

Construction and demolition waste can be substantial in amount and may create a bigger challenge for the generator as well as the authorities for its collection and disposal. The survey, to collect and analyze the samples, may follow the same procedures as discussed for municipal waste in the previous chapter. However, the following information may be important to establish the trends for construction and demolition waste.

5.1. Important Issues related with C&D Waste

- **Types of Materials**

Construction and demolition (C&D) waste is not a monolithic waste stream, but it is a family of waste streams. Therefore, it is important to define the types of materials, which could be available in C&D waste. The most common materials could be paper/cardboard, garden/vegetation, wood/timber, carpets, other textiles, rubber, glass, plastics, metals, hazardous wastes, ceramics, soil/rubble <150mm, cobbles/boulders, clean soil, concrete, plasterboard, bricks, asphalt/bitumen, cement sheet, insulation and others.

Based on the local information and pilot surveys, a list of materials should be prepared for designing comprehensive sample analysis.

- **Material Densities**:

The other important issue is to identify the material densities (this will establish local volume-to-weight conversion factors – an example of standard volume-to-weight conversion is shown in Annexure II). For C&D debris, it is useful to establish material densities in tonne/m^3. The densities could be calculated by applying the formulae, as discussed in Chapter 2. For example, following are the material densities for C&D debris in Melbourne, Australia:

Table 5.1: Material Densities for Construction and Demolition Debris in Melbourne

Material	Density	Material	Density	Material	Density
Paper/Cardboard	0.1	Plastics	0.2	Concrete	1.5
Garden/Vegetation	0.15	Metals	0.9	Plasterboard	0.2
Wood/Timber	0.3	Hazardous Wastes	0.2	Bricks	1.2
Carpets	0.3	Ceramics	1.0	Asphalt/Bitumen	0.8
Other Textiles	0.15	Soil/Rubble <150mm	1.4	Cement Sheet.	0.5
Rubber	0.3	Cobbles/Boulders	1.4	Insulation	0.05
Glass	0.7	Clean Soil	1.6	Others	0.3

- **Proportion of Various Materials**

After analyzing the samples, the distribution of material type could be established in proportion or percentage with respect to the total C&D waste. This distribution could vary from place to place, depending upon the type of building materials and that of construction technology. For example, one study estimated that in C&D debris in USA, the ratio of concrete and mixed rubble would be 40-50%, wood 20-30%, drywall 5-15%, asphalt roofing 1-10%, metals 1-5%, bricks 1-5% and plastics 1-5%. The composition of C&D debris for Melbourne and Maunsell (Australia) in 1993 was:

Table 5.2: Material Composition for C&D Debris in Melbourne

Category	Maunsell (1993) [% by weight]	Survey [% by weight]
Paper/Cardboard	1.2	0.4
Garden/Vegetation	0.1	1.7
Wood/Timber	12.2	9.5
Carpets and Other Textiles	1.2	0.5
Rubber	1.1	0.1
Glass	0.5	0.2
Plastics	1.1	0.5
Metals	7.3	4.5
Ceramics	4.5	0.9
Soil/Rubble, Cobbles/Boulders,& Clean Soil	41.7	40.9
Other (1)	29.0	40.8
Total	100	100

(1) Other includes concrete, plasterboard, bricks, asphalt/bitumen, cement sheet, and insulation

- **C&D Debris by Sector & Activity**

The other important aspect for data collection is to estimate the C&D debris being generated by different sectors and by their level of activity. The sectors may cover residential (new private and public housing), private non-residential (private and public industry, commercial, agricultural, tourism and religious), productive infrastructure (water and sanitary services, airports, ports, harbours, energy and telecommunications), and social infrastructure (education, health, public buildings, local authority services and others). This classification can differ from country to country or from city to city. Therefore, an appropriate local classification should be used.

- **Recovery and Recycling**

At many places, most of the C&D debris is being recycled and most of the materials are either recovered at site or at the specific facilities. The information on the amount of recycling/recovery is important so as to estimate the amount of C&D debris requiring final disposal.

5.2. Designing Survey for C&D Waste

There are two levels of survey, which may help to quantify and characterize C&D waste. First level would be to analyze the samples (vehicles) entering at waste disposal facility (landfill) and the other level would be to get information at the C&D sites. This is a crucial factor because a major proportion of C&D waste could be reused or recycled and may not be transported to disposal site.

5.2.1 Survey for Vehicles at Landfill Site

Prior to collecting and analysing the samples (waste collection vehicles), it is important to get information from landfill site records about the timing, number of vehicles and the amount of C&D waste. Based on this information, and the number of samples required in view of cost and confidence level for data (see Chapter 3), the survey timings for randomly identified samples (vehicles) could be planned. The information about the samples should be recorded properly. The formats could be developed locally in the following manner:

Sample No. 1; Location: Landfill site Y
Sample Type: C&D waste vehicle
Sample Type: Mixed C&D waste / segregated (concrete/rubble, carpets, wood, etc.)
Volume: 3 ^{m3}; Weight: 1000 Kg

Component Wet	**Weight**	**Composition**	
	kg	**Moisture Content**	**Calorific Value**
Soil/Rubble, Cobbles Boulders			
Ceramics			
Paper/ Cardboard			
Wood / Timber			
Plastic			
Carpet / Textiles			
Rubber			
Leather			
Garden / Yard / Vegetation			
Wood			
Glass			
Metals			
Others*			
Total			

* Others may include concrete, plasterboard, bricks, asphalt/bitumen, cement sheet and insulation

5.2.2 Survey for Recovery at Landfill site

In many places, recyclables may be recovered at the landfill site. It may be difficult to assess the recovery rate per sample (vehicle) or for every sample. However, either the records at landfill site may provide the information on the type and amount of materials recovered, or a direct monitoring and survey could be conducted at the landfill site:

Location: Landfill site Y
Landfill for: C&D waste / Mixed municipal waste
Date of Survey: Full day

Component Recovered	
	Kg
Soil/Rubble, Cobbles Boulders	
Ceramics	
Paper/ Cardboard	
Wood / Timber	
Plastic	
Carpet / Textiles	
Rubber	
Leather	
Garden / Yard / Vegetation	
Wood	
Glass	
Metals	
Others*	
Total	

* Others may include concrete, plasterboard, bricks, asphalt/bitumen, cement sheet and insulation

Based on these results, the overall quantities could be estimated through extrapolation and then those could be compared with the overall quantities of C&D waste disposed at that landfill site. The overall quantification and characterization of discarded C&D waste may also follow the same procedures, as was the case for municipal waste (Chapter 3 and 4). The data can also be presented in the similar fashion.

5.2.3 Survey at C&D Sites

A major proportion of C&D waste is either reused at C&D sites or directly sent or sold for recycling. The vehicles only bring the remaining waste to the landfill site, which is discarded at C&D sites. Therefore, to get the holistic picture for C&D waste, it is important to conduct a survey at C&D sites. Depending on the availability of the resources and requirements for the confidence levels of the data, the number of samples and methods for analysis could be determined (see Chapter 3). If there are enough resources, then detailed surveys could be conducted including the sorting and weighing of all the materials (recyclables and discarded at C&D sites). However, if there are limited resources, then the information could be gathered from the generators at C&D sites:

Site No. 1; Location: District B
C&D waste generator: Residential / Commercial / Industrial / Government

C&D	Waste	Re-used on site and recyclables	Discarded & sent to landfill
	Tons	Tons	Tons
Soil/Rubble, Cobbles Boulders			
Ceramics			
Paper/ Cardboard			
Wood / Timber			
Plastic			
Carpet / Textiles			
Rubber			
Leather			
Garden / Yard / Vegetation			
Wood			
Glass			
Metals			
Others*			
Total			

* Others may include concrete, plasterboard, bricks, asphalt/bitumen, cement sheet and insulation

Overall quantity could be estimated based on the proportion of reused/recycling waste versus discarded waste at C&D sites, and the proportion of recovered recyclables versus disposed waste at landfill:

	Recycling at C&D site	Recovery at landfill site	Discarded for landfill
	% % %		
Soil/Rubble, Cobbles Boulders			
Ceramics			
Paper/ Cardboard			
Wood / Timber			
Plastic			
Carpet / Textiles			
Rubber			
Leather			
Garden / Yard / Vegetation			
Wood			
Glass			
Metals			
Others*			
Total			

* Others may include concrete, plasterboard, bricks, asphalt/bitumen, cement sheet and insulation

Then we can present the data, in similar fashion with data for municipal waste, on overall quantity and its recyclable proportion.

There could be a possibility of hazardous waste in C&D waste. In many places, C&D waste is the responsibility of the generator, and hazardous waste is required to be segregated at source. For data collection and analysis on hazardous waste, please see Chapter 7.

References:

NOLAN-ITU PTY Ltd (1998), *Construction and Demolition Waste: Landfill Traffic and Compositional Surveys*. Eco Recycle Victoria, Australia http://www.recyclecddebris.com/rCDd/Resources/Documents/CSIAustralia01.pdf (6 April 2006)

EPA Ireland (2001), *Construction and Demolition Waste: Fact Sheet Series 2001*. Environmental Protection Agency, Ireland

6. Industrial Solid Waste

Industries generate two types of waste streams. One is due to the production process, which also includes the waste from laboratories and sludge from effluent treatment plants. This waste stream is divided into hazardous and non-hazardous waste. In addition to the solid waste stream, as a consequence of production, the other solid waste stream is due to maintenance of the buildings and staff. This stream includes office wastes, C & D waste and wastes from staff canteens or restaurants.

The first part of this chapter discusses the guidelines to collect and analyze the data for the waste stream related with the production process. The second part discusses the guidelines for the waste stream related with daily activities of staff and maintenance of the premises.

6.1. Waste Stream due to Production Process

The production process depends on the product and the production technology. Therefore characterization of waste is mainly dependent on these two factors, while the quantity depends on the size of production and efficiency of the technology. Based on this information, waste generation factors (WGF) could also be developed to extrapolate the data for future trends. WGF are discussed in Chapter 3. WGF may already be available at national or regional basis and some pilot surveys could confirm their validity within the required confidence level for data. However, if either WGF are not available or they are not providing representative results, then based on the new survey for industrial solid waste, these factors could be developed at the end of the day for their future use. Here, we consider that WGF are not available and we have to undertake the survey to collect and analyze the data.

The first step would be to prepare the list of the industries according to their type, size and technology and to determine major clusters from that list. The next step would be the collection of data from records and reports produced by these industries. If this data is available, then this would be a good benchmark and fewer samples would be required only to confirm the applicability of this data. In other case, a detailed survey would be designed. The fourth step would be the analysis of the data and to incorporate the changes in industries which may affect solid waste generation patterns.

I. Clustering the Industries

First a list of the industries would be required to provide the basic information regarding their type and specific product, size and technology. The information on the efficiency of the technology, especially with reference to input-output ratio or solid waste generation, would also be useful to cluster those industries under major categories. These categories could be based on the national or local classification system. The classification system is usually based on more than two layers or 2-digits. The first level covers all type of industries as well as services and businesses which are nominated as an industry in that particular country. The second layer or 2-digit classification is more important. For example “manufacturing” is shown as just one type of industry in the first layer or 1-digit classification whereas in 2-digit classification there would be broad categories of manufacturing industries, for example steel, leather, electronics, automobile, etc. Industrial classification system (1-digit) in People’s Republic of China (PRC) is shown in Table 6.1. The first round for this survey would be to list out the industries according to at least 2-digit classification. If the basic data is available from the industries, then a further sub-categorization could be done based on the size (e.g., small, medium, large) and type of technology (modern or traditional).

Table 6.1: Chinese Industrial Classification System, GB/T4754-2002.
Basic construction of "Industrial classification for national economic activities (GB/T4754-2002)"

Section	Division	Group	Class
A Agriculture, Forestry, Animal husbandry and fishing	5	18	38
B Mining	6	15	33
C Manufacturing	30	169	482
D Production and distribution of electricity, gas and water	3	7	10
E Construction	4	7	11
F Traffic, transport, storage and post	9	24	37
G Information transfer, computer services and software	3	10	14
H Wholesale and retail trade	2	18	93
I Accommodation and Restaurants	2	7	7
J Finance	4	16	16
K Real estate	1	4	4
L Tenancy and business services	2	11	27
M Scientific research, technical service and geologic perambulation	4	19	23
N Management of water conservancy, environment and public establishment	3	8	18
O Resident services and other services	2	12	16
P Education	1	5	13
Q Sanitation, social security and social welfare	3	11	17
R Culture, sports and entertainment	5	22	29
S Public management and social organization	5	12	24
T International organizations	1	1	1
(Total) 20	95	396	913

Based on the information and local classification, the formats could be developed in the following manner:

Category	Large		Medium		Small	
	Modern	Traditional	Modern	Tra ditional	Modern	Tra ditional
Manufacturing						
Electronics (TV, Computer)						
Textiles (Silk, Cotton Sheets)						
Wood / Timber (Furniture)						
Medical (Surgical Equipment)						
Agro-based (Sugar, fertilizer)						

Note: Large, medium and small shows the size of the industry based on the ranges provided in national classification (if available, otherwise setup the virtual ranges). Modern and traditional either depends on the age of the industry or on the efficiency of the industry with respect to input-output ratio

II. Survey Design

Data collection and analysis for hazardous waste would be different, so it is discussed in Chapter 7.In this chapter, the survey guidelines are primarily for non-hazardous waste.

The clustering of industries would provide a clear picture of the number of industries under each cluster and with respect to size and technology. This would also help to select the appropriate number of samples in accordance with the number of industries under each cluster. If there are many different types of industries with different sizes and technologies, then great efforts will be required to collect the data for high confidence level. However, if there are fewer types of industries with little variation in size and technology, then fewer samples may provide data with higher confidence level. As discussed in Chapter 3, the number of samples depends on the trade-off between the requirement for the confidence level and the budget.

To prepare a list of materials in the waste stream from different types of industries, the best approach would be to go through the industries' reports and records on solid waste generation. The other approach would be to consult the government departments responsible for the industries. The third approach would be to consult the literature on various types of industries to finalize the list of materials present in the waste stream.

III. Solid Waste Generation

Some of the materials of solid waste could be reused or recycled or used as a source of energy (waste exchange) within the same or different industries. However, it is important to get the full information on the overall solid waste and the amount and type of waste which is being recycled and reused.

Table 6.2: Solid Waste Generation from Industries (Production related Waste)

Type of Industry	Solid Waste Generation		Waste Recycling/Reused		Final Discarded Waste	
	A	B	A B		A B	
Electronics (TV, Computer) – Large						
Electronics (TV, Computer) – Small						

Type of Industry	Solid Waste Generation		Waste Recycling/Reused		Final Discarded Waste	
	A	C	A C		A C	
Textiles (Silk, Cotton Sheets) – Large (Modern)						
Textiles (Silk, Cotton Sheets) – Large (Traditional)						
Textiles (Silk, Cotton Sheets) – Medium (Modern)						
Textiles (Silk, Cotton Sheets) – Medium (Traditional						

Note: A, B, C… are the materials of solid waste at each type of industry

Time series data for each type of industry would be helpful to follow the trends for waste generation in the future. This data may also reflect the relationship between the variation in solid waste generation with respect to changes in technology and scale of the production.

Table 6.3: Time Series Data and Projections (1991-2010) for Residential Waste in City X

Year Electronics				**Year**	**Textiles**		
A		**B**	**Total**		**A**	**C**	**Total**
1991							
1992							
1993							
1994							
1995							
1996							
1997							
1998							
1999							
2000							

Note: A, B, C… are the materials of solid waste at each type of industry

There may be some similar materials in solid waste at different types of industries. This would be clearly revealed in an overall dataset that could be developed based on the aggregated data. This data could be analyzed to provide current and future trends. The tables and graphs should provide the necessary information including the overall and material-wise waste generation trends. The following type of tables and graphs may be helpful for the decision-makers.

Table 6.4: Aggregated Data on Waste Components

Components	**Electronics**	**Textiles**	**Steel**	**Automobile**	**Wood/Timber**	**Total**
A						
B						
C						
D						
E						
F						
G						
H						
I						
J						
K						
L						
Total						

Note: A, B, C… are the materials of solid waste at each type of industry

If required, the time series data tables and graphs may also be developed for all of the materials to take the decisions for each of the waste material. This would be helpful for planning recycle and reuse activities for certain components and for planning proper disposal facilities for others. The future forecast are very important as the investments in recycling plants and disposal facilities are bulky and require good assessment of each of the waste materials. Furthermore, based on Chapter 3, the graphical presentation for industrial waste should be developed.

6.2. Waste Stream due to Other Activities

Apart from the waste generation due to the production activities, solid waste is generated due to maintenance of buildings, office work and daily food consumption of staff. For staff, the major solid waste is generated from restaurants and canteens. The office wastes include paper, equipment, cleaning materials and so on. The building maintenance may generate construction and demolition waste. These waste components may be more or less similar across the different types of industries; however, the amount of waste may vary in accordance with the size and type of the industry.

Survey Design and Data Presentation

The survey for this type of waste from industries may be conducted together with the survey to assess the waste due to production activities. However, the data could be presented separately. The data can be categorized under food wastes, office wastes and building maintenance wastes. The list of the components should be prepared based on the local information or data from the industries' records and reports.

Table 6.5: Solid Waste from Industries (Non-Production related waste)

Component	Wet Weight	Composition		Re-used on site	Discarded & sent to landfill
	Tons	MC	CV	Tons	Tons
Food Wastes					
Office Wastes					
Paper					
Electronics (printer, copier, etc)					
C&D Wastes					
Soil/Rubble, Cobbles Boulders					
Ceramics					
Paper/ Cardboard					
Wood / Timber					
Plastic					
Carpet / Textiles					
Rubber					
Leather					
Garden / Yard / Vegetation					
Wood					
Glass					
Metals					
Others*					
Total					

Note: MC and CV are moisture content and calorific value respectively

The graphs and tables may be prepared in similar fashion to provide information on current and future trends for this waste stream from industries.

7. Hazardous Waste

Industrial, Healthcare, Laboratory and C&D Wastes

Hazardous waste should be segregated at source in a proper manner and should be treated and disposed off carefully in accordance with the national and international guidelines. This chapter discusses the guidelines and procedures for data collection and analysis for hazardous waste. This waste is generated mainly by the commercial and public entities including healthcare and laboratories, industries, and construction and demolition activities. In some places, urban agriculture may also generate hazardous waste.

The data collection for each sector should be carried out separately as hazardous waste should be properly collected at source and carefully disposed off in the most appropriate way to avoid its negative impacts on public health and environment.

7.1. Hazardous Substances

Hazardous waste is classified on the presence of hazardous substances. The list of hazardous substances may vary a bit from one country to another. The minimum allowable quantity of hazardous substance may also vary. In European Waste Catalogue (ECW), these substances are classified as:

- **Explosive:** Substances or preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene.
- **Oxidizing:** Substances or preparations which exhibit highly exothermic reactions when are in contact with other substances, particularly flammable ones.
- **Highly Flammable:**
  - (a) Liquid substances or preparations having flash point below 21^{o}C (including extremely flammable liquids), or
  - (b) Substances or preparations which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy, or
  - (c) Solid substances or preparations which may readily catch fire after brief contact with source of ignition and which continue to burn or to be consumed after removal of the source of ignition, or
  - (d) Gaseous substances or preparations which are flammable in air at normal pressure, or
  - (e) Substances or preparation which in contact with water or damp air, evolve highly flammable gases in dangerous quantities.
- **Flammable**: Liquid substances or preparations having a flash point of not less than 21^{o}C and not more than 55^{o}C.
- **Irritant:** Non-corrosive substances or preparation, which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation.
- **Harmful:** Substances or preparations which, if inhaled or ingested or if they penetrate the skin, may involve limited health risks.
- **Toxic:** Substances or preparations (including very toxic substances or preparations) which, if inhaled or ingested or if they penetrate the skin, may cause serious, acute or chronic health risks or death.
- **Carcinogenic**: Substances or preparations which, if inhaled or ingested or if they penetrate skin, may induce cancer or increase its incidence.
- **Corrosive:** Substances or preparations which may destroy living tissue on contact.
- **Infectious**: Substances containing viable micro-organisms or their toxins which are known or reliably believed to cause disease in humans or other living organisms.

- **Teratogenic:** Substances or preparation which, if inhaled or ingested or if they penetrate the skin, may induce non-hereditary congenital malformations or increase their incidence.
- **Mutagenic:** Substances or preparations which if inhaled or ingested or if they penetrate the skin, may induce hereditary genetic defects or increase their incidence.
- **Ecotoxic:** Substances or preparations which present or may present immediate or delayed risks for one or more sectors of the environment.
- **Residuary Hazardous Property:**
  - (a) Substances or preparations which release toxic or very toxic gases in contact with water, air or an acid, or
  - (b) Substances or preparations which after being disposed off, by any means, are capable of yielding another substance which may possess any property referred to in this or any other paragraph of this Part.
- **Threshold:** The thresholds or minimum allowable percentages of these substances should be identified. Some substances may have zero thresholds, for example, explosive, oxidising, infectious, ecotoxic and residuary hazardous property.

7.2. Classification System

There may be a classification system for hazardous waste at national level, as national governments may have to report hazardous waste under the Basel Convention. Otherwise a classification system of another country or international organization may be referred to prepare the questionnaires for data collection. The appropriate level of classification system may be used to chalk out a list of the hazardous materials for data collection. Following example shows two-digit level and six-digit level list of hazardous materials from European Waste Catalogue (ECW).

Table 7.1: Hazardous Waste at Two-Digit Level from EWC

Code	Description
1	Waste resulting from exploration, mining, dressing and further treatment of minerals and quarry
02	Waste from agricultural, horticultural, hunting, fishing and aquaculture primary production, food preparation and processing
03	Wastes from wood processing and the production of paper, cardboard, pulp, panels and furniture
04	Wastes from the leather and textile industries
05	Wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal
06	Wastes from inorganic chemical processes
07	Wastes from organic chemical processes
08	Wastes from the manufacture, formulation, supply and use (MSFU) of coating (paints, varnishes and vitreous enamels), adhesives, sealants and printing inks
09	Wastes from the photographic industry
10	Inorganic wastes from thermal processes
11	Inorganic waste with metals from metal treatment and the coating of metals; non-ferrous hydro-metallurgy

Code	Description
12	Wastes from shaping and surface treatment of metals and plastics
13	Oil wastes and other liquids (except edible oils 05 00 00 and 12 00 00)
14	Wastes from organic substances employed as solvents and coolants (except 07 00 00 and 08 00 00)
15	Packaging, absorbents, wiping cloths, filter materials and protective clothing not otherwise specified
16	Waste not otherwise specified in the catalogue
17	Construction and demolition waste (including road construction)
18	Wastes from human or animal health care and/or related research
19	Wastes from waste treatment facilities, off-site waste water treatment plants and the water industry
20	Municipal wastes and similar commercial, industrial and institutional wastes including separately collected fractions

Table 7.2: Hazardous Waste at Six-Digit Level from EWC

EWC codes	Description
01 03 99	Wastes not otherwise specified
02 01 02	Animal tissue waste
05 05 01	Waste containing sulphur
05 08 99 01	Alkalines containing oil or tars
06 01 02	Hydrochloric acid
06 01 99	Wastes not otherwise specified
06 02 99	Wastes not otherwise specified
07 01 01	Aqueous washing liquids and mother liquors
07 01 02	Sludges from on-site effluent treatment
07 01 99	Wastes not otherwise specified
07 05 04	Other organic solvents, washing liquids and mother liquors
07 05 99	Wastes not otherwise specified
07 07 04	Other organic solvents, washing liquids and mother liquors
10 01 02	Coal fly ash
10 01 08	Other sludges from gas treatment
10 02 03	Solid wastes from gas treatment
10 02 04	Sludges from gas treatment
10 03 04	Primary smelting slags/white drosses
10 04 01	Slags (1st and 2nd smelting)
11 01 04	Cyanide-free wastes not containing chromium
11 01 05	Acidic pickling solutions
11 02 02	Sludges from zinc hydrometallurgy (incl. jarosite, goethite)

EWC codes	Description
12 01 00	Wastes from shaping
12 01 09	Waste machining emulsions free of halogens
13 02 02	Non-chlorinated engine, gear and lubricating oils
13 02 03	Other engine, gear and lubricating oils
13 05 03	Interceptor sludges
16 01 04 01	Discarded vehicles, not de-polluted
16 06 01	Lead batteries
16 08 02	Oil contaminated drilling mud
17 01 99 D1	Bricks, concrete, tiles and gyp-sum based or asbestos based materials…
17 02 99 D1	Wood, glass and plastic with noxious contaminants
17 05 01 01	Soil and stones, hazardous con-taminated
18 01 03	Other wastes whose collection and disposal is subject to special requirements…
19 01 01	Bottom ash and slag
19 01 03	Fly ash
19 01 06	Aqueous liquid waste from gas treatment and other aqueous liquid waste
19 01 07	Solid waste from gas treatment
19 03 01	Wastes stabilised/solidified with hydraulic binders
20 01 21	Fluorescent tubes and other mercury containing waste

7.3. Designing Survey and Data Collection

A. Identification of Hazardous Wastes

First step for designing survey would be the preparation of the list of possible hazardous wastes based on the classification system or on the identified list of hazardous substances. For example, depending on the local hazardous substance, the list of hazardous waste could be prepared based on the following list of hazardous wastes to collect the data. If necessary, additional hazardous wastes may be included in the list:

Group I

1. Anatomical substances, hospital or other clinical waste
2. Pharmaceutical, medicinal or veterinary compounds
3. Wood preservatives
4. Biocides or phyto-pharmaceutical substances
5. Residue from substances employed as solvents
6. Halogenated organic substances not employed as solvents, excluding inert polymerized materials
7. Tempering salts containing cyanides
8. Mineral oils or oily substances (including cutting sludges)
9. Mixtures or emulsions of oil and water or hydrocarbon and water
10. Substances containing polychlorinated biphenyls or polychlorinated terphenyls (including dielectrics)
11. Tarry materials arising from refining, distillation or any pyrolytic treatment (including still bottoms)
12. Inks, dyes, pigments, paints, lacquers or varnishes
13. Resin, latex, plasticizers, glues, or adhesives
14. Chemical substances arising from research and development or teaching activities (including laboratory residues) which are not identified or are new and whose effects on humans and the environment are not known
15. Pyrotechnics or other explosive materials
16. Photographic chemicals or processing materials
17. Any material contaminated with any congener of polychlorinated dibenzo-furan
18. Any material contaminated with any congener of polychlorinated dibenzo-p-dioxin

Group II

19. Animal or vegetable soaps, fats or waxes
20. Non-halogenated organic substances not employed as solvents
21. Inorganic substances without metals or metal compounds
22. Ashes or cinders
23. Soil, sand or clay (including dredging spoils)
24. Non-cyanidic tempering salts
25. Metallic dust or powder
26. Spent catalyst materials
27. Liquids or sludges containing metals or metal compounds
28. Residue (other than scrubber sludges, sludges from water purification plants and sewage sludge (untreated or unsuitable for use in agriculture)) from pollution control operations (including baghouse dusts)
29. Scrubber sludges
30. Sludges from water purification plants
31. Decarbonization residue

32. Ion-exchange column residue
33. Sewage sludges, untreated or unsuitable for use in agriculture
34. Residue from cleaning of tanks or equipment
35. Contaminated equipment
36. Contaminated containers (including packaging and gas cylinders)
37. Batteries or other electrical cells
38. Vegetable oils
39. Materials resulting from the selective collection of waste from households
40. Any other waste

Group III

41. Beryllium or beryllium compounds
42. Vanadium compounds
43. Chromium (VI) compounds
44. Cobalt compounds
45. Nickel compounds
46. Copper compounds
47. Zinc compounds
48. Arsenic or arsenic compounds
49. Selenium or selenium compounds
50. Silver compounds
51. Cadmium or cadmium compounds
52. Tin compounds
53. Antimony or antimony compounds
54. Tellurium or tellurium compounds
55. Barium compounds, excluding barium sulphate
56. Mercury or mercury compounds
57. Thallium or thallium compounds
58. Lead or lead compounds
59. Inorganic sulphides
60. Inorganic fluorine compounds, excluding calcium fluoride
61. Inorganic cyanides
62. Any of the following alkaline or alkaline earth metals, namely, lithium, sodium, potassium, calcium, magnesium in uncombined form
63. Acidic solutions or acids in solid form
64. Basic solutions or bases in solid form
65. Asbestos (dust or fibers)
66. Phosphorus, phosphorus compounds
67. Metal carbonyls
68. Peroxides
69. Chlorates
70. Perchlorates
71. Azides
72. Polychlorinated biphenyls or polychlorinated terphenyls
73. Pharmaceutical or veterinary compounds
74. Biocides or phyto-pharmaceutical substances (including pesticides)
75. Infectious substances
76. Creosotes
77. Isocyanates or thiocyanates
78. Organic cyanides (including nitriles)
79. Phenols or phenol compounds

80. Halogenated solvents
81. Organic solvents, excluding halogenated solvents
82. Organohalogen compounds, excluding inert polymerized materials and other substances referred to in this list
83. Aromatic compounds; polycyclic and heterocyclic organic compounds
84. Aliphatic amines
85. Aromatic amines
86. Ethers
87. Substances of an explosive character, excluding those referred to elsewhere in this list
88. Sulphur organic compounds
89. An congener of polychlorinated dibenzo-furan
90. Any congener or polychlorinated dibenzo-p-dioxin
91. Hydrocarbons and their oxygen, nitrogen or sulphur compounds not otherwise referred to in this list

B. Formats for Data Collection

Second step would be the finalization of the format for data collection. There are various factors which should be considered. Firstly, the data collection process for hazardous waste is different from that of non-hazardous waste as we cannot imply similar sample collection, sorting, and analysis methods for hazardous waste. Therefore, we have to either rely on the information provided by the generator, or any monitoring agency (for example a government organization or its representative). Secondly, in many places it is not possible to carry out the required tests to establish the level of hazardous substances in the waste. Therefore, we have to rely on the standard input-output ratios for hazardous waste generation for a given industry or service (healthcare facilities and laboratories).

Based on the list of the substances and its corresponding list of hazardous wastes, the following type of format could be developed:

Name of the Faculty:
Type of the Facility: Industry / Healthcare facility / laboratory
Type and Size of Industry/Service:

Type of Substance	**Type of Hazardous Waste**	**Generation**
		Tons/year
Explosive.	A	
	B	
	C	
Oxidizing	D	
	E	
	F	
Highly Flammables	G	
	H	
Flammable	I	
	J	
	K	
Irritant	L	
	M	
Harmful	N	
Toxic	O	
	P	
Carcinogenic	Q	
	R	
Corrosive	S	
	T	
Infectious	U	
Teratogenic	V	
	W	
Metals	X	
	Y	
	Z	
Mutagenic	AA	
	AB	
Ecotoxic	AC	
Residuary Hazardous Property	AD	
	AE	

Note: A,B,C, … are types of hazardous wastes from the list of hazardous wastes

C. Data Analysis and Data Presentation

Based on the information collected from the individual industry or service, the data could be analyzed for the similar types of industries. The alternative way, could be the use of industrial classification system (at least 2-digit). In this case, Industry Output would be replaced with Industry Type.

Table A: Aggregated Data for (Type of the Industry)

Hazardous Waste	Industry Output or Type	Amount
Tons/year		Tons/year
A		
B		
C		
D		
E		
F		
G		
H		
I		
J		
K		
L		

Note: A,B,C, … are types of hazardous wastes from the list of hazardous wastes

This information may also help to develop waste generation factors for hazardous wastes for various types of industries.

For healthcare and laboratory services, the input-output ratios may not be straightforward. Depending on the local standards, the indicators for output may be identified. For example, in some cases, number of beds is considered as the size of the hospital. If these indicators are not available, then we can only tabulate the amount of hazardous waste and aggregate it for all the similar type of healthcare and laboratory services.

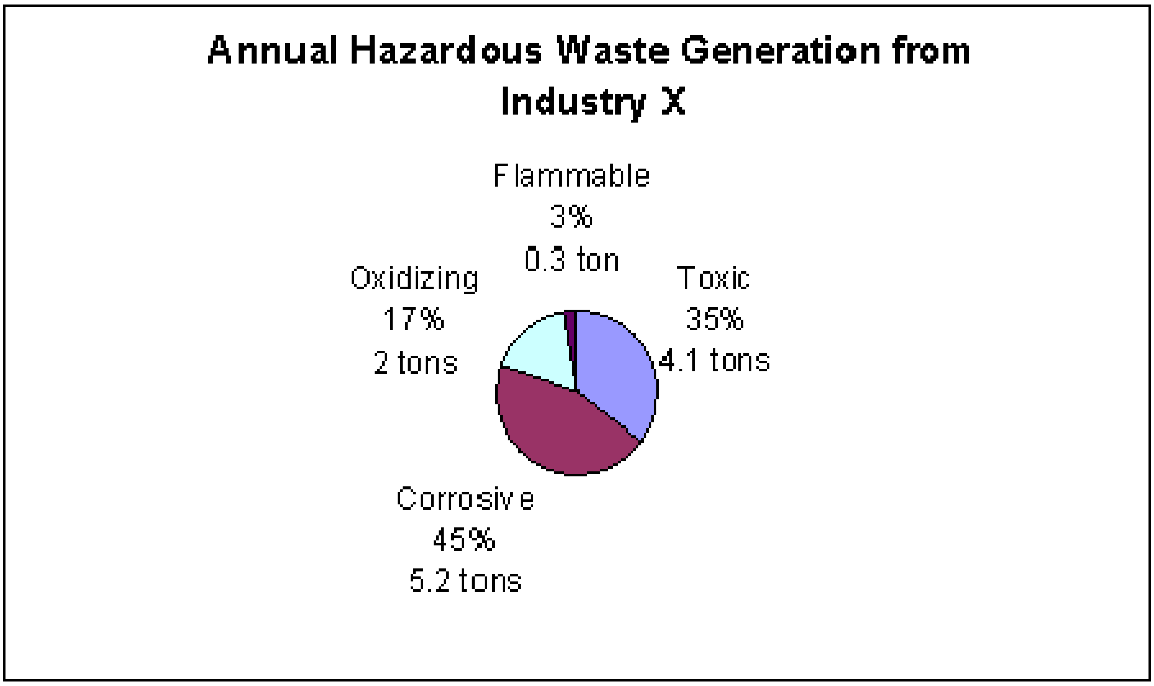
The next step would be the aggregation of all hazardous waste from all industries and services. This aggregation of data will provide the information including the overall and component wise waste generation trends. The following type of tables and graphs may be helpful for the decision-makers.

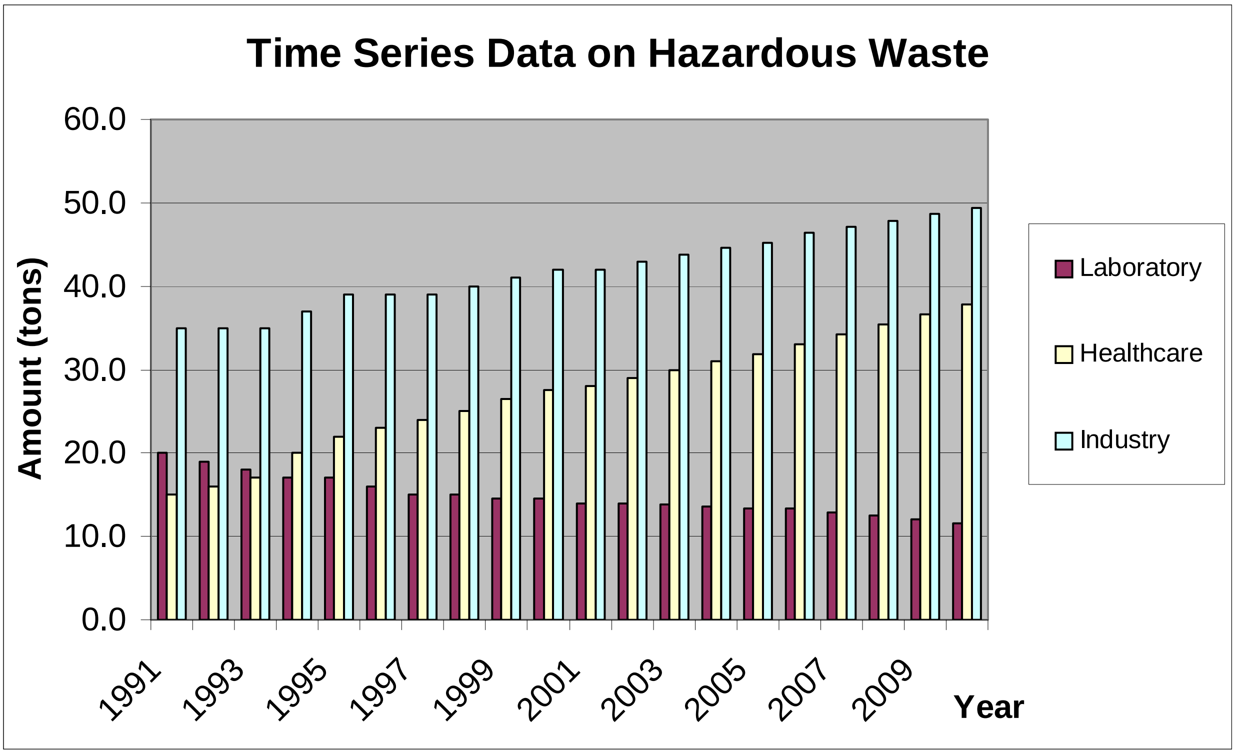
Table B: Aggregated Data on Hazardous Wastes

Hazardous Wastes	Industry			Healthcare / Laboratory		Amount
a		**b**	**c**	**aa**	**bb**	**Tons/year**
A						
B						
C						
D						
E						
F						
G						
H						
I						
J						
K						
L						
Total						

Note: A,B,C, … are types of hazardous wastes from the list of hazardous wastes
a,b,c, .. are types of industries (e.g. leather, steel, etc.)
aa, bb are types of healthcare facilities and laboratories (e.g. hospitals, university lab, etc.)

This information may also be presented in graphical form to make it visually understandable. The graphs can be drawn for data from individual industry, from cluster of similar industries, from similar sector and overall aggregated data. As discussed in Chapter 3, different types of graphs (pie, bar, column, and XY) can be drawn to present different types of data. For example pie charts are useful for comparing different types of wastes or industries, while column or XY charts are useful for future projections for individual components or for aggregated hazardous waste. For details on graphical presentation, please see chapter 3.





References:

European Waste Catalogue (EWC) 2004

Annexure 1

California Integrated Waste Management Board's List of Materials

Condensed List of Material Types

The list below was used to track composition data throughout this report. It is a condensed version of the 98 material types (shown in bold type) that were used for sorting.

	Paper		
		Uncoated Corrugated Cardboard and Paper Bags	
1			**Uncoated Corrugated Cardboard**
2			**Paper Bags**
3		**Newspaper**	
		Office Paper	
4			**White Ledger**
5			**Colored Ledger**
6			**Computer Paper**
7			**Other Office Paper**
		Miscellaneous Paper	
8			**Magazines and Catalogs**
9			**Phone Books and Directories**
10			**Other Miscellaneous Paper**
11		**Remainder/Composite Paper**	
	Glass		
12		**Clear Glass Bottles and Containers**	
13		**Green Glass Bottles and Containers**	
14		**Brown Glass Bottles and Containers**	
15		**Other Colored Bottles and Containers**	
16		**Flat Glass**	
17		**Remainder/Composite Glass**	
	Metal		
		Ferrous Metals	
18			**Tin/Steel Cans**
19			**Major Appliances**
20			**Used Oil Filters***
21			**Other Ferrous**
		Non-Ferrous Metals	
22			**Aluminum Cans**
23			**Other Non-Ferrous**
24		**Remainder/Composite Metal**	
	*NOTE: This type was previously classified under "Other Ferrous."		
	Electronics*		
25			**Brown Goods**
26			**Computer-related Electronics**

27			**Other Small Consumer Electronics**
28			**Television and Other Items with CRTs**
	***NOTE**: These types were previously classified under "Remainder/Composite Metal."		
	Plastic		
29		**PET Containers**	
30		**HDPE Containers**	
31		**Miscellaneous Plastic Containers**	
		Film Plastic*	
32			**Trash Bags**
33			**Grocery and Other Merchandise Bags**
34			**Non-Bag Commercial and Industrial Packaging Film**
35		**Film Products**	
36		**Other Film**	
37		**Durable Plastic Items**	
38		**Remainder/Composite Plastic**	
		***NOTE**: These types were previously classified under the more general type "Film Plastic."	
	Other Organic Materials		
39		**Food**	
		Landscape and Agricultural	
40			**Leaves and Grass**
41			**Prunings and Trimmings**
42			**Branches and Stumps**
43			**Agricultural Crop Residues**
		Miscellaneous Organic	
44			**Manures**
45			**Textiles**
46			**Carpet***
47			**Remainder/Composite Organic**
	***NOTE**: Previously classified under "Remainder/Composite Organic."		
	Construction & Demolition		
48		**Concrete**	
49		**Asphalt Paving**	
50		**Asphalt Roofing**	
51		**Lumber**	
52		**Gypsum Board**	
53		**Rock, Soil and Fines**	
54		**Remainder/Composite Construction & Demolition**	
	Household Hazardous Waste		
55		**Paint**	
56		**Vehicle and Equipment Fluids**	
57		**Used Oil**	

58		**Batteries**
59		**Remainder/Composite Household Hazardous**
	Special Waste	
60		**Ash**
61		**Sewage Solids**
62		**Industrial Sludge**
63		**Treated Medical Waste**
64		**Bulky Items**
65		**Tires**
66		**Remainder/Composite Special Waste**
67	**Mixed Residue**	

Expanded List of Material Types

The list below shows a hierarchy of material classes and sub-classes. As part of the Statewide Waste Characterization Study, solid waste was sorted into the 98 specific material types shown in bold type, and composition percentages were calculated for those material types.

	Paper		
		Uncoated Corrugated Cardboard and Paper Bags	
1			**Uncoated Corrugated Cardboard**
2			**Paper Bags**
3		**Newspaper**	
		Office Paper	
4			**White Ledger**
5			**Colored Ledger**
6			**Computer Paper**
7			**Other Office Paper**
		Miscellaneous Paper	
8			**Magazines and Catalogs**
9			**Phone Books and Directories**
10			**Other Miscellaneous Paper**
11		**Remainder/Composite Paper**	
	Glass		
		Clear Glass Bottles and Containers	
12			**Clear Glass Small CRV**
13			**Clear Glass Large CRV**
14			**Clear Glass Non-CRV**
		Green Glass Bottles and Containers	
15			**Green Glass Small CRV**
16			**Green Glass Large CRV**
17			**Green Glass Non-CRV**
		Brown Glass Bottles and Containers	
18			**Brown Glass Small CRV**
19			**Brown Glass Large CRV**
20			**Brown Glass Non-CRV**
		Other Colored Glass Bottles and Containers	

21			**Other Colored Glass Small CRV**
22			**Other Colored Glass Large CRV**
23			**Other Colored Glass Non-CRV**
24		**Flat Glass**	
25		**Remainder/Composite Glass**	
	Metal		
		Ferrous Metals	
26			**Tin/Steel Cans**
27			**Small CRV Bimetal Cans**
28			**Large CRV Bimetal Cans**
29			**Major Appliances**
30			**Used Oil Filters***
31			**Other Ferrous**
		Non-Ferrous Metals	
32			**Small CRV Aluminum Cans**
33			**Large CRV Aluminum Cans**
34			**Non-CRV Aluminum Cans**
35			**Other Non-Ferrous**
36		**Remainder/Composite Metal**	
	*NOTE: This type was previously classified under "Other Ferrous."		
	Electronics*		
37			**Brown Goods**
38			**Computer-Related Electronics**
39			**Other Small Consumer Electronics**
40			**Television and Other Items with CRTs**
	*NOTE: These types were previously classified under "Remainder/Composite Metal."		
	Plastic		
		PET Containers	
41			**RPPC Small CRV PET Bottles**
42			**RPPC Large CRV PET Bottles**
43			**RPPC Non-CRV PET Bottles**
44			**Other RPPC PET Containers**
45			**Non-RPPC Non-CRV PET Containers**
		HDPE Containers	
46			**RPPC CRV Small HDPE Natural Bottles**
47			**RPPC CRV Large HDPE Natural Bottles**
48			**RPPC Non-CRV HDPE Natural Bottles**
49			**RPPC CRV Small HDPE Colored Bottles**
50			**RPPC CRV Large HDPE Colored Bottles**
51			**RPPC Non-CRV HDPE Colored Bottles**
52			**Other RPPC HDPE Containers**
53			**Non-RPPC Small CRV HDPE Containers**
54			**Non-RPPC Non-CRV HDPE Containers**
		Miscellaneous Plastic Containers	

55			**RPPC Small CRV Bottles not HDPE or PET**
56			**RPPC Large CRV Bottles not HDPE or PET**
57			**RPPC Non-CRV Bottles not HDPE or PET**
58			**RPPC Clamshells not HDPE or PET**
59			**Other RPPC Containers not HDPE or PET**
60			**Non-RPPC Small CRV Miscellaneous Plastic Containers**
61			**Non-RPPC Non-CRV Miscellaneous Plastic Containers**
		Film Plastic*	
62			**Trash Bags**
63			**Grocery and Other Merchandise Bags**
64			**Non-Bag Commercial and Industrial Packaging Film**
65		**Film Products**	
66		**Other Film**	
		Durable Plastic Items	
67			**RPPC HDPE Buckets**
68			**Other Durable Plastic Items**
69		**Remainder/Composite Plastic**	
		***NOTE**: These types were previously classified under the more general type "Film Plastic."	
	Other Organic Materials		
70		**Food**	
		Landscape and Agricultural	
71			**Leaves and Grass**
72			**Prunings and Trimmings**
73			**Branches and Stumps**
74			**Agricultural Crop Residues**
		Miscellaneous Organic	
75			**Manures**
76			**Textiles**
77			**Carpet***
78			**Remainder/Composite Organic**
	***NOTE**: Previously classified under "Remainder/Composite Organic."		
	Construction & Demolition		
79		**Concrete**	
80		**Asphalt Paving**	
81		**Asphalt Roofing**	
82		**Lumber**	
83		**Gypsum Board**	
84		**Rock, Soil and Fines**	
85		**Remainder/Composite Construction & Demolition**	
	Household Hazardous Waste		
86		**Paint**	

87		**Vehicle and Equipment Fluids**
88		**Used Oil**
89		**Batteries**
90		**Remainder/Composite Household Hazardous**
	Special Waste	
91		**Ash**
92		**Sewage Solids**
93		**Industrial Sludge**
94		**Treated Medical Waste**
95		**Bulky Items**
96		**Tires**
97		**Remainder/Composite Special Waste**
98	**Mixed Residue**	

Definitions of Material Types

PAPER

"Uncoated Corrugated Cardboard and Paper Bags" includes the two subtypes described below. The subtypes are "uncoated corrugated cardboard" and "paper bags."

1. **Uncoated Corrugated Cardboard** usually has three layers. The center wavy layer is sandwiched between the two outer layers. It does not have any wax coating on the inside or outside. Examples include entire cardboard containers, such as shipping and moving boxes, computer packaging cartons, and sheets and pieces of boxes and cartons. This type does not include chipboard.

2. **Paper Bags** means bags and sheets made from Kraft paper. Examples include paper grocery bags, fast food bags, department store bags, and heavyweight sheets of Kraft packing paper.

3. **Newspaper** means paper used in newspapers. Examples include newspaper and glossy inserts, and all items made from newsprint, such as free advertising guides, election guides, plain news packing paper, stapled college schedules of classes, and tax instruction booklets.

"Office Paper" includes the four subtypes described below. The subtypes are "white ledger," "colored ledger," "computer paper," and "other office paper."

4. **White Ledger** means uncolored bond, rag, or stationary grade paper. It may have colored ink on it. When the paper is torn, the fibers are white. Examples include white photocopy, white laser print, and letter paper.

5. **Colored Ledger** means colored bond, rag, or stationery grade paper. When the paper is torn, the fibers are colored throughout. Examples include colored photocopy and letter paper. This subtype does not include fluorescent dyed paper or deep-tone dyed paper such as goldenrod colored paper.

6. **Computer Paper** means paper used for computer printouts. This subtype usually has a strip of form feed holes along two edges. If there are no holes, then the edges show tear marks. This subtype can be white or striped. Examples include computer paper and printouts from continuous feed printers. This subtype does not include "white ledger" used in laser or impact printers, nor computer paper containing groundwood.

7. **Other Office Paper** means other kinds of paper used in offices. Examples include manila folders, manila envelopes, index cards, white envelopes, white window envelopes, white or

colored notebook paper, carbonless forms, and junk mail. This subtype does not include "white ledger," "colored ledger," or "computer paper."

"Miscellaneous Paper" includes the three subtypes described below. The subtypes are "magazines and catalogs," "phone books and directories," and "other miscellaneous paper."

8. **Magazines and Catalogs** means items made of glossy coated paper. This paper is usually slick, smooth to the touch, and reflects light. Examples include glossy magazines, catalogs, brochures, and pamphlets.

9. **Phone Books and Directories** means thin paper between coated covers. These items are bound along the spine with glue. Examples include whole or damaged telephone books, "yellow pages," real estate listings, and some non-glossy mail order catalogs.

10. **Other Miscellaneous Paper** means items made mostly of paper that do not fit into any of the above subtypes. Paper may be combined with minor amounts of other materials such as wax or glues. This subtype includes items made of chipboard, groundwood paper, and deep-toned or fluorescent dyed paper. Examples include cereal and cracker boxes, unused paper plates and cups, goldenrod colored paper, school construction paper/butter paper, milk and ice-cream cartons and other frozen food boxes, unopened junk mail, colored envelopes for greeting cards, pulp paper egg cartons, unused pulp paper plant pots, and hardcover and soft cover books.

11. **Remainder/Composite Paper** means items made mostly of paper but combined with large amounts of other materials such as wax, plastic, glues, foil, food, and moisture. Examples include waxed corrugated cardboard, aseptic packages, waxed paper, tissue, paper towels, blueprints, sepia, onion skin, fast food wrappers, carbon paper, self-adhesive notes, and photographs.

GLASS

"Clear Glass Bottles and Containers" means clear glass beverage and food containers with or without a CRV label.

12. **Clear Glass Small CRV Bottles and Containers** means clear glass containers that meet the criteria for CRV containers designed to contain less than 24 ounces of material. Examples include whole or broken clear soda and fruit juice bottles, and whole or broken clear wine cooler bottles.

13. **Clear Glass Large CRV Bottles and Containers** means clear glass containers that meet the criteria for CRV containers designed to contain 24 ounces or more of material.

14. **Clear Glass Non-CRV Bottles and Containers** means clear glass containers that do not meet the criteria for CRV containers. Examples include clear wine bottles, mayonnaise jars, and jam jars.

"Colored Glass Bottles and Containers" includes food and beverage containers of the three subtypes described below. The subtypes are "green glass bottles and containers," "brown glass bottles," and "other colored containers."

15. **Green Glass Small CRV Bottles and Containers** means green-colored glass containers that meet the criteria for CRV containers designed to contain less than 24 ounces of material. Examples include whole or broken green soda and beer bottles.

16. **Green Glass Large CRV Bottles and Containers** means green-colored glass containers that meet the criteria for CRV containers designed to contain 24 ounces or more of material.

17. **Green Glass Non-CRV Bottles and Containers** means green-colored glass containers that do not meet the criteria for CRV containers. Examples include green wine bottles.

18. **Brown Glass Small CRV Bottles and Containers** means brown-colored glass containers that meet the criteria for CRV containers designed to contain less than 24 ounces of material. Examples include whole or broken brown soda and beer bottles.

19. **Brown Glass Large CRV Bottles and Containers** means brown-colored glass containers that meet the criteria for CRV containers designed to contain 24 ounces or more of material.

20. **Brown Glass Non-CRV Bottles and Containers** means brown-colored glass containers that do not meet the criteria for CRV containers. Examples include brown wine bottles.

21. **Other Colored Glass Small CRV Bottles and Containers** means colored glass containers bottles and containers other than green or brown that meets the criteria for CRV containers designed to contain less than 24 ounces of material. Examples include whole or broken soda bottles.

22. **Other Colored Glass Large CRV Bottles and Containers** means colored glass bottles and containers other than green or brown that meets the criteria for CRV containers designed to contain 24 ounces or more of material.

23. **Other Colored Glass Non-CRV Bottles and Containers** means colored glass bottles and containers other than green or brown that does not meet the criteria for CRV containers.

24. **Flat Glass** means clear or tinted glass that is flat. Examples include glass windowpanes, doors, and tabletops, flat automotive window glass (side windows), safety glass, and architectural glass. This type does not include windshields, laminated glass, or any curved glass.

25. **Remainder/Composite Glass** means glass that cannot be put in any other type or subtype. It includes items made mostly of glass but combined with other materials. Examples include Pyrex, Corningware, crystal and other glass tableware, mirrors, non-fluorescent light bulbs, and auto windshields.

METAL

The type "ferrous metals" includes three subtypes described below. The subtypes are "tin/steel cans," "major appliances," and "other ferrous."

26. **Tin/Steel Cans** means rigid containers made mainly of steel. These items will stick to a magnet and may be tin-coated. This subtype is used to store food, beverages, paint and a variety of other household and consumer products. Examples include canned food and beverage containers, empty metal paint cans, empty spray paint and other aerosol containers, and non-CRV bimetal containers with steel sides and aluminum ends.

27. **Small CRV Bimetal Cans** means rigid container that have steel sides and aluminum ends and that meet the CRV criteria for containers designed to hold less than 24 ounces of material. These cans are often used to store beverages.

28. **Large CRV Bimetal Cans** means rigid containers that have steel sides and aluminum ends and that meet the CRV criteria for containers designed to hold 24 ounces or more of material.

29. **Major Appliances** means discarded major appliances of any color. These items are often enamel-coated. Examples include washing machines, clothes dryers, hot water heaters, stoves, and refrigerators. This subtype does not include electronics, such as televisions and stereos.

30. **Used Oil Filters** means metal oil filters used in motor vehicles and other engines, which contain a residue of used oil. **NOTE**: This type was previously classified under "Other Ferrous."

31. **Other Ferrous** means any iron or steel that is magnetic or any stainless steel item. This subtype does not include "tin/steel cans." Examples include structural steel beams, metal clothes hangers, metal pipes, stainless steel cookware, security bars, and scrap ferrous items.

"Non-Ferrous Metals" includes the two subtypes described below. The subtypes are "Aluminum Cans" and "Other Non-Ferrous."

32. **Small CRV Aluminum Cans** means any food or beverage container that is made mainly of aluminum and that meets the CRV criteria for containers designed to hold less than 24 ounces of material. Examples include most aluminum soda or beer cans. This subtype does not include bimetal containers with steel sides and aluminum ends.

33. **Large CRV Aluminum Cans** means any food or beverage container that is made mainly of aluminum and that meets the CRV criteria for containers designed to hold 24 ounces or more of material.

34. **Non-CRV Aluminum Cans** means any food or beverage container that is made mainly of aluminum and that does not meet the CRV criteria. Examples include some cat food and meat cans.

35. **Other Non-Ferrous** means any metal item, other than aluminum cans, that is not stainless steel and that is not magnetic. These items may be made of aluminum, copper, brass, bronze, lead, zinc, or other metals. Examples include aluminum window frames, aluminum siding, copper wire, shell casings, brass pipe, and aluminum foil.

36. **Remainder/Composite Metal** means metal that cannot be put in any other type or subtype. This type includes items made mostly of metal but combined with other materials and items made of both ferrous and non-ferrous metal combined. Examples include small non-electronic appliances such as toasters and hair dryers, motors, insulated wire, and finished products that contain a mixture of metals, or metals and other materials, whose weight is derived significantly from the metal portion of its construction.

ELECTRONICS

"Electronics" includes four subtypes described below. The subtypes are "Brown Goods," "Computer-related Electronics," "Other Small Consumer Electronics," and "Televisions and Other Items with CRTs." **NOTE**: These types were previously classified under "Remainder/Composite Metal."

37. **Brown Goods** means generally larger, non-portable electronic goods that have some circuitry. Examples include microwaves, stereos, VCRs, DVD players, radios, audio/visual equipment, and non-CRT televisions (such as LCD televisions).

38. **Computer-related Electronics** means electronics with large circuitry that is computer-related**.** Examples include processors, mice, keyboards, laptops, disk drives, printers, modems, and fax machines.

39. **Other Small Consumer Electronics** means portable non-computer-related electronics with large circuitry. Examples include personal digital assistants (PDAs), cell phones, phone systems, phone answering machines, computer games and other electronic toys, portable CD players, camcorders, and digital cameras.

40. **Televisions and Other Items with CRTs**. Examples include televisions, computer monitors, and other items containing a cathode ray tube (CRT).

PLASTIC

NOTE: Many of the plastic types have been designed to collect information on Rigid Plastic Packaging Containers (RPPCs), a category that is subject to specific regulation. Please see the subsequent section for definitions and examples of RPPCs.

"PET Containers" means clear or colored PET containers. When marked for identification, it bears the number "1" in the center of the triangular recycling symbol and may also bear the letters "PETE" or "PET." The color is usually transparent green or clear. A PET container usually has a small dot left from the manufacturing process, not a seam. It does not turn white when bent. This includes subtypes 41–45 below.

41. **RPPC Small CRV PET Bottles** means clear or colored PET bottles designed to contain less than 24 ounces of material and meet the RPPC and CRV criteria.

42. **RPPC Large CRV PET Bottles** means clear or colored PET bottles designed to contain 24 ounces or more of material and meet the RPPC and CRV criteria.

43. **RPPC Non-CRV PET Bottles** means clear or colored PET bottles that meet the RPPC criteria but do not meet the CRV criteria.

44. **Other RPPC PET Containers** means non-bottle PET containers that meet the RPPC criteria. Includes clamshell containers.

45. **Non-RPPC Non-CRV PET Containers** means PET bottles and containers that do not meet the criteria for being either CRVs or RPPCs.

“HDPE Containers” means natural and colored HDPE containers. This plastic is usually either cloudy white, allowing light to pass through it (natural) or a solid color, preventing light from passing through it (colored). When marked for identification, it bears the number “2” in the triangular recycling symbol and may also bear the letters “HDPE.” This includes types 46–54 below.

46. **RPPC CRV Small HDPE Natural Bottles** means clear/translucent HDPE bottles designed to contain less than 24 ounces of material and meet the RPPC and CRV criteria.

47. **RPPC CRV Large HDPE Natural Bottles** means clear/translucent HDPE bottles designed to contain 24 ounces or more of material and meet the RPPC and CRV criteria.

48. **RPPC Non-CRV HDPE Natural Bottles** means clear/translucent HDPE bottles that meet the RPPC criteria but do not meet the CRV criteria.

49. **RPPC CRV Small HDPE Colored Bottles** means colored, non-translucent HDPE bottles designed to contain less than 24 ounces of material and meet the RPPC and CRV criteria.

50. **RPPC CRV Large HDPE Colored Bottles** means colored, non-translucent HDPE bottles designed to contain 24 ounces or more of material and meet the RPPC and CRV criteria.

51. **RPPC Non-CRV HDPE Colored Bottles** means colored, non-translucent HDPE bottles that meet the RPPC criteria but do not meet the CRV criteria.

52. **Other RPPC HDPE Containers** means non-bottle HDPE containers that meet the RPPC criteria.

53. **Non-RPPC Small CRV HDPE Containers** means HDPE bottles and containers that do not meet the RPPC criteria but that meet the criteria for CRV containers designed to contain less than 24 ounces of material.

54. **Non-RPPC Non-CRV HDPE Containers** means HDPE bottles and containers that do not meet the criteria for being either CRVs or RPPCs.

“Miscellaneous Plastic Containers” means plastic containers made of types of plastic other than HDPE or PET. Items may be made of PVC, PP, or PS. When marked for identification, these items may bear the number “3,” “4,” “5,” “6,” or “7” in the triangular recycling symbol. This subtype also includes unmarked plastic containers. This includes types 55–61 below.

55. **RPPC Small CRV Bottles not HDPE or PET** means bottles made of types of plastic other than HDPE or PET (that is, made of types #3–7, or unmarked) that meet the RPPC and the CRV criteria for plastic items that contain less than 24 ounces of material.

56. **RPPC Large CRV Bottles not HDPE or PET** means bottles made of types of plastic other than HDPE or PET (that is, made of types #3–7, or unmarked) that meet the RPPC and the CRV criteria for plastic items that contain 24 ounces or more of material.

57. **RPPC non-CRV Bottles not HDPE or PET** means bottles made of types of plastic other than HDPE or PET (that is, made of types #3–7, or unmarked) that meet the RPPC criteria but do not meet the CRV criteria.

58. **RPPC Clamshells not HDPE or PET** means clamshell packaging that meets the RPPC criteria, made out of plastic types #3-7 or unmarked. This category includes polystyrene egg cartons.

59. **Other RPPC Containers not HDPE or PET** means other plastic containers of types #3-7, or unmarked, that meet the RPPC criteria.

60. **Non-RPPC Small CRV Miscellaneous Plastic Containers** means other containers made of types #3-7 that do not meet the RPPC criteria but do meet the CRV criteria for plastic items that contain less than 24 ounces of material.

61. **Non-RPPC non-CRV Miscellaneous Plastic Containers** means other containers made of types #3-7 that do not meet the RPPC criteria or the CRV criteria. This includes single-serving drink cups from take-away food stores and restaurants.

"Film Plastic" means flexible plastic sheeting. It is made from a variety of plastic resins including HDPE and LDPE. It can be easily contoured around an object by hand pressure. This includes types 62–66 below. **NOTE**: These types were previously classified under the more general type "Film Plastic."

62. **Trash Bags** means plastic bags sold for use as trash bags, for both residential and commercial use. Does not include other plastic bags like shopping bags that might have been used to contain trash.

63. **Grocery and Other Merchandise Bags** means plastic shopping bags used to contain merchandise to transport from the place of purchase, given out by the store with the purchase. Includes dry-cleaning plastic bags intended for one-time use.

64. **Non-Bag Commercial and Industrial Packaging Film** means film plastic used for large-scale packaging or transport packaging. Examples include shrink-wrap, mattress bags, furniture wrap, and film bubble wrap.

65. **Film Products** means plastic film used for purposes other than packaging. Examples include agricultural film (films used in various farming and growing applications, such as silage greenhouse films, mulch films, and wrap for hay bales), plastic sheeting used as drop cloths, and building wrap.

66. **Other Film** means all other plastic film that does not fit into any other type. Examples include other types of plastic bags (sandwich bags, zipper-recloseable bags, newspaper bags, produce bags, frozen vegetable bags, bread bags), food wrappers such as candy-bar wrappers, mailing pouches, bank bags, X-ray film, metallized film (wine containers and balloons), and plastic food wrap.

"Durable Plastic Items" means plastic objects other than disposable package items. These items are usually made to last for a few months up to many years. These include the plastics used in construction, communication, electrical and electronics, furniture, transportation, and recreation industries. This includes types 67–68 below.

67. **RPPC HDPE Buckets** means colored and natural buckets and pails made of HDPE and designed to hold 5 gallons or less of material. This category includes buckets regardless of whether they are attached to metal handles. Examples include large paint buckets and commercial buckets used to contain food for commercial use (restaurants, etc.). These objects

are packages containing material for sale, and are not sold as buckets themselves (such as mop buckets).

68. **Other Durable Plastic Items** means all other plastic objects other than containers, film plastic, or HDPE buckets. Examples include mop buckets, plastic outdoor furniture, plastic toys, CD's, plastic stay straps, and sporting goods, and plastic house wares such as dishes, cups and cutlery. This type also includes building materials such as house siding, window sashes and frames, housings for electronics (such as computers, televisions and stereos), fan blades, impact-resistance cases (for example, tool boxes, first aid boxes, tackle boxes, sewing kits, etc.), and plastic pipes and fittings.

69. **Remainder/Composite Plastic** means plastic that cannot be put in any other type or subtype. They are usually recognized by their optical opacity. This type includes items made mostly of plastic but combined with other materials. Examples include auto parts made of plastic attached to metal, plastic drinking straws, foam drinking cups, produce trays, foam meat and pastry trays, foam packing blocks, packing peanuts, foam plates and bowls, plastic strapping, plastic lids, some kitchen ware, toys, new plastic laminate (for example, Formica), vinyl, linoleum, plastic lumber, insulating foams, imitation ceramics, handles and knobs, plastic string (such as is used for hay bales), and plastic rigid bubble/foil packaging (as for medications).

ORGANIC

70. **Food** means food material resulting from the processing, storage, preparation, cooking, handling or consumption of food. This type includes material from industrial, commercial or residential sources. Examples include discarded meat scraps, dairy products, egg shells, fruit or vegetable peels, and other food items from homes, stores and restaurants. This type includes grape pomace and other processed residues or material from canneries, wineries or other industrial sources.

"Landscape and Agricultural" includes the four subtypes described below. The subtypes are "Leaves and Grass," "Prunings and Trimmings," "Branches and Stumps," and "Agricultural Crop Residues."

71. **Leaves and Grass** means plant material, except woody material, from any public or private landscapes. Examples include leaves, grass clippings, sea-weeds and plants. This subtype does not include woody material or material from agricultural sources.

72. **Prunings and Trimmings** means woody plant material up to 4 inches in diameter from any public or private landscape. Examples include prunings, shrubs and small branches with branch diameters that do not exceed 4 inches. This subtype does not include stumps, tree trunks, or branches exceeding 4 inches in diameter. This subtype does not include material from agricultural sources.

73. **Branches and Stumps** means woody plant material, branches and stumps that exceed four inches in diameter from any public or private landscape.

74. **Agricultural Crop Residues** means plant material from agricultural sources. Examples include orchard and vineyard prunings, vegetable by-products from farming, residual fruits, vegetables, and other crop remains after usable crop is harvested. This subtype does not include processed residues from canneries, wineries, or other industrial sources.

"Miscellaneous Organic" includes three subtypes described below. The subtypes are "Manures," "Textiles," and "Carpet."

75. **Manures** means manure and soiled bedding materials from domestic, farm, or ranch animals. Examples include manure and soiled bedding from animal production operations, racetracks, riding stables, animal hospitals and other sources.

76. **Textiles** means items made of thread, yarn, fabric, or cloth. Examples include clothes, fabric trimmings, draperies, and all natural and synthetic cloth fibers. This subtype does not include cloth-covered furniture, mattresses, leather shoes, leather bags or leather belts.

77. **Carpet** means flooring applications consisting of various natural or synthetic fibers bonded to some type of backing material. Does not include carpet padding. *NOTE: Previously classified under "Remainder/Composite Organic."

78. **Remainder/Composite Organic** means organic material that cannot be put in any other type or subtype. This type includes items made mostly of organic materials but combined with other materials. Examples include leather items, cork, hemp rope, garden hoses, rubber items, hair, carpet padding, cigarette butts, diapers, feminine hygiene products, wood products (popsicle sticks and toothpicks), sawdust, and animal feces.

CONSTRUCTION & DEMOLITION

79. **Concrete** means a hard material made from sand, gravel, aggregate, cement mix, and water. Examples include pieces of building foundations, concrete paving, and cinder blocks.

80. **Asphalt Paving** means a black or brown, tar-like material mixed with aggregate used as a paving material.

81. **Asphalt Roofing** means composite shingles and other roofing material made with asphalt. Examples include asphalt shingles and attached roofing tar and tar paper.

82. **Lumber** means processed wood for building, manufacturing, landscaping, packaging, and processed wood from demolition. Examples include dimensional lumber, lumber cutoffs, engineered wood such as plywood and particleboard, wood scraps, pallets, wood fencing, wood shake roofing, and wood siding.

83. **Gypsum Board** means interior wall covering made of a sheet of gypsum sandwiched between paper layers. Examples include used or unused, broken or whole sheets of sheetrock, drywall, gypsum board, plasterboard, gypboard, gyproc, and wallboard.

84. **Rock, Soil and Fines** means rock pieces of any size and soil, dirt, and other matter. Examples include rock, stones, and sand, clay, soil, and other fines. This type also includes non-hazardous contaminated soil.

85. **Remainder/Composite Construction & Demol ition** means construction and demolition material that cannot be put in any other type or subtype. This type may include items from different types combined, which would be very hard to separate. Examples include brick, ceramics, tiles, toilets, sinks, dried paint not attached to other materials, and fiberglass insulation. This type may also include demolition debris that is a mixture of items such as plate glass, wood, tiles, gypsum board, and aluminum scrap.

HOUSEHOLD HAZARDOUS WASTE

86. **Paint** means containers with paint in them. Examples include latex paint, oil based paint, and tubes of pigment or fine art paint. This type does not include dried paint, empty paint cans, or empty aerosol containers.

87. **Vehicle and Equipment Fluids** means containers with fluids used in vehicles or engines, except used oil. Examples include used antifreeze and brake fluid. This type does not include empty vehicle and equipment fluid containers.

88. **Used Oil** means the same as defined in Health and Safety Code section 25250.1(a). Examples include spent lubricating oil such as crankcase and transmission oil, gear oil, and hydraulic oil.

89. **Batteries** mean any type of battery including both dry cell and lead acid. Examples include car, flashlight, small appliance, watch, and hearing aid batteries.

90. **Remainder/Composite Household Hazardous** means household hazardous material that cannot be put in any other type or subtype. This type also includes household hazardous material that is mixed. Examples include household hazardous waste which if improperly put in the solid waste stream may present handling problems or other hazards, such as pesticides, caustic cleaners, and fluorescent light bulbs.

SPECIAL WASTE

91. **Ash** means a residue from the combustion of any solid or liquid material. Examples include ash from structure fires, fireplaces, incinerators, biomass facilities, waste-to-energy facilities, and barbecues.

92. **Sewage Solids** means residual solids and semi-solids from the treatment of domestic waste water or sewage. Examples include biosolids, sludge, grit, screenings, and septage. This category does not include sewage or waste water discharged from the sewage treatment process.

93. **Industrial Sludge** means sludge from factories, manufacturing facilities, and refineries. Examples include paper pulp sludge, and water treatment filter cake sludge.

94. **Treated Medical Waste** means medical waste that has been processed in order to change its physical, chemical, or biological character or composition, or to remove or reduce its harmful properties or characteristics, as defined in section 25123.5 of the California Health and Safety Code.

95. **Bulky Items** means large hard-to-handle items that are not defined separately, including furniture, mattresses, and other large items. Examples include all sizes and types of furniture, mattresses, box springs, and base components.

96. **Tires** mean vehicle tires. Examples include tires from trucks, automobiles, motorcycles, heavy equipment, and bicycles.

97. **Remainder/Composite Special Waste** means special waste that cannot be put in any other type. Examples include asbestos-containing materials, such as certain types of pipe insulation and floor tiles, auto fluff, auto-bodies, trucks, trailers, truck cabs, untreated medical waste/pills/hypodermic needles, and artificial fireplace logs.

MIXED RESIDUE

98. **Mixed Residue** means material that cannot be put in any other type or subtype in the other types. This category includes mixed residue that cannot be further sorted. Examples include clumping kitty litter and residual material from a materials recovery facility or other sorting process that cannot be put in any of the previous remainder/composite types.

Definitions of RPPCs and CRV Containers

In coordination with classifying all materials according to the 98 material types, certain plastic materials were classified as RPPC (Rigid Plastic Packaging Containers) from each sample into the nine types listed below:

Table B-1: Definitions of RPPC and CRV Containers

	RPPC Material	Description and Examples
1	RPPC PET (#1) Bottles	PET bottles containing beverages or other liquids. Examples include bottles for soda pop, some sports drinks, sparkling waters, cooking oil, shampoo, and some liquors.
2	RPPC PET (#1) Other Containers	PET containers and packages, other than bottles, that are recloseable. Examples include packages containing small toys or hardware items.
3	RPPC HDPE (#2) Natural Bottles	Primarily milk jugs and some juice bottles.
4	RPPC HDPE (#2) Colored Bottles	Any HDPE bottle that is not clear/translucent. Examples include some orange juice bottles, many laundry detergent bottles, and some shampoo bottles.
5	RPPC HDPE (#2) Other Containers	Examples include some margarine containers, some food jars, and some yogurt containers.
6	RPPC #3–#7 Bottles	All plastic bottles that are not PET or HDPE. Examples include some sports drink bottles, many shampoo bottles, and some detergent bottles.
7	RPPC #3–#7 Clamshells	Food clamshell containers such as those often used by restaurants, delicatessens and fast food restaurants; and non-food clamshells used for packaging such as for hardware, electronics, automotive parts, sports gear, safety equipment, and personal care products.
8	RPPC #3–#7 Other Containers	Includes containers for some prepared foods, such as chip dip. Also includes some yogurt and margarine containers.
9	RPPC HDPE (#2) Buckets	HDPE buckets, often used as containers for paint and other household chemicals and building materials. These buckets are sometimes used for shipment of bulk foods.

A container must meet all of the following criteria to be considered an RPPC:

- It is made entirely of plastic, except that lids, caps, or labels may be made of some other material.
- It is capable of maintaining its shape while holding a product.
- It has an attached or unattached lid or cap.
- Contains at least 8 fluid ounces but no more than 5 gallons, or the equivalent volumes.

Also, certain glass, plastic, and metal containers were classified as CRV (California Redemption Value) containers. CRV containers were defined for sorting as beverage containers that display the CRV notification. Generally, CRV containers include carbonated soft drinks, beer, bottled water, and juice and sports drinks. For more details, see the Department of Conservation, Division of Recycling websites at www.bottlesandcans.com/what_main.html and www.consrv.ca.gov/dor/crcp/recyclers/Images/Act-2004.pdf.

Annexure 2

Volume-to-Weight Conversion Factors

(Guidelines for Waste Characterization Studies in the State of Washington)

The following table provides material density estimates for use in visual waste characterization methods. It is important to note that the density figures presented here are estimates intended for use as "rules of thumb." Situations often exist where the actual density of each material differs from the figure presented here.

1 pounds per (cubic yard) = 0.593276421 kg per (cubic meter)

Material	Density (lbs per cubic yard)	Source
Paper		
Newspaper	400	EPA Business Guide
Cardboard	50	Tellus
Other Groundwood	250	EPA Government Guide
High-Grade Paper	364	Tellus
Magazines	400	EPA Government Guide
Mixed / Low-Grade Paper	364	EPA Government Guide
Compostable Paper	903	Cascadia
Remainder/Composite Paper		
Process Sludge / Other Industrial Sludge		
Plastic		
PET Bottles	35	EPA Government Guide
HDPE Bottles, CLEAR	24	EPA Government Guide
HDPE Bottles, COLORED	24	EPA Government Guide
Film and Bags	23	Tellus
Bottles Types 3 - 7		
Expanded Polystyrene	22	Tellus
Other Rigid Plastic Packaging	50	EPA Government Guide
Other Plastic Products		
Remainder/Composite Plastic	50	EPA Government Guide
Organics		
Yard, Garden and Prunings	108	EPA Business Guide
Food Waste	1,443	Tellus
Manures	1,628	Tellus
Disposable Diapers		
Carcasses, Offal		
Crop Residues	910	Cascadia
Septage		
Remainder/Composite Organics		

Material	Density (lbs per cubic yard)	Source
Wood Wastes		
Natural Wood	330	CIWMB
Treated Wood	330	CIWMB
Painted Wood	330	CIWMB
Dimensional Lumber	330	Tellus
Engineered	425	Tellus
Packaging		
Other Untreated Wood	330	CIWMB
Wood Byproducts	375	Tellus
Remainder/Composite Wood		
Construction, Demolition & Landclearing Wastes		
Insulation	17	CIWMB
Asphalt	1,215	FEECO
Concrete	2,700	FEECO
Drywall	394	Tellus
Soil, Rocks & Sand	2,200	Average of CIWMB figures
Roofing Waste	600	Average of figures from San Diego, CIWMB, Cascadia
Ceramics	320	Cascadia measurement
Remainder/Composite C&D		
Glass		
Clear Beverage Glass	600	EPA Government Guide
Green Beverage Glass	600	EPA Government Guide
Brown Beverage Glass	600	EPA Government Guide
Clear Container Glass	600	EPA Government Guide
Green Container Glass	600	EPA Government Guide
Brown Container Glass	600	EPA Government Guide
Plate Glass	1,000	EPA Government Guide
Remainder/Composite Glass	1,000	EPA Government Guide
Non-glass Ceramics		
Metal		
Aluminum Cans	91	Tellus
Aluminum Foil / Containers		
Other Aluminum	175	Tellus
Copper	1,094	Tellus
Other Non-Ferrous Metals		
Tin Cans	850	EPA Business Guide
White Goods	180	EPA Government Guide
Other Ferrous	906	EPA Business Guide
Remainder/Composite Metals		

Material	Density (lbs per cubic yard)	Source
Consumer Products		
Computers	440	Cascadia
Other Electronics	440	Cascadia
Textiles, SYNTHETIC		
Textiles, ORGANIC		
Textiles, MIXED/Unknown		
Shoes		
Tires & Other Rubber	380	Cascadia
Furniture & Mattresses		
Carpet	305	San Diego
Carpet Padding		
Rejected Products	340	FEECO
Returned Products		
Other Composite		
Residuals		
Ash	1,000	FEECO
Dust		
Fines / Sorting Residues	2,700	Tellus
Sludge & Other Indust.		
Hazardous and Special Wastes		
Used Oil		
Oil Filters	200	Minnesota
Antifreeze		
Auto Batteries		
Household Batteries		
Pesticides & Herbicides		
Latex Paint	1,600	Cascadia
Oil Paint	1,200	Cascadia
Medical Waste		
Fluorescent Tubes	300	Cascadia
Asbestos		
Other Hazardous Waste		
Other Non-hazardous Waste		

About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

> sustainable consumption and production,
> the efficient use of renewable energy,
> adequate management of chemicals,
> the integration of environmental costs in development policies.

The Office of the Director, located in Paris, coordinates activities through:

> **The International Environmental Technology Centre** - IETC (Osaka, Shiga), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.
> **Production and Consumption** (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.
> **Chemicals** (Geneva), which catalyzes global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
> **Energy** (Paris), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
> **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
> **Economics and Trade** (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies.

UNEP DTIE activities focus on raising awareness, improving the transfer of knowledge and information, fostering technological cooperation and partnerships, and implementing international conventions and agreements.

For more information,
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UNEP

This book is the first volume in the series of training manuals on developing Integrated Solid Waste Management (ISWM) plan. This manual aims to build the capacity of practitioners and policy makers in waste characterization and quantification with projections for future for all the waste generating sectors viz.: residential, commercial, construction and demolition, healthcare and industrial sectors.

The objective of the manual is to facilitate characterization of different types of wastes from each sector and quantification of the level of waste generation. The manual provides a methodology to conduct studies leading to collection and analysis of the data from different sectors. An example has been worked out to make this manual user friendly.

DTI/1140/JP