Kementerian Kesejahteraan Bandar,
Perumahan Dan Kerajaan Tempatan

Jabatan Pengurusan Sisa
Pepejal Negara

Survey on Solid Waste Composition, Characteristics & Existing Practice of Solid Waste Recycling in Malaysia

MAIN REPORT

JABATAN PENGURUSAN SISA PEPEJAL NEGARA

**KEMENTERIAN KESEJAHTERAAN BANDAR,
PERUMAHAN DAN KERAJAAN TEMPATAN**

PREAMBLE

Malaysia is a developing country that has recorded remarkable economic development consistently since its independence. The economic growth has brought prosperity, population increase, accelerated urbanisation and industrialisation. However, with the increase in population and affluence of the society, there has also been substantial increase in the amount of solid waste generated in the country. In recognising the urgent need to enhance the efficiency and effectiveness of solid waste management, the ***Solid Waste and Public Cleansing Management Act 2007*** (Act 672) was gazetted in 2007 and was enforced on 1st September 2011, the main tenets of which underpin the institutionalisation of policies, strategies and plan of actions for solid waste management. ***Jabatan Pengurusan Sisa Pepejal Negara*** (**JPSPN**), created to integrate solid waste management system at the national level, was established under this Act.

The ***National Solid Waste Management Policy*** aims to establish a solid waste management system which is holistic, integrated, cost effective and sustainable while being acceptable by the public. To develop and implement an effective solid waste management system requires comprehensive data on present conditions. Composition studies and surveys for household waste are an essential component for proper and effective management of solid waste. The studies provide vital information in estimating materials recovery potential, identifying sources and components of the waste, facilitating in the design of processing equipment, implementing appropriate technologies in treating and disposing Malaysian waste, and estimating physical, chemical, and thermal properties of the waste.

JPSPN commissioned GSR Environmental Consultancy Sdn. Bhd. (GSR) to conduct a comprehensive ***Survey on Solid Waste Composition, Characteristics and Existing Practice of Solid Waste Recycling in Malaysia*** in July 2011. The study was undertaken from September 2011 to September 2012. A Technical Committee appointed by the Ministry, consisting of representatives from the Government Agencies as well as experts from local universities and Non-governmental Organisations, was tasked to examine and review the study report prepared by the Consultant.

The approach and methodology for the Survey was approved after the presentation to the Technical Committee on the 9th September 2011. The Draft Final Report was presented to the Technical Committee at a meeting on 25th March 2013, after which the Survey was finalised and the findings and recommendations accepted.

Jabatan Pengurusan Sisa Pepejal Negara
Kementerian Kesejahteraan Bandar,
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ACRONYMS

ASTM	American Standard Testing Method
DOE	Department of Environment
FMM	Federation of Malaysian Manufacturers
GMAM	Glass Manufacturers Association of Malaysia
GSR	GSR Environmental Consultancy Sdn. Bhd.
HDPE	High Density Polyethylene
ICI	Industrial, Commercial, and Institutional
JICA	Japan International Cooperation Agency
JPSPN	Jabatan Pengurusan Sisa Pepejal Negara
	National Solid Waste Management Department
KPKT	Kementerian Kesejahteraan Bandar, Perumahan Dan Kerajaan Tempatan
	Ministry Of Urban Wellbeing, Housing and Local Government
LA	Local Authority
LDPE	Low Density Polyethylene
MIDA	Malaysian Industrial Development Authority
MITI	Ministry Of International Trade And Industry
MPMA	Malaysian Plastics Manufacturers Association
MPPMA	Malaysian Pulp & Paper Manufacturers Association
MSW	Municipal Solid Waste
MT	Metric Tonne
NGO	Non-Governmental Organisation
ONP	Old Newspaper
PET	Polyethylene Terephthalate
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl Chloride
SOWACO	Solid Waste Contractors' Association
SEDC	Sarawak Economic Development Corporation
SMIDEC	Small And Medium Industries Development Corporation
SWM	Solid Waste Management
TOR	Terms Of Reference
USEPA	United States Environmental Protection Agency

1 INTRODUCTION

Effective solid waste management begins with the adequate and reliable information of what is in the waste stream entering from the Households, Industries, and Commercial and Institutional entities and ending up at the Landfills/Dumpsites, which in Malaysia is the primary mode of disposal. This basic information is essential to all aspects of policy and program implementation. The collected information can be used for purposes such as:

- Obtaining information to quantify recyclables and to prioritize recovery opportunities;
- Establishing a baseline for continued long-term measurement of system performance;
- Understanding the differences between waste sub streams so targeted recycling programs can be designed, implemented, and monitored;
- Comparing waste composition and waste diversion accomplishments among jurisdictions with different solid waste policies.

Since the 21st century, proper management of a nation's municipal solid waste (MSW) has become and continues to be a high priority area for every country's government. Stemming from the current problems of disposing MSW, a holistic concept of integrated solid waste management has become a necessity in planning for the future. This includes source reduction of waste before entering the waste stream, recovery of generated waste for recycling and composting and environmentally sound disposal through combustion facilities and sanitary landfills that comply with best management practices.

A historical perspective is particularly beneficial as it establishes trends and highlights the changes, of types of waste generated and the ways they are managed over the years. This perspective on MSW and its management is valuable in assessing national solid waste management needs and policies, and setting realistic national targets for recycling rates.

Findings from future studies, following the same methodology and scope used in this survey, will serve as a useful method in reporting waste generation patterns over time and forecast future trends. This baseline is achieved by conducting a comprehensive investigation on solid waste composition, characteristics and current practices of recycling activities.

Information currently available on solid waste composition and recycling in Malaysia is based on previous *ad hoc* studies done by ***Kementerian Kesejahteraan Bandar, Perumahan Dan Kerajaan Tempatan*** (***KPKT***) (and various aid partners), individual local authorities, research institutions and universities. These studies were mainly conducted in the last decade hence are not a true representation of the current rates of recycling in the whole country.

The approach taken was to first confirm commitment and ownership of the study by the key stakeholders, i.e. ***JPSPN*** and ***KPKT***. This is mandatory, in view of the anticipated changes and reforms of the overall SWM and recycling system in Malaysia, as a result of the findings of the overall study. Other stakeholders that closely worked with the team included select local governments, particularly the sections that are in-charge of solid waste recycling, non-governmental organisations, residents' associations or public participation apart from key institutions that are in-charge of overall solid waste recycling and management and Concessionaires.

The purpose of the Survey is to establish a reliable baseline that can be used in the planning for an Integrated Solid Waste Management of both the collection and disposal of solid waste in Malaysia.

2 OBJECTIVES OF THE SURVEY

The aim of ***Survey on Solid Waste Composition, Characteristics and Existing Practice of Solid Waste Recycling in Malaysia*** was to achieve the following main objectives:

- To obtain information on the household solid waste composition at different stages of solid waste management, i.e. from generation to disposal.
- To analyse household solid waste samples for physical, chemical and biological characteristics at different stages of solid waste management, i.e. from generation to disposal.
- To obtain information on the solid waste generation at Industrial (non-production waste), Commercial and Institution (ICI) sectors but not including Construction and Demolition Waste (C&D).
- To determine the existing recycling practices in the market, including identification of the main recycling players, informal sectors and the recyclable material flows.
- To determine the existing recycling rate and total recyclable materials remaining in the waste disposed off at the landfill.
- To update information on the household waste generation rate in terms of per capita generation based on number of household members.

The overall Survey comprised of three main activities namely:

- ***Waste Composition*** (Activity 1)
- ***Waste Characterisation*** (Activity 2)
- ***Recycling studies*** (Activity 3).

These activities resulted in findings that were then pieced together to create a clearer understanding of waste stream. The stream which is the composition of waste generated and their characteristics at various stages of the process (from collection to disposal) and the volume and type of materials that are taken out of the waste stream for recycling becomes quantifiable. The findings of these three activities, namely Waste Composition (Activity 1), Waste Characterisation (Activity 2) and Recycling studies (Activity 3) are presented in ***Chapter 10, Chapter 11*** and ***Chapter 12*** respectively.

3 SURVEY AREAS

The survey areas covered Peninsular Malaysia and the states of Sabah and Sarawak. The study areas for detailed survey included 18 sites or locations which were selected taking into account the following:

- Geographical distribution covering both Peninsular Malaysia and the states of Sabah and Sarawak;

- Regional distribution which includes one location in each state and covering:
  - the Northern, Central (Klang Valley), Southern regions, East Coast states and the state of Sabah and Sarawak;
- Size variation by including:
  - City-centres or Dewan/Majlis Bandaraya, Municipal Councils or Majlis Perbandaran and Districts or Majlis Daerah as shown in ***Table 1***;

Table 1: Breakdown of Local Authorities in Malaysia

Number of LAs		Breakdown of Local Authorities(LA)/ Pihak Berkuasa Tempatan (PBT)			Total Number of LAs
		Dewan / Majlis Bandaraya	Majlis Perbandaran	Majlis Daerah	
LAs in each region in Malaysia	Peninsular Malaysia	8	34	57	99
	Sabah	1	2	21	24
	Sarawak	3	3	20	26
	Total	12	39	98	149
LAs selected for the Study in each region	Peninsular Malaysia	2	6	4	12
	Sabah	1	1	1	3
	Sarawak	1	1	1	3
	Total	4	8	6	18
Percentage of LAs represented		33.3%	20.5%	6.1%	12.1%

Source: Jabatan Kerajaan Tempatan, Jun 2013 (http://www2.epbt.gov.my)

- Socio-economic groupings as roughly represented by housing type; and
- Sectoral diversity by households, Industrial, Commercial and Institutional sectors.

The 18 Local Authorities (LAs) selected as part of the Survey, cover approximately 35 per cent of the total population of Malaysia. It also represents the different levels of urbanisation and standard of living as it categorised income levels, i.e. high, medium or low income areas based on the housing types. Taking into account these characteristics in the selection of the 18 sites facilitates an all-encompassing coverage of waste composition, waste characteristics and recycling practices in the country.

The Terms of Reference provided at the inception of the project divided Malaysia into 5 regions, namely Northern, Southern, Central and the states of Sabah and Sarawak. The Central region comprised of the states of:

- Kelantan
- Terengganu
- Pahang
- Selangor
- The Federal Territories of Kuala Lumpur and Putrajaya

However, due to the income disparity in the Central region between the three East Coast states and the more urbanised state of Selangor, and Federal Territories of Putrajaya and Kuala Lumpur, this document further divides the Central region into Central Region / Klang Valley and East Coast. The locations of these 18 sites are presented in ***Table 2*** and in Figures, ***Figure 1*** & ***Figure 2*** below.

Table 2: Locations of the Study areas

Region	State	Local Authority	Population*	Area (km²)*
Central/ Klang Valley	Selangor	MP Klang	832,600	636
	WP Kuala Lumpur /Putrajaya	DBKL	1,722,500	243
East Coast	Kelantan	MP Kota Bharu	509,400	403
	Pahang	MP Kuantan	416,000	3,067
	Terengganu	MD Besut	142,500	1,234
Northern	Kedah	MD Kubang Pasu	230,100	954
	Perak	MD Tanjong Malim	85,200	189
	Perlis	MP Kangar	237,000	821
	Pulau Pinang	MP Pulau Pinang	740,200	297
Southern	Johor Melaka Negeri Sembilan	MB Johor Bahru	1,463,800	1,865
		MP Jasin	128,700	301
		MD Kuala Pilah	75,700	1,031
Sabah	Sabah	MD Beaufort	75,900	1,735
		DB Kota Kinabalu	436,100	351
		MP Sandakan	453,500	2,266
Sarawak	Sarawak	MB Miri	281,300	4,707
		MD Samarahan	54,700	407
		MP Sibu	257,800	2,230

*Source: Basic Population Characteristics by Administrative Districts, Department of Statistics, 2010

The choice of the 18 locations or sites represents a well-distributed baseline that shall be used in future studies.

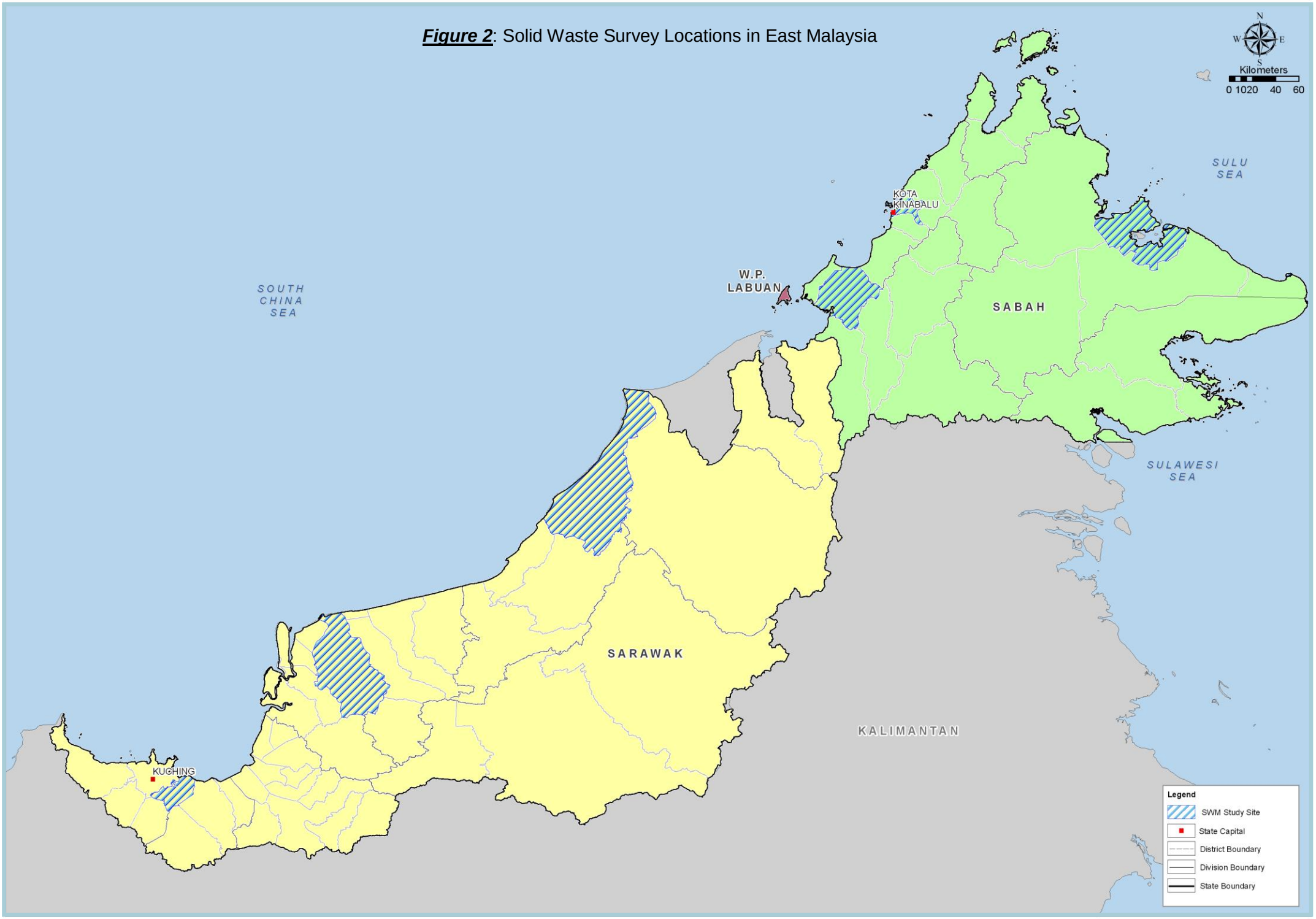
Apart from the Regional Classification, the LAs were regrouped into Urban and Rural areas. There are few proxy variables in classification of rural and urban areas. In this study, state capitals or main towns were the main criteria for the classification. Of the total 18 LA(s) in this study, 11 of them were classified as urban areas while the other 7 LA(s) were classified as rural areas. The details are as shown in ***Table 3***.

Table 3: Distribution of Rural and Urban areas by LA

Strata	Local Authority Areas
Urban	MB Johor Bahru, MP Kangar, MP Klang, MP Kota Bharu, DB Kota Kinabalu, DB Kuala Lumpur, MP Kuantan, MB Miri, MP Pulau Pinang, MP Sandakan, MP Sibu
Rural	MD Beaufort, MD Besut, MP Jasin, MD Kuala Pilah, MD Kubang Pasu, MD Samarahan, MD Tanjung Malim,


Figure 1: Solid Waste Survey Locations in Peninsular Malaysia
N
W
E
S
Kilometers
0 10 20 40 60
THAILAND
PERLIS
Kangar
Alor Setar
KEDAH
Georgetown
PULAU PINANG
PULAU PINANG
Kota Bharu
South China Sea
Kuala Terengganu
KELANTAN
TERENGGANU
PERAK
Ipoh
Kuantan
PAHANG
SELANGOR
Kuala Lumpur
Shah Alam
WILAYAH PERSEKUTUAN
Straits of Malacca
NEGERI SEMBILAN
Seremban
MELAKA
Bandar Melaka
JOHOR
Johor Bahru
SINGAPORE
INDONESIA
Legend
SWM Study Site
State Capital
District Boundary
State Boundary

Figure 2: Solid Waste Survey Locations in East Malaysia



4 DEFINITIONS

Solid waste and Controlled solid waste

The ***Solid Waste and Public Cleansing Management (SWPCM) Act 2007 Part I: Preliminary - Interpretation*** defines solid waste and controlled solid waste as;

"Solid waste" includes—

(a) any scrap material or other unwanted surplus substance or rejected products arising from the application of any process;

(b) any substance required to be disposed of as being broken, worn out, contaminated or otherwise spoiled; or

(c) any other material that according to this Act or any other written law is required by the authority to be disposed of, but does not include scheduled wastes as prescribed under the ***Environmental Quality Act 1974 [Act 127],*** sewage as defined in the ***Water Services Industry Act 2006 [Act 655]*** or radioactive waste as defined in the ***Atomic Energy Licensing Act 1984 [Act 304]***.

"Controlled solid waste" means any solid waste falling within any of the following categories:

- Commercial solid waste
- Construction solid waste
- Household solid waste
- Industrial solid waste
- Institutional solid waste
- Imported solid waste
- Public solid waste
- Solid waste which may be prescribed from time to time

As Generated Waste

As Generated Waste is solid waste produced from its source. It is also the summation of waste retained by the generator for other purposes and waste discarded for collection. Generation refers to the weight of materials and products as they enter the waste management system from residential sources but before recovery or combustion. Pre-consumer (industrial) scrap is not included in the generation estimates. Source reduction activities (e.g., backyard composting of yard trimmings) take place ahead of generation.

As Discarded and As Disposed Waste

As Discarded waste are solid waste placed at the collection point (e.g. Kerbside, Roll-off Roll-on (RoRo) Bins) and to be collected by licensed waste collector/contractor.

As Disposed waste are solid waste taken from the collection points and delivered to solid waste management facilities (e.g. Sanitary Landfill).

5 SCOPE OF WORK

The scope of work for the study included sampling of waste for compositional analysis and characteristic analysis at the laboratory as well as on the ground survey through observations and interview questionnaires. As per the Terms of Reference, there were four parts to this survey that have been divided into 3 distinct activities.

PART 1:

- Waste Composition and Waste Characteristic Study at Households
- Waste Composition and Waste Characteristic Study at Landfill Site

PART 2:

- Waste Generation and Composition from Commercial and Institutions

PART 3:

- Waste Generation and Composition from Industries

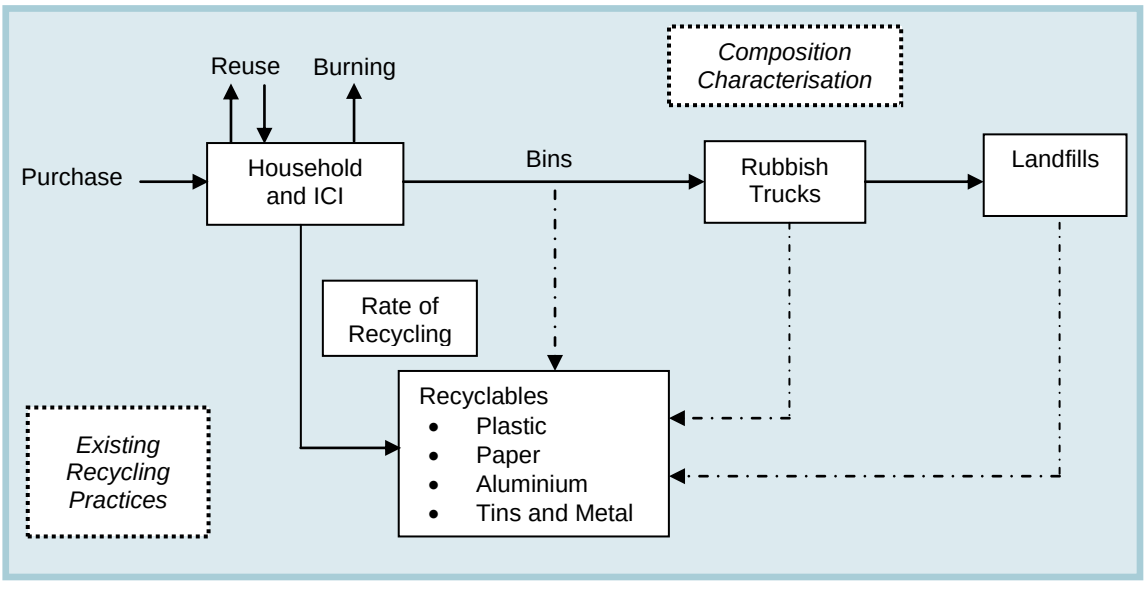
PART 4:

- Survey on Existing Recycling Practice

The survey comprised of three (3) activities as presented in ***Figure 3***:

- The composition of waste at different stages of the waste stream, from collection to disposal **(Waste Composition Study- Refer Chapter 10)**;
- The characteristics of the generated waste at different stages of the waste stream, from collection to disposal **(Waste Characterisation Study- Refer Chapter 11)**; and
- The recycling rate i.e. volume and type of materials that are taken out from the waste stream for recycling **(Existing Recycling Practice Study- Refer Chapter 12)**.

Figure 3: The Solid Waste Composition, Characteristics and Existing Practice of Solid Waste Recycling Components



It must be noted that *not* all solid waste and controlled solid waste is included in this survey. Although defined as solid waste in the ***SWPCM Act 2007***, this study did *not* include construction and demolition debris, bio-solids (sewage sludge), automobile bodies, municipal sludge, combustion ash, wastes from imports or exports, production waste from industries and industrial waste including waste sludge being disposed of at landfills in Malaysia.

6 CRITERIA USED FOR AREA SELECTION IN EACH LOCAL AUTHORITY

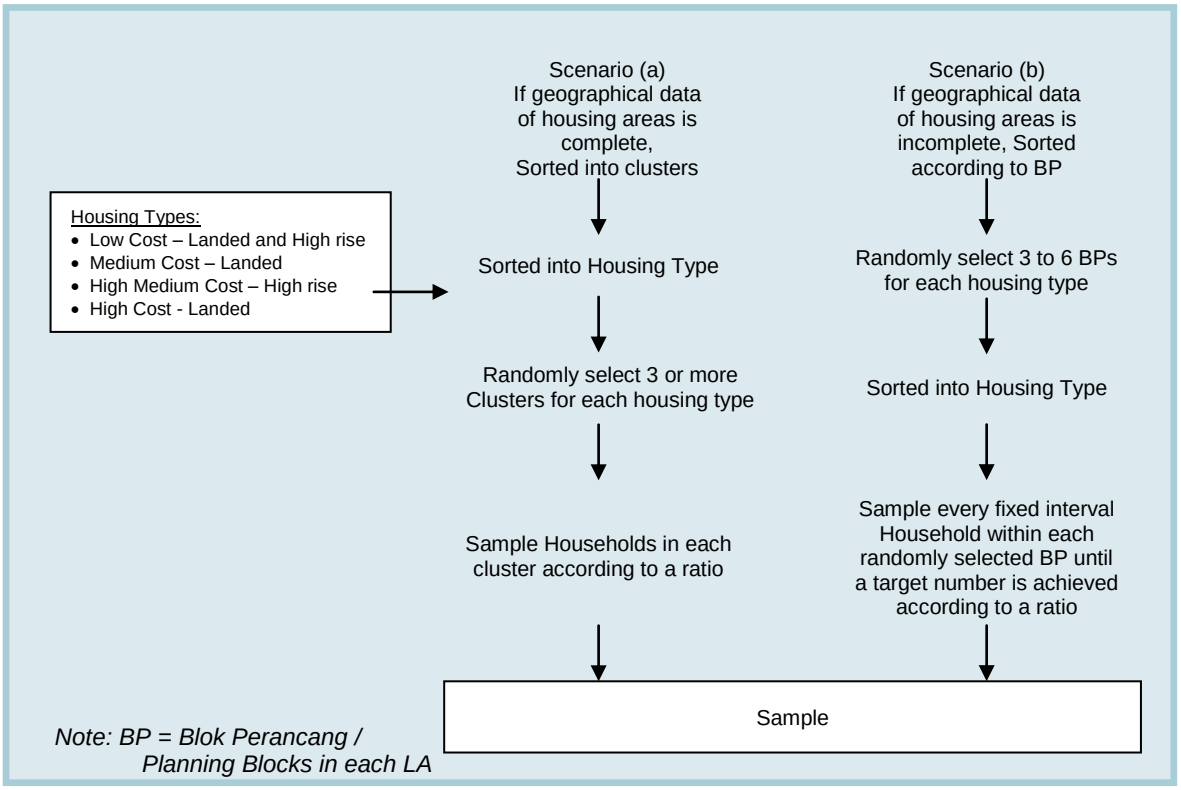
6.1 Households for Recycling Survey

The selection criteria used in identifying the locations of the samples (both for the waste composition and the recycling survey) for the LAs was based on two scenarios. These two scenarios are the consequence of the basic housing information available at each Local Authority (LA) and as follows:

- LAs with detailed housing type information according to geographical location; and
- LAs with general housing type information.

Accordingly, two different sampling methods were used in this study and they are presented in ***Figure 4*** and described in following section.

Figure 4: Sampling method for households according to housing types and location.



6.1.1 Scenario (a) - LAs with detailed housing type information

- Areas that are geographically proximate to each other were grouped into clusters.
- Within each cluster, the households were sorted into housing types. These housing types are assumed to represent the income level of the household.
- Each cluster was then coded, after which three clusters were randomly selected within each housing type, by using the random number generator in Microsoft Excel. These housing types represented the housing type for the LA.
- The total number of samples is then divided proportionately to determine the number of sample (n) in each cluster i.e. if there were three clusters representing each housing type, $^{n}/_{3}$ samples was taken from each cluster.
- Both the teams for the Waste Composition Survey and the Recycling Survey collected the samples from the houses within the same clusters; however the number of houses in each cluster for these surveys differed.
- For the ***Survey on Existing Recycling Practice***, 5 main housing types were identified, namely low-cost landed, low-cost high rise, medium-cost landed, high-medium cost high rise and high-cost landed. As a general guideline, 30 samples were needed for each housing type in a local authority (LA). Therefore, 150 households (HHs) per LA were needed in general for LAs with 5 housing types. The high-medium cost high-rise were split and combined into the medium and high cost housing for the ***Waste Composition*** and ***Waste Characterisation*** Survey.
- The housing data used for this Survey was extracted from the Residential Property Stock Report which has comprehensive classification for the housing sector. Using the above matrix as a guide, the table, ***Table 4*** shows the classification of housing type for each LA (the lowest level of disaggregation). With this kind of stratification, a quota of 30 households per cell is acceptable as it is the minimum (recommended) size for examining variations within the stratified cell.
- In order to compensate for all “inappropriate” cases (e.g. migrant workers’ house, respondent is under 18), 50% over sampling was applied. In other words, a total of 45 households (n) were sampled per housing type in this survey. These 45 households included all households that agreed to participate, irrespective of whether they recycle or not.
- In some LAs, certain household types were not available (e.g. high-rise high income units in rural areas) or they contributed to less than 3% of the total households in that LA. In such cases, these housing types were not chosen in that LA and the 30 samples originally allocated for these housing types was reallocated to the five larger LAs namely Penang, Kuala Lumpur, Johor Bahru, Kota Kinabalu and Miri.

The reason for the increase in the sample size in the more populated LAs was to capture the greater diversity and to analyse that diversity in greater detail. The total number of samples for each housing type from each LA is shown in ***Table 4***.

- Specifically for the ***Survey on Existing Recycling Practice***, to evenly spread out the sampling effort in each cluster, a ratio was calculated for each cluster by dividing total households of that particular housing type by total number of targeted samples in each cluster. This ratio was then used as the interval by which every i^{th} household within cluster was taken.

Table 4: Number of household surveys needed for each housing type in each local authority

Region	Local Authority	Low income		Medium income	High-Med Income	High income	Total
		Landed	**High rise**	**Landed**	**High rise**	**Landed**	
Northern	MP Kangar	45	45	45	0	45	180
	MD Kubang Pasu	45	0	45	0	45	135
	MP Pulau Pinang	45	195	60	90	60	450
	MD Tanjung Malim	45	0	45	0	45	135
Central	MP Klang	45	0	45	45	45	180
	DB Kuala Lumpur	60	60	150	60	75	405
	MD Besut	45	0	45	0	45	135
	MP Kota Bharu	45	45	45	45	45	225
	MP Kuantan	45	0	45	45	45	180
Southern	MP Jasin	45	0	45	0	45	135
	MB Johor Bahru	0	75	135	75	75	360
	MD Kuala Pilah	45	45	45	0	45	180
Sabah	MD Beaufort	45	0	45	0	0	90
	DB Kota Kinabalu	0	90	180	45	45	360
	MP Sandakan	45	45	45	45	45	225
Sarawak	MB Miri	45	45	90	0	90	270
	MD Samarahan	45	45	45	45	45	225
	MP Sibu	45	45	45	0	45	180
Total		735	735	1200	495	885	4050

For example, a selected cluster has 300 medium landed households and a total of 15 samples must be taken from this cluster. The ratio (*i*) that is used for sampling will therefore be

$$i = 300 / 15$$
$$= 20$$

In other words, after randomly choosing a household to start sampling, the sample is taken on every 20th household in that cluster until 45 households was sampled.

To illustrate the methodology further, a typical example of a Local Authority for which samples have been defined is shown in ***Table 5,*** where the various clusters and the selected clusters for sampling are shown for each type of housing. ***Table 6*** presents the actual number of households in the selected clusters in each housing type along with the interval between each household, calculated by dividing the number of household by the number of samples***.***

Table 5: Number of Samples for each Housing Type

	Areas in MD Kubang Pasu	**Low Cost**	**Medium Cost**	**High Cost**
		Landed	**Landed**	**Landed**
1	Kepala Batas		15	15
	Tok Jalai			
2	Jenan- Tanah Merah			15
	Tanjung Pauh			
3	Bandar Darul Aman	15		15
4	Jitra		15	
5	Jitra Utara	15		
	Hosba			
7	Tunjang		15	
	Megat Dewa			
	Padang Sera			
	Kodiang			
8	Sanglang	15		
	Kerpan			
	Air Hitam			
	Total (N)	45	45	45

Table 6: Number of Households in each Housing type and the ratio for the interval between households

	Areas in MD Kubang Pasu- All Landed	Low Cost	Ratio	Medium Cost	Ratio	High Cost	Ratio
1	Kepala Batas			1,250	83	180	12
	Tok Jalai						
2	Jenan- Tanah Merah					204	13
	Tanjung Pauh						
3	Bandar Darul Aman	102	6			1,179	78
4	Jitra			3,000	200		
5	Jitra Utara	761	50				
	Hosba						
7	Tunjang			361	24		
	Megat Dewa						
	Padang Sera						
	Kodiang						
8	Sanglang	104	6				
	Kerpan						
	Air Hitam						

6.1.2 Scenario (b) - LAs with general housing type information

- The LA was first sorted into *Blok Perancang* or Planning Blocks (BP) in the LA, obtained from the Local Plan.
- Each BP was numbered using a random number that was generated from Microsoft Excel. Depending on the number of BPs in a LA, between 2 to 6 BPs were chosen to represent each housing type.
- The presence of the housing types required in a certain BP was determined in the field.
- Specifically for the ***Survey on Existing Recycling Practice***, where the housing type was available, samples were selected by randomly selecting a starting point and taking every k^{th} (a pre-fixed interval) household in that BP until approximately 15 households of that housing type were sampled. If the housing type required was unavailable in the selected BP, the interviewer contacted the Consultant for further instructions.

6.2 Households for Waste Composition Survey

For the ***Waste Composition Study***, the Number of Households for each LA to make one daily sample, for each housing type, was based on the ***Draft Malaysian Standard 10Z011R0 (2011).*** This Standard recommends that the waste be taken from a minimum of 1,250 houses. The minimum number of houses for each LA was set at 30. The distribution of the households was set based on the population of each LA. The number of housing type in each LA is then equally distributed within the same clusters selected for the ***Recycling Survey*** to ensure the at least 30% of the houses are common between the 2 surveys.

The breakdown for which is as presented in ***Table 7***.

Table 7: Number of Household from which waste is collected at each site per day

Site Location	Housing Types (No. of Houses)		
	Low	Medium	High
Beaufort	30	30	30
Besut	30	30	30
Jasin	30	30	30
Johor Bahru	177	239	318
Kangar	30	30	30
Klang	146	178	114
Kota Bharu	30	30	30
Kota Kinabalu	30	30	30
Kuala Lumpur	313	319	266
Kuala Pilah	30	30	30
Kuantan	52	33	58
Kubang Pasu	30	30	30
Miri	30	30	32
Pulau Pinang	172	91	102
Samarahan	30	30	30
Sandakan	30	30	30
Sibu	30	30	30
Tanjung Malim	30	30	30
Total	1,250	1,250	1250

6.3 Industrial establishments

Taking into account that LAs may have different types of industries, samples were selected according to industrial categories. As a general guideline, 50 samples per industrial category were sampled for the ***Recycling Survey.*** A total of 11 industrial categories were identified as shown in the ***Table 8***. In other words, a total of 550 industrial establishments were sampled for this study. 54 samples were collected for the ***Waste Composition Survey*** within the 18 LAs. The selection criteria ensured at least 3 samples in each category were selected of the 54 samples.

Table 8: Industrial Sector Categories

Industrial Categories:
• **Food and beverage** • **Textile and Apparel** • **Fabricated metal** • **Basic metal** • **Machinery, motor vehicles and transport equipment** • **Electrical and electronic products** • **Wood and product of wood and cork, except furniture; manufacture of articles of straw and plaiting materials** • **Paper and paper product** • **Chemical, petrochemical and plastic products** • **Non-metallic mineral product** • **Other industries**

Note:

- For LAs that mainly produced rice or palm oil, rice mills or palm oil mills was sampled under the Food and Beverage.
- The number of samples needed refers to the number of establishments that practice recycling and not the number of establishments that were approached for the survey because no oversampling is done for this survey.

To integrate information collected by the Waste Composition team and the Recycling team, a number of industrial samples were shared between both teams per LA. First, the Recycling Team provided the Waste Composition team with a list of companies/factories that were surveyed and currently practice recycling. Next, the Waste Composition team selected company/factory on that list to sample and these were the shared samples.

Using a list of industries from the Local Authority, companies were asked if they practiced recycling. If no, the interviewer would ask for the type of business activity and the reason for not recycling before ending the call. If yes, an appointment will be made for an interview with the establishment. Face-to-face and telephone interviews were conducted.

For companies that only have addresses, the interviewer will try to go to the address and obtain the phone numbers before trying walk-in interviews or calling to ask if they practice recycling or not. If yes, an appointment for an interview would be made.

6.4 Commercial and Institutional (CI) establishments

A total of 8 main CI categories were identified for this survey with 50-60 samples in each category. This amounts to 470 establishments as the total number of samples needed for this survey. While the categories were not listed in the TOR, the establishment types (as agreed in the Inception Report) belonging to these categories will be followed as closely as possible. The CI categories that were identified for this study and the types of establishments belonging to each category are as presented in ***Table 9***. 108 samples were collected for the ***Waste Composition Survey*** within the 18 LAs. The selection criteria ensured at least 3 samples in each category were selected of the 108 samples.

Table 9: Commercial and Institutional Categories

CI Categories	Type of establishments sampled
Wholesale and retail, motorised vehicle repair	Supermarkets, hypermarkets, shopping complex, sundry shop, convenience stores etc
Transportation and storage	Central bus station, Train station, Airports etc
Accommodation and food services	Hotel, eatery
Health and Social work	Clinics / hospitals
Business offices	Private offices
Public administration	Government offices, army camps, police stations
Education	Schools, Colleges/Universities
Other services	Wet Markets, Stadiums, Mosques etc

To integrate information collected by the Waste Composition team and the Recycling team, at least six (6) samples per LA were shared between the teams conducting the waste composition analysis and the recycling survey. In the fieldwork, these shared samples were completed first. Sampling for CI was conducted through face-to-face interviews without making prior arrangements to interview the establishment. Note: Samples refer to the establishments that practice recycling and not the establishments who were approached for the survey because no oversampling is done for this survey.

If there was only one establishment of the required type available in that LA and does not practice recycling, this sample was replaced with another establishment type in the same CI category. For example, in Kubang Pasu LA the only army camp did not practice recycling and it was replaced with another Public Administration establishment (e.g. Police station, Government Office).

After completion of the 6 shared samples, the interviewer continued to select for the remaining samples until the total samples needed for each CI category in that LA was collected. For example, 8 CI samples are needed from Kubang Pasu.

The interviewer selected 6 establishment types that will be the shared samples. After submitting a name list of the 6 establishments to the supervisor, the interviewer then did another 2 more samples. ***Table 9*** shows the categories and establishment types associated with them.

7 METHODOLOGY OF THE SURVEY

The methodology is discussed based on 3 main activities, namely, Waste Composition, Waste Characterisation and Recycling survey.

7.1 ACTIVITY 1: Waste Composition Study

Waste collected from Households, Institutions, Commercial and Industries (As Generated and As Discarded) and Landfills (As Disposed)

This Section discusses the methodology used in the ***Waste Composition Survey***. The objective of the compositional study was to determine the current composition of solid waste as generated, discarded and disposed off from the generation sources. Four types of waste generation sources were identified:

- Waste generated, discarded and disposed from households
- Waste generated from industries
- Waste generated from commercial sectors
- Waste generated from institutional establishments

The study area was identified and is as presented in ***Table 2: Locations of the Study areas.*** The study covered the following criteria:

- Each state in northern, central/Klang Valley and southern region, Sabah and Sarawak.
- Study areas included district councils, municipal councils and city areas.
- The solid waste sample for composition from households was taken from high, medium and low income areas (based on housing types such as bungalows, apartments, terrace houses, squatters etc.).
- 3 solid waste samples in each LA for composition from the Commercial sector. The 3 samples were from a different category e.g. Shop lots, Hotels, Shopping Complexes, Hypermarkets and Offices. All the categories were covered with a minimum of 3 in each category.
- 3 solid waste samples in each LA for composition from the Institutional sector. The 3 samples were from a different category e.g. Schools/Universities and Hospitals. All the categories were covered with a minimum of 3 in each category.
- A mixed solid waste sample for composition from Industries was taken from Heavy and Light industries.
- The selected landfill sites were correlated with the study areas presented in ***Table 2***.

Appendix 1 presents the forms used for the Waste Composition Study

Standards/documents used as reference:

The Sampling and Analysis Methodology was based on the following documents:

- ***Draft Malaysian Standard 10Z011R0 (2011)*: Guidelines for sampling of household solid waste – Composition and characterisation analysis.** This Malaysian Standard specifies the sampling methodology for household solid waste composition and characterisation analysis which applies to waste As Generated, As Discarded and As Disposed; reporting format after sampling and characterisation analysis; and the minimum number of components for household solid waste composition.
- ***ASTM D 5231-92*: *The Test Method to determine the Composition of Unprocessed Municipal Solid Waste***. This standard describes the procedures for measuring the composition of unprocessed municipal solid waste (MSW) by employing manual sorting. This test method is used to determine the mean composition of MSW based on the collection and manual sorting of a number of samples of waste over a selected time period covering one week.
- ***HANDBOOK 1 SOLID WASTE MANAGEMENT, Solid Waste Stream Composition Analysis, COWI,* 2002.**

7.1.1 Sampling protocol

a) Households

When calculating waste compositions from households, a three-way stratification method was developed to account for variations between:

- Seasons
- Geographical regions
- Socio-economic grouping

The first level of stratification was the seasonal stratification. The waste composition study was conducted to include the maximum and minimum rainfall period in at least 2 sites, to account for the wet season and the dry season. Part of the study was also conducted during the festive/holiday season.

The second level is geographical stratification which takes into consideration the 18 sites identified by JPSPN and presented in ***Table 1***. The survey also stratified each local authority into housing types and selected the sample based on the housing mix as presented in ***Table 10.***

Table 10: Socio-economic Status and Housing Stratification Matrix

	Low Income	Medium Income	High Income
Landed units	Low cost houses, Squatters, kampong and traditional houses	Terrace, town house	Detached, semi- detached
High rise units	Low cost flats	Apartments and Condominiums	

The waste was collected and sorted for each of the housing type. As the number of low, medium and high cost households in each LA varied considerably, the number of households in each housing type, from which the As Generated and As Discarded waste was collected to make the 3 composite samples for sorting, followed a similar proposition.

The overall objective of this study was to obtain the average waste composition information of the nation, using the 18 sites to represent that average. The ***Draft Malaysian Standard 10Z011R0 (2011)*: *Guidelines for sampling of household solid waste – Composition and Characterisation analysis*** recommends that if the number of households involved is greater than 50,000, the minimum number of households from which the waste shall be collected is 1,250.

As each of the 3 housing types (Low, Medium and High) in the 18 sites exceeded the 50,000 threshold, the number of households in each housing type from which waste was collected was at least 1,250. It was observed that when the minimum value of 1,250 households was distributed over the sites based on the number of housing units in each LA and the three housing types, most of the waste would be collected from more urbanised sites.

The total number of households from which waste was taken increased from the original planned number of 1,620 to 3,750 and redistributed into each housing type and site. Apart from increasing the total number, a minimum threshold of the number of households in each housing type was set at 30.

Table 7 shows the number of low, medium and high cost households required in each site to form a sample. The generation rate from the households was calculated based on the waste collected from the As Generated waste at the low, medium and high income households.

b) Institutional, Commercial and Industry (ICI)

Two levels of stratification were used in the Institutional, Commercial and Industry (ICI) study:

- Seasonal
- Geographical

For the seasonal stratification, the Waste Composition study was conducted to determine the maximum and minimum rainfall period in at least 2 sites, to account for the wet and dry seasons. Part of the study was also conducted during the festive/holiday season. The geographical stratification considers the 18 sites identified by JPSPN and presented in ***Table 2***.

- Commercials and Institutions were sub-divided into the following categories:

  - Offices (office complexes, shop lots)
  - Hotels
  - Transport hubs (railway stations, bus stations, airports)
  - Shopping areas and markets (shopping complexes, hypermarkets, supermarkets, wet markets, night markets)
  - Shop lots (restaurants)
  - Hospitals and clinics
  - Stadiums
  - Army camps
  - Government complexes
  - Police stations
  - Mosques
  - University, colleges, schools

Waste from at least 5 premises (if available in LA) from each of the above sources was collected to form a sample in a day for each site.

- Industrial was divided into 2 categories (Heavy and Light industry) – for each category, a minimum of 5 premises was sampled. The priority areas were palm oil processing mills, rice processing mills and animal slaughtering houses.

For the ICI, unlike the households where distinct housing units were used as a measure, total weight of the waste collected was the basis of measurement. The amount of waste collected in each site was based on the size and population of the LA.

Table 11 presents the minimum quantity of ICI waste collected in each site per day.

Table 11: Breakdown of the Quantity of ICI waste collected in each LA

District	Source (Kgs.)	
	Industrial	Institutional /Commercial
Beaufort	200	200
Besut	200	200
Jasin	200	200
Johor Bahru	1,000	1,000
Kangar	200	200
Klang	1,000	1,000
Kota Bharu	200	200
Kota Kinabalu	500	500
Kuala Lumpur	500	1,000
Kuala Pilah	200	200
Kuantan	1,000	1,000
Kubang Pasu	200	200
Miri	1,000	500
Pulau Pinang	1,000	1,000
Samarahan	200	200
Sandakan	500	500
Sibu	500	500
Tanjung Malim	1,000	1,000
Total	9,600	9,600

7.1.2 As Generated Sampling (Sampling at Source)

Procedure of Obtaining the Composition of Waste from Households

Households were divided into 3 types based on housing type (Low, Medium & High Cost). The number of households by category sampled is presented in ***Table 7***.

The procedure for carrying out collection of waste for composition analysis at source in Households was as follows:

- Each of the selected households was contacted and notified about the study, and their cooperation sought to participate in the survey.
- The selected households were asked to retain their wastes that are normally discarded, including the recyclable components that are kept for separate disposal with the recyclers.
- The sample representative per sampling area of selected households was at least 30 residents.
- The activity carried out in groups of 3 persons. One person (recorder) recorded the number of premises visited.
- The compositional analysis done in groups of 9 persons. One person (recorder) recorded the number of households according to the categories.
- Two persons bagged the waste, weighed the contents and recorded in the data sheets provided.
- The information on the number of newspapers and magazines was also logged.
- The recorder recorded the information of the premises and passed this information to the data analyst.
- Waste collected was placed on trucks and transported to the landfill site, where the quantity of collected waste was weighed, sorted into its components and the sorted components weighed to record the waste composition.
- Six persons conducted the sorting of the waste, weighing the sorted waste and recording of the waste composition by weight.
- A laboratory sample of about 1 kg per component was placed in a sample bag and sealed. The sample bag was weighed and marked before it was wrapped in boxes. The whole sample was boxed and couriered to the laboratory the same day.
- The survey duration covered a one-week cycle to identify the weekly trend of the waste composition and generation rate.

7.1.3 As Discarded Sampling (Sampling at kerbside)

Procedure of Obtaining the Composition of Waste from Households, Industry, Commercial and Institution

Each LA was divided into the following different categories of sources:

- The Households in each LA was divided into 3 types based on housing types (Low, Medium & High Income). Housing type is assumed to represent the income level of the household.

- Commercials was divided into categories which included offices (office complexes, shop lots), hotels, transport hubs (railway stations, bus stations, airports), shopping areas and markets (shopping complexes, hypermarkets, supermarkets, wet markets, night markets), shop lots (restaurants), hospital and clinics, stadiums, army camps, Government complexes, police stations, Mosques, (universities, colleges, schools). Waste from at least 5 premises (if available in LA) from each of the above sources was collected to form a sample in a day for each LA.

- Industrial was divided into 2 categories (Heavy and Light industry) – for each source a minimum of 5 premises were sampled to form a specific sample in a day for each LA. The priority areas were palm oil processing mills, rice processing mills and animal slaughtering houses.

The locations of the households, industry, commercial and institution were determined using information obtained from the LA; collection was done based on the collection frequency of the specified area. The survey's sampling truck first collected the waste from the kerbside before the daily waste collection trucks did the normal collection.

Activities that were carried out during the sampling period were as follows:

- The activity carried out in groups of 3 persons. One person (recorder) recorded the details of the premises.
- Two persons bagged the waste, weighed the content and recorded it in the data sheet provided.
- The recorder recorded the information of the premise and passed this information to the data analyst.
- Waste collected was placed on trucks and transported to the landfill site, where the quantity of collected waste is weighed, sorted into its components and the sorted components weighed to record the waste composition.
- Six persons conducted the sorting of the waste, weighing the sorted waste and recording of the waste composition by weight.

- A laboratory sample of about 1 kg per component was placed in a sample bag and sealed. The sample bag was weighed and marked before it was wrapped in boxes. The waste samples in boxes were couriered to the laboratory the same day.
- The survey duration covered one-week cycle to identify the weekly trend of the waste composition and discarded rate.
- Where possible and practicable, the quantity of water collected at the bottom of the waste receptacle was measured and logged.

7.1.4 As Disposed Sampling (Sampling at landfill)

Procedure of Obtaining the Composition of Incoming Waste at Landfills

The composition of the waste at the landfills requires sampling of only one main landfill that receives the largest amount of waste from the predetermined LA. The quantity of waste disposed and location of illegal dumpsites were not part of the study. However, the waste collection trucks servicing these sites arriving at the landfill were randomly selected for the composite samples.

The method of “Random Sampling” was used to form the representative samples. This is where the waste was extracted from multiple waste collecting trucks that service the same areas as the samples collected for the As Generated / As Discarded waste. A grab sample of 50 to 100 kgs was taken from 10 trucks before the “cone and quarter” method for extracting sub-samples from the sample material collected was employed. The procedure for carrying out composition analysis at source at the landfill was as follows:

- Waste trucks entering the landfill site with solid waste collected from same household areas as the As Generated / As Discarded sampling was selected for the survey.
- The waste from the trucks was directed to a pre-prepared sampling site and the waste unloaded onto the tip floor.
- Bulky items, medical waste or scheduled waste found in the waste was separated from the load, weighed and logged in the datasheets.
- The remaining material was mixed by mechanical shovel, or manually using rakes or shovels, into a uniform, homogeneous pile approximately 0.8 m high.
- The pile was then divided into two equal portions by drawing a straight line through the centre of the pile. The pile was further divided by drawing a second line roughly perpendicular to the first.
- A pair of opposite quarters was removed, leaving half the original sample.
- The steps d) through f) were repeated until the required amount of sorting sample of 200kgs remained.

- The sorting sample was then sorted into the different components, weighed and each waste component's weight was recorded.
- Two persons bagged the waste, weighed the content and recorded it in the data sheet provided.
- A laboratory sample of about 1 kg per component was placed in a sample bag and sealed. The sample bag was weighed and marked before it is wrapped in boxes. The whole sample in boxes was couriered to the laboratory the same day.
- The survey duration covered a week cycle to identify the weekly trend of the waste composition and disposal rate.

7.1.5 Sampling Plan

The Sampling Plan for the Compositional Analysis was devised to reach the objectives, cover the scope and deliver the outputs of the ***Terms of Reference*** of the Study. The Sampling Plan for the Compositional Analysis is presented in ***Table 12.*** With this Sampling Plan, the composition of the Solid Waste from the various categories and the differences in the generated and disposed waste in the Household category can be determined.

Table 12: Sampling Plan for the Compositional Analysis

Category	Days							Number of Samples taken for Composition Analysis for the Study
	1	2	3	4	5	6	7	
Household (HH) High	One week cycle – As Generated							126
	One week cycle – As Discarded							126
Household (HH) Med	One week cycle – As Generated							126
	One week cycle – As Discarded							126
Household (HH) Low	One week cycle – As Generated							126
	One week cycle – As Discarded							126
Landfill (LF)	1	1	1	1	1	1		108
Institutional / Commercial (IC)	1	1	1	1	1	1		108
Industrial (IND)		1		1		1		54
Total								1026

The **ASTM standard D 5231-92**: **The Test Method to determine the Composition of Unprocessed Municipal Solid Waste** and Aarne Vesilind *et al*. in his book "Solid Waste Engineering", recommend that 50 samples of 91 kgs. each will give a precision better than ±5 per cent for food waste and ±15 per cent newsprint, aluminium and ferrous components.

Based on this information, the Sampling Plan was designed with each stratum having at least 50 samples.

7.1.6 Sorting Sample weight

The waste sample was mixed, coned and quartered to get a Sorting Sample. The Sorting Sample weight for waste composition analysis was based on ***Draft Malaysian Standard 10Z011R0 (2011)*: Guidelines for sampling of household Solid Waste – Composition and characterisation analysis** that recommends Sorting Sample weight be a minimum of 200 kg.

7.1.7 Field protocol - Sorting

The Field Sorting procedure of waste was as follows:

- The bulk density of every waste sample was measured. The bulk density was measured by filling a 250-liter standard container/bin with the waste.
- The container was lifted and dropped 3 times from a height of about 100 mm. Each time additional waste was added to the top before repeating the process.
- The weight of the waste divided by the volume gave the bulk density.
- The As Generated and As Discarded waste material from the sampling truck carrying the waste collected from households, industry, commercial or institutional was unloaded at the working area at the landfill site.
- A bucket front-end loader removed the material longitudinally along one entire side of the discharged load in order to obtain a representative cross-section of the material.
- The sorting sample was mixed, coned, and quartered before selecting one quarter as the Sorting Sample.
- A random method of selection was used to eliminate or minimize bias of the sample.
- All bulky waste were noted of in datasheet and weighed.
- The sample was then transferred to the sorting area, while the remainder of the material was disposed off at the landfill.

The Sorting Waste Sample was then segregated into the waste components, as presented in ***Table 13*** by the Sorters at the landfill. In the case a composite item is found in the waste, the individual materials was separated and placed into the appropriate storage containers**.** Sorting continued until the maximum particle size of the remaining waste particles was approximately 12 mm. At this point, the remaining material was apportioned into the storage containers corresponding to the waste components represented in the remaining mixture.
The As Disposed waste material collection was done at the landfill from waste collection trucks from the same geographical area as the waste collected for the As Generated / As Discarded waste.

The truck drivers were interviewed to collect information on the areas the waste load was collected. Once the waste from the selected truck was unloaded on to the floor, steps of quartering, coning and sorting followed the same Field Sorting protocol for As Generated.

Table 13: List of Waste Components and its description

Components		Description
Food waste		Food material resulting from the processing, storage, preparation, cooking, handling or consumption of food. This type includes material from industrial, commercial or residential sources and other food items from homes, stores and restaurants. Vegetable peelings & trimmings, including cooked vegetables etc. kitchen waste that contains or is potentially contaminated with meat/meat products etc.
Garden waste		Branches, twigs, leaves, grass, and other plant material (Branches < 4 inches in Diameter)
Plastic	Low density polyethylene, LDPE [Type 4]:	Films such as plastic bags/films, polystyrene, foam, garment and produce bags, refuse sacks, packaging films, bubble wrap.
	High density polyethylene, HDPE [Type 2]:	Packaging household and industrial chemicals (e.g. detergents, bleaches), snack and food packages, cereal box liners, milk and non-carbonated drinks bottles, margarine tubs, toys, buckets, rigid pipes, crates, garden furniture & flower pots
	Polyethylene terephthalate, PET [Type 1]:	Mineral water bottles, Fizzy drink, pre-prepared foods trays and boil in the bag food pouches, shampoo & vegetable oil bottles.
	Poly (vinyl chloride), PVC [Type 3]:	Pipes & fittings, credit cards, shampoo & vegetable oil bottles, synthetic leather products.
	Polypropylene, PP [Type 5]:	Large moulded products such as battery casings, bottle tops, ketchup & pancake bottles, yoghurt & margarine containers, crisp bags, drinking straws, medicine containers.
	Polystyrene, PS [Type 6]:	Yoghurt pots, fast food trays, disposable cutlery, video cases, vending cups, seed trays, coat hangers, low cost brittle toys. Expanded polystyrene is also used for egg boxes food trays, hot drink cups, protective packaging for fragile items and insulation.
	Other plastic	Plastic where type is not readily recognisable and polymers other than the six most common.
Paper	Newsprint / old newspaper	Newsprint Newspaper
	Mixed paper	Other recyclable paper: Office quality paper: letter/writing paper, computer paper, loose leaf paper, photocopies Other unused wall paper, paper bags, paper packaging, mail in an envelope, diaries, envelopes, posters, books, travel tickets, non-glossy pamphlets, telephone directories, yellow pages, glossy magazines, catalogues, travel brochures. Non-recyclable paper Wall paper removed from walls, photos, facial and toilet tissues, kitchen paper
	Cardboard	Boxes and packets for: cereal, washing powder, eggs, tissues, powdered milks, washing soda, biscuits, ice cream, fruit juice, milk, fabric conditioner. Corrugated card, greetings cards, postcards, beer mats, files.
Rubber		All rubber including gloves, handbags, shoes, rubber mat etc
Wood		Lumber, wood products, pallets

Table 13: List of Waste Components and its description (Cont'd)

Components	Description
Leather	Leather products e.g. Bags, leather coats, shoes, belts
Diapers	Disposable diapers for babies and elderly, ladies sanitary napkins
Textiles	All textiles including clothes, shirt, bed sheet, curtains, pants and other household items made from man-made or natural fibres.
Tetra Pak©	Carton used for packaging liquids: Milk, juices, coconut milk etc.
Ferrous metal	Food, beverage bimetal cans & aerosols: canned drinks, pet food, food, perfume, hairspray etc. Other ferrous material: keys, cutlery, bike locks, ring pulls, paper clips, safety pins, tools, car parts, oil filters, biscuit tins, radiators, saucepans, bike parts, metal shelving units etc.
Aluminium	Food, beverage cans & aerosols: canned drinks, ring pulls etc. Foil: aluminium foil, milk bottle tops, yoghurt tops etc.
Other non-ferrous metals	Other non-ferrous metal: copper pipe, wires, brass, washers, old metal pipe fittings etc.
Sheet glass	All non-packaging glass e.g. Mirrors, reinforced glass, non-fluorescent light bulbs.
Glass bottle	All glass bottles such as brown, green, clear, other coloured glass
E-waste	Consumer electronics : Vacuum cleaners, carpet sweepers ,appliances for sewing, knitting, , irons, toasters, fryers, grinders, coffee machines, hair dryers, toothbrushes, shavers, massage and other body care appliances, clocks, watches etc. Electric stoves, microwaves, electric heating appliances, printers, personal computers, laptops and accessories (CPU, mouse, screen and keyboard included), electrical and electronic typewriters, calculators, fax machines, telex, telephones (including cordless & cellular), answering machines radio, video, cameras, video recorders, Hi-fi systems, audio amplifiers, musical instruments (electric, e.g. keyboards) Toys electric trains, car racing sets, hand-held video games & consoles; video games, sports related electronic equipment, smoke detectors, thermostats etc.
Fluorescent tube	
Batteries	Any type of battery including both dry cell and lead acid. Examples include car battery, flashlight battery, small appliance battery, watch battery, and hearing aid batteries.
Paint container	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.
Aerosol cans	
Bulky waste	Bulky waste means oversize household solid waste which cannot be placed in the receptacle (mobile garbage bin, MGB 120 L or 240 L) provided for residual waste including appliances, furniture, tree trunks and stumps. Furniture: Bed, mattress, cupboard, sofa, chairs, table Garden waste Tree Trunks, Branches > 4 inches in Diameter
Rocks	
Porcelain / ceramic/china	
Fruit peel /Husk	Durian peels, Tender coconut husk, coconut shell etc

7.2 ACTIVITY 2: Waste Characterisation Study
Waste collected from Households, Institutions, Commercial areas & Industries (Generation) and Landfills (Disposal)

The waste samples collected in the Waste Composition phase were sent for analysis to laboratories. The parameters of analysis to determine the physical, chemical and biological characteristics of the waste samples were the same for waste samples from the households, industries, commercial/ institutional and landfills.

Table 14 presents the *S*ampling plan for the waste characterisation.

Table 14: Sampling Plan for Waste Characterisation

No.	Category	Source	Tests	Sampling Days							Total No of Samples
				1	2	3	4	5	6	7	
1	Household - As generated / discarded	Low income, sampling at homes	Proximate Analysis, Ultimate Analysis, Calorific Value, Metals	1		1		1			162
		Medium income, sampling at homes		1		1		1			
		High income, sampling at homes		1		1		1			
2	Institutional / Commercial - As discarded sample	Composite Sample from Institutions and commercial areas		1	1	1	1	1	1		108
3	Industrial - As discarded	Composite sample from industries		1		1		1			54
4	Landfill - As Disposed Taken from 5 LAs	18 components from Landfill		18							90
	Landfill - As disposed	Composite from Landfill		1	1	1	1	1	1		108
		Composite sample from Landfill	NPK	1	1	1	1	1	1		108
Total											630

The Sampling plan for waste characterisation primarily focussed on the analysis on composite samples. However, at 5 of the 18 landfill sites, a sample from the landfill was sorted into 18 components (See ***Table 14 Item no. 4 and Table 15***) for the proximate analysis, Ultimate analysis and metals analysis.

Table 15: Waste Components Analysed

Components		
Food waste	Garden waste	LDPE
HDPE	PET	PVC
PP	PS	Other plastic
Mixed paper	Newsprint / old newspaper	Cardboard
Rubber	Wood	Leather
Textiles	Diapers	Tetra Pak©

To take into account the possible future diversion of Solid Waste from the current method of disposal i.e. landfill disposal to thermal treatment of the solid waste by incineration or the biological treatment of the organic fraction of the waste by composting, additional tests to determine the Calorific Value and the NPK value were included in this study.

The following analysis was conducted for each of the parameters to achieve the requirements of the TOR:

- Physical parameters – Specific weight, Proximate analysis
- Chemical parameters – Ultimate Analysis, Calorific Value and Metals
- Biological parameters – NPK value

Biodegradability is an important parameter when using treatment techniques such as composting. If a large fraction of the Solid Waste is not biodegradable, then this fraction will have to be disposed off by other means if composting is the primary mode of treatment. The potential biodegradability of the waste samples was determined using the estimated percentage of degradation of the individual components of the waste sample as recommended by Aarne Vesilind *et al*. in his book “Solid Waste Engineering”.

7.2.1 Laboratory Analysis Procedure

The wet waste sample was prepared by drying and size reducing before the analysis. The following were the pre-treatment processes of the waste sample:

- From the sorted waste components (sorted into the individual waste composition category), each component was taken with an estimated weight of about 1 kg. This 1 kg sample was then put into air-tight plastic bags and weighed accurately prior to sending to the laboratory. The exact weight of the sample was recorded.

- At the laboratory, the sealed containers were opened and dried at 85^{o}C for 24 hrs until constant weight to determine the moisture content. The dried composite sample was then processed to obtain an analysis stock of about 200 gram by coarse and fine shredding and fine grinding.

- Coarse Shredding - Shear mill/shredder was used to reduce the size of the waste when samples contain particles larger than 40 mm in size. The cutting action of the shredder also achieves some degree of mixing of the samples.

- Fine Shredding – This stage of size reduction process reduces the particle size from 50 mm to 1 mm. The size reduction is achieved using a general purpose hammer mill (1400 rpm), suitable for either pellets or coarsely shredded materials with a maximum size of 40 mm.

The following are the analyses that were performed on the sample:

- Specific gravity – This is to measure the ratio of density of the waste sample.

- Proximate Analysis - This analysis is carried out to obtain the Moisture Content, Fixed Carbon, Ash Content and Volatile Matter of a waste sample. This testing is performed according to ASTM standards, E949, E830-81 and E891.

- Ultimate Analysis - This analysis is carried out to obtain the elementary components of C, H, O, N, S, Organic Chlorine, and heavy metals present in a waste sample. This testing is in accordance to ASTM the standards, E777-81, E778-81, E775, E776-81 and E885-82.

- Metals – The laboratory analysis for heavy metal content of the waste samples shall include Magnesium, Vanadium, Silver, Copper, Aluminium, Iron, Lead, Mercury, Zinc, Chromium, Arsenic Cobalt, Manganese and shall be tested according to the ASTM standards E 926-94 and E 885-96.

- Calorific Value - This analysis is carried out in an apparatus known as a bomb calorimeter to obtain the heating value of a waste sample. This test is performed in accordance to the ASTM standard E711-81.

Table 16 presents the ASTM standard test methods that were used to analyse the collected waste samples from the households, institutional / commercial areas, industries and landfills.

Appendix 1 presents the forms used for the Waste Characterisation Study.

Table 16: Waste Characteristics, Parameters and Test Methods

No.	Waste Characteristics	Parameters	Test Method
1	Proximate Analysis	Total Moisture Content Volatile Matter Fixed Carbon Ash Content	ASTM D 3172-89, ASTM D 3175-89a, ASTM D 3171-97, ASTM E 949-88, ASTM E 897-88, and ASTM E 830-87
2	Ultimate Analysis	Carbon and Hydrogen Nitrogen Sulphur Organic Chlorine Oxygen	ASTM D 3176-89, ASTM D 3178-89, ASTM D 3179-89, ASTM D 3177-89, ASTM E 777-87, ASTM E 778-87, and ASTM E 775-87
3	Metals	Magnesium, Vanadium, Silver, Copper, Aluminium, Iron, Lead, Mercury, Zinc, Chromium, Arsenic, Cobalt, Manganese	ASTM E 926-94 ASTM E 885-96/ USEPA 6010B, USEPA 7471A
4	Calorific Value	HHV, LCV	ASTM D 3286-96 ASTM E 711-87

7.2.2 Calorific Values Calculations

The energy value of the waste components depends on its calorific value (CV). There are two types of CV:

- The Higher Heating Value (HHV)
- The Lower Calorific Value (LCV)

The Higher Heating Value (HHV) is the gross heat released when a small bone-dry sample of the material is burned in a test calorimeter at a reference temperature (usually 25°C) and all products are in their standard states at that temperature. The HHV includes the heat of condensation of water vapour formed in the combustion reaction, which is not realistic for Waste to Energy plant design calculations.

In calculating the initial heat balance, to determine the amount of supplemental fuel required, the usable heat released from the waste must be calculated or analysed.

The Lower Calorific Value (LCV) may be defined as the Usable heat less the heat required to vapourise any free water in the waste. The effect of the elemental hydrogen from the ultimate analysis is taken into consideration in the formula.

The formulas for determining the calorific value of waste components are:

$$\mathbf{HHV_{wet} = HHV_{dry} \times (1 - W/100)}$$

$$\mathbf{LCV_{wet} = HHV_{wet} - 219^{**} \times (\%H_2) \times (1 - W/100) - 24.41^{*} \times W}$$

Where:

LCV_{wet} = Lower calorific value of "as-is" wet sample in kJ/kg

$\%H_2$ = %age of Hydrogen in the Wet MSW obtained from the Ultimate analysis

HHV_{dry} = Higher Heating Value of dried sample in kJ/kg

HHV_{wet} = Higher Heating Value of "as-is" wet sample in kJ/kg

W = %age of Moisture content of the wet sample

* Vapourisation enthalpy of water (2441 kJ/kg at 25 °C) /100

** Vapourisation enthalpy of water (2441 kJ/kg at 25 °C) x 18 moles of water / 2 moles of H_2 /100

Equations adapted from the "Developing Integrated Solid Waste Management Plan. Volume 1: Waste Characterisation and Quantification with Projections for Future", UNEP. 2009 .

7.3 ACTIVITY 3: Survey on Existing Recycling Practice

This Section discusses the methodology of the recycling study, with a focus on the approach and assumptions. The objective of this Study is to estimate the recycling rates and practices by households in the selected local authority areas; understand the channels of recycling network and structure; and examine the recycling patterns of industrial, commercial and institutional establishments.

Four (4) types of surveys were carried out under the ***Survey on Existing Recycling Practice***, viz.

- Household survey
- Commercial and Institutional establishments survey
- Industrial establishment survey
- Recycling players survey

Appendix 2 presents the Survey Instruments used for the ***Survey on Existing Recycling Practice.***

7.3.1 Households and ICI Surveys

These surveys gathered background information on households and ICI establishments. For example, information on household monthly income, number of household members, type of housing and reasons for recycling were collected for households. Information such as type of business, type of premise, the capacity of the premise and reasons for recycling was attained for ICI. All these data are necessary to determine the potential factors that influence current recycling practices.

Coupled with the amount of waste generated in households and establishments taken from the Waste Composition Study ($r_1 + w_1$), the recycling rates (RR) of each establishment were estimated. The model for estimating the recycling rate is illustrated in ***Figure 5.***

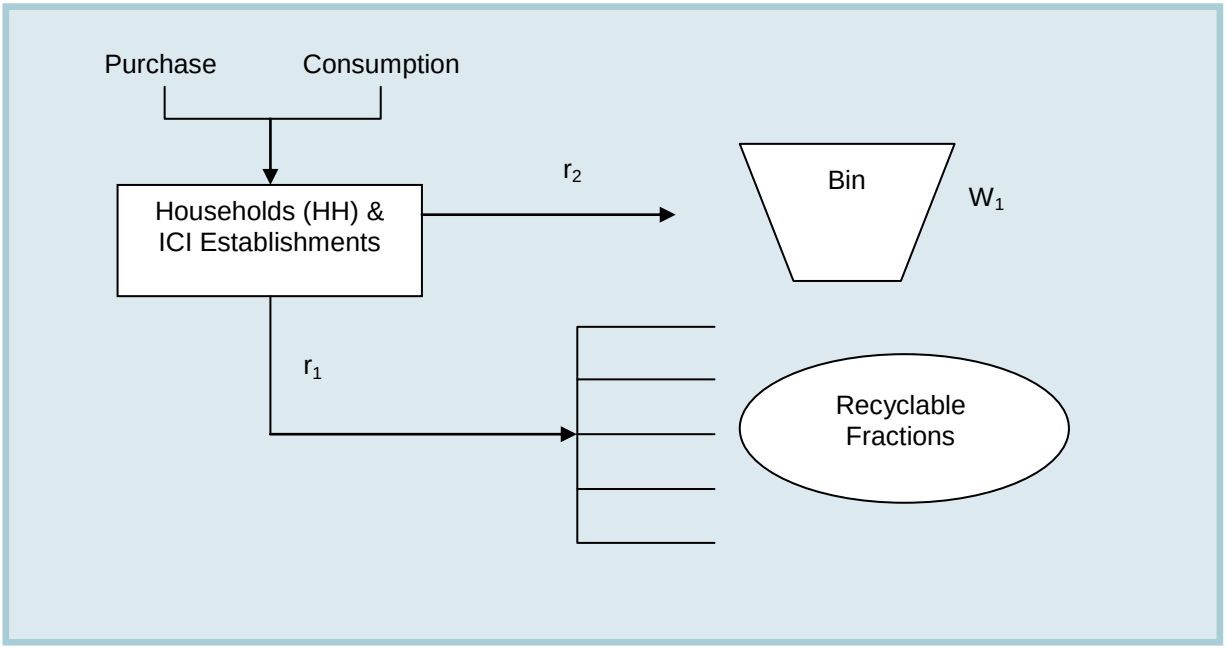
where,

r_1 = source-segregated recyclables (e.g. old newspapers, aluminium cans, etc)

r_2 = comingled recyclable items in the waste bin

w_1 = waste generated as in the waste bin.

Figure 5: Model to estimate the Recycling Rate from Households, Industries, CI Establishments



Using this model (***Figure 5***), the following recycling rates were estimated:

Household recycling rate is the amount (weight) of recyclable items as a proportion of total solid waste generated at source, which can be represented as

$$\text{(HRR) Household recycling rate (\%)} = \frac{\sum (THC_h) \text{ Total household recyclables } (r_1)}{\sum (TWG_h) \text{ Total waste generated by household } (r_1 + w_1)}$$

Where:

THC_h = total amount of recyclables segregated at source (household) for recycling (kg)

TWG_h = total amount of waste generated (kg) based on unit amount generation

ICI recycling rate is the amount (weight) of recyclable items as a proportion of total solid waste generated at source (i.e. source separated by the establishments). The rates are calculated as follows:

$$\text{(IndRR) Industrial recycling rate (\%) by industry sub-sectors} = \frac{\sum (THC_i) \text{ Total Industrial recyclables (at source)}}{\sum (TWG_i) \text{ Total waste generated by Industries}}$$

$$\text{(CRR) Commercial and Institutional recycling rate (\%) by commercial sub-sectors} = \frac{\sum (THC_c) \text{ Total Commercial and Institutional recyclables}}{\sum (TWG_c) \text{ Total waste generated by Commercial \& Institutional}}$$

Where:

THC = total amount of recyclables sorted at source for recycling (kg) for each sector

TWG = total amount of waste generated/computed based on unit amount generation for each sector

7.3.2 Recycling Players

The survey is used to understand the current recycling system by determining the functions played by the various categories of recycling players in the collection, transportation, processing and trading of recyclables. Data is also collected from households, commercial, institutions and industries. Information about types and amounts of recyclables gathered and traded between recycling players include:

- Recycling activities
- Imported or exported recyclables and the material
- Price flow of recyclables

7.3.3 Total Recycling Rate (Overall)

The information above would then be used to estimate the overall recycling rate of Malaysia as follows:

$$\text{(TRR) Total recycling rate (\%)} = \frac{\sum \text{household recyclables} + \sum \text{ICI establishment recyclables} + \sum \text{scavenged recyclables*}}{\text{Total solid waste generated**}}$$

Note:

- ICI establishment recyclables = $THC_i + THC_c + THC_s$
- *scavenged recyclables are items that are retrieved outside of the household or ICI establishments by municipal waste collectors, waste pickers or scavengers at the landfill (as obtained from the recycling players survey).
- **total solid waste generated from household and ICI only. This excludes special waste e.g. C&D, tyres, bulky waste etc.

7.3.4 Survey Methodology

7.3.4.1 Survey Design

This section provides information on the sampling methodology used in each survey of the Recycling Study and details out the method used to select samples for interview.

7.3.4.2 Households

Household samples were first to be grouped according to geographical location before sorting into housing types (***Figure 3***). For this portion of the survey, 5 main housing types have been identified namely:

- Low cost landed
- Low cost high rise
- Medium cost landed
- High-medium cost high rise
- High cost landed

As a general guideline, 30 samples are needed for each housing type in a LA. Therefore, 150 households (HHs) per local authority (LA) are needed in general. In order to compensate for "outliers" (e.g. cases where houses for migrant workers, respondent in the house are under 18), 50 per cent over sampling was applied. In other words, a total of 45 households will be sampled per housing type in each LA in this survey. These 45 households include all households that agree to participate, irrespective of whether they recycle or not.

Selecting samples in the field for the Recycling Survey

- When in the field, samples were selected by randomly choosing a house to be the starting point or the first sample.
- If the survey was successfully conducted, we moved on to the next block of houses for the second sample.

Note: Only one sample can be chosen from one interval block. As an example, a random starting point is chosen for high cost houses in Cluster 1 of Kubang Pasu with an interval block of 12 houses (***Table 6***). In other words, a total of 15 interval blocks of 12 houses are needed to obtain 15 samples. If a successful survey is conducted for the first house chosen, we move on to the 13th house to choose the second sample.

7.3.4.3 Industrial, Commercial and Institutional (ICI) establishments

The sample sizes of Recycling Players 2 had to be readjusted given that previous efforts to survey this category indicated that:

a) there are fewer players than expected,

b) there are only a few companies and have secured a significant portion of the market-share within a region and

c) recyclables movement were concentrated mostly in the Central region/Klang Valley.

Therefore, a total of 450 Recycling Player 2 samples were shifted to:

a) Industrial samples (220 additional samples)

b) Commercial and Institutional (CI) samples (230 additional samples).

A total of 570 establishments were sampled for the ICI category with the original distribution of samples being 540 establishments for industries and 30 establishments from commercial and institutions respectively. A revision of the sample sizes for industries and for commercial and institutional establishments were made with the approval of our request to redistribute the samples amongst the ICI establishments as suggested in the Inception Report and Progress Report 2. After the revision, a total of 550 industrial establishments and 470 commercial and institutional establishments were sampled.

7.3.4.4 Recycling Players

As there is very little information about how many and who the recycling players are in each LA, sampling was done using the "*snowball method*" where information about the recycling players was built up gradually. Known recycling players were first approached and information about other recycling players was collected from them. These other recycling players were then contacted for the survey and subsequently provided more information about the other recycling players. The *Direktori Kitar Semula*, a telephone directory produced by Yellow Pages and ***Kementerian Perumahan dan Kerajaan Tempatan*** was used as an additional source of information for recycling players in a LA.

Taking into account that recycling players may not be confined to a single LA, recycling players were surveyed as an entire region. As a general guideline, ten players from Recycle Player 1 (RP1) and five players from Recycle Player 2 (RP2) were sampled from each LA. This ensured that all LAs were included in the regional sampling of recycling players. Recycling Players 1 and 2 are defined follows:

- Recycling Players 1 (RP1) are street collectors, waste pickers at collection vehicles, and scavengers at landfills.
- Recycling Players 2 (RP2) are traders, middle man and junk shops that collect, buy and deal recyclables, recycling drop-offs such as recycle bins at NGO or charity-based collection points and buy back centres, recyclers that convert recyclables into raw/intermediate material and that manufacture new products from recycled material.

A total of 450 Recycling Players were sampled for this survey. ***Table 17*** presents the number of samples for each Recycling Player in each Region.

Table 17: Number of Samples for each Recycling Player for each Region

Region	RP1	RP 2	Total RP
Northern	40	75	115
Central	50	100	150
Southern	30	45	75
Sarawak	30	25	55
Sabah	30	25	55
Total	180	270	450

RP1 *-street collectors, waste pickers at collection vehicles, and scavengers at landfills*
RP2 *- traders, middle man, recycling drop-off and buy back centres, recyclers that convert recyclables into raw/intermediate material, manufacture new products from recycled material*

The major cities/towns sampled included Penang (Northern region), Klang Valley (Central region), Johor Bahru (Southern region), Kuching (Sarawak region) and Kota Kinabalu (Sabah region). The selection of major city/town in a region was based on the fact that the rate of recyclables in a region and recycling players of higher recycling function are expected to be higher in the major cities in each region. The remainder of the regional samples were then taken from the major city/town in a region.

Due consideration was also given to the fact that a single player, particularly in the Recycling Players 2 category may play multiple functions in the recycling industry. Therefore, players were identified according to their highest hierarchical function. Based on the highest function played, Recycling Players 2 can be further sub-grouped into:

Sub-group	Function
Agents, buyers and collectors	Players that are solely involved in trading of recyclables. This includes players that do not buy the recyclables collected (e.g. drop-off centres) and players that are mobile or have a fixed place to buy recyclables.
Processors	Players that do processing of recyclables such as crushing, washing, baling etc
Converters and Manufacturers	Recyclers that are involved in converting recyclables into raw/intermediate material and that manufacture new products from recycled material

8 WASTE GENERATION

Waste generation is the solid waste produced from its source. It is the summation of waste retained by the generator for other purposes and waste discarded for collection. The waste generation refers to the weight of materials and products as they enter the waste management system from sources but before being subjected to treatment which includes materials recovery or combustion processes. Source reduction activities (e.g., backyard composting) and industrial scrap are not included in the generation estimates.

The generation rate is the amount of waste generated by one person or other appropriate units, which includes employees, square metres, etc. in one day and is presented as kg per capita per day (based on population) or kg per employee per day. The generation rates are influenced by:

- Societal affluence
- The standard of living and urbanisation
- The degree of industrialisation
- Public habits
- Local climate

Generally, the higher the economic development and extent of urbanisation, the greater the amount of solid waste produced.

A recent study by the World Bank (*What a waste: a global review of solid waste management*. Hoornweg, Daniel; Bhada-Tata, Perinaz, The World bank 2012) reports the current global MSW generation level as being approximately 1.3 billion metric tonnes (MT) per year or 1.2 kg per person per day on average.

The MSW is defined in the World Bank report as encompassing residential, industrial, commercial, institutional, municipal, and construction and demolition (C&D) waste. It must be noted that in this report, construction and demolition waste is not included.

The World Bank report expects the MSW generation to increase to approximately 2.2 billion metric tonnes per year by 2025.

8.1 Waste Generation from Household

Table 18 and ***19*** show the household waste generation per capita by strata and housing type in Peninsular Malaysia and Sabah and Sarawak. The household waste generation is about 18,000 metric tonnes per day in Peninsular Malaysia. With the population 22 million, the per capita waste generation is about 0.8 kg/capita/day.

On average, the waste generation by urban (0.83 kg/capita/day) is relatively higher than the waste generation by rural (0.73 kg/capita/day). The results show that the per capita waste generations of medium and high cost housing types is higher than the low cost housing types as well.

***Table 18*: Average Household Waste Generation in 2012, Peninsular Malaysia**

PENINSULAR MALAYSIA									
Housing Type	**Urban**			**Rural**			**Overall**		
	Population	Per Capita (kg/capita/day)	Total (MT/day)	Population	Per Capita (kg/capita/day)	Total (MT/day)	Population	Per Capita (kg/capita/day)	Total (MT/day)
Low cost Landed	2,284,650	0.78	1,772	1,395,530	0.73	1,024	3,680,180	0.76	2,797
Low cost High-rise	3,279,077	0.65	2,139	452,967	0.77	350	3,732,044	0.67	2,490
Medium cost Landed	6,888,828	0.93	6,414	2,298,782	0.72	1,647	9,187,610	0.88	8,061
High-Medium cost High-rise	2,012,187	0.91	1,826	-		-	2,012,187	0.91	1,826
High cost Landed	2,526,676	0.76	1,933	1,430,647	0.72	1,023	3,957,324	0.75	2,956
Total	**16,991,419**	**0.83**	**14,083**	**5,577,926**	**0.73**	**4,045**	**22,569,345**	**0.80**	**18,129**

Note: the population of each housing type by urban and rural was estimated based on the ratio in Property Stock Report 2010 and Census 2010.

***Table 19*: Average Household Waste Generation in 2012, Sabah and Sarawak**

Sabah and Sarawak									
Housing Type	**Urban**			**Rural**			**Overall**		
	Population	Per Capita (kg/capita/day)	Total (MT/day)	Population	Per Capita (kg/capita/day)	Total (MT/day)	Population	Per Capita (kg/capita/day)	Total (MT/day)
Low cost Landed	388,369	0.59	229	618,650	0.61	375	1,007,019	0.60	604
Low cost High-rise	488,638	0.49	241	403,683	0.61	244	892,321	0.54	486
Medium cost Landed	1,279,249	0.62	796	1,077,513	0.58	629	2,356,762	0.60	1,425
High-Medium cost High-rise	352,379	0.73	256	-		-	352,379	0.73	256
High cost Landed	624,916	0.61	380	531,393	0.61	326	1,156,309	0.61	706
Total	**3,133,551**	**0.61**	**1,902**	**2,631,239**	**0.60**	**1,575**	**5,764,790**	**0.60**	**3,477**

Note: the population of each housing type by urban and rural was estimated based on the ratio in Property Stock Report 2010 and Census 2010.

Table 20 shows the household waste generation in Malaysia. The per capita waste generation rate comes down marginally with the addition of the population of approximately 6 million people from Sabah and Sarawak. The household waste generation rates for the states of Sabah and Sarawak is lower compared to the household waste generation rate in Peninsular Malaysia. The per capita household waste generation rate for Malaysia is 0.76 kg/capita/day, which is slightly lower than that of the rate in Peninsular Malaysia (0.8 kg/capita/day).

In terms of strata, the urban household waste generation rate (0.8 kg/capita/day) is higher than the rural household waste generation rate (0.68 kg/capita/day). In terms of housing type, the pattern follows that of Peninsular Malaysia, where the per capita household waste generation rate for medium-high cost housing types is higher than the low cost housing types.

***Table 20*:** Average Household Waste Generation in 2012, Malaysia

MALAYSIA									
Housing Type	**Urban**			**Rural**			**Overall**		
	Population	Per Capita (kg/capita/day)	Total (MT/day)	Population	Per Capita (kg/capita/day)	Total (MT/day)	Population	Per Capita (kg/capita/day)	Total (MT/day)
Low cost Landed	2,675,954	0.74	1,988	2,019,579	0.69	1,397	4,695,533	0.72	3,384
Low cost High-rise	3,778,052	0.63	2,394	830,781	0.71	586	4,608,833	0.65	2,981
Medium cost Landed	8,167,292	0.89	7,245	3,377,231	0.67	2,276	11,544,523	0.82	9,521
High-Medium cost High-rise	2,366,232	0.89	2,095	-		-	2,366,232	0.89	2,095
High cost Landed	3,137,440	0.73	2,303	1,981,574	0.68	1,343	5,119,014	0.71	3,646
Total	**20,124,970**	**0.80**	**16,025**	**8,209,165**	**0.68**	**5,601**	**28,334,135**	**0.76**	**21,627**

Note: the population of each housing type by urban and rural was estimated based on the ratio in Property Stock Report 2010 and Census 2010.

8.2 Waste generation by Industrial, Commercial and Institution

Waste generation by Industrial, Commercial and Institution (ICI) encompasses municipal waste but exclude construction and demolition waste and industrial scrap. The types of municipal waste generated by ICI includes housekeeping wastes, packaging, food wastes, paper, cardboard, plastics, wood, glass, metals and etc.

Table 21 and ***Table 22*** show the municipal waste generated by the ICI in Peninsular Malaysia and Sabah and Sarawak respectively. Based on the survey results, it is estimated that the total waste generated from the Industrial sector in Peninsular Malaysia is about 2,100 metric tonnes per day whereas about 7,500 metric tonnes are generated per day for the Commercial and Institution. In total, the waste generation of ICI sector in Peninsular Malaysia is 9,600 metric tonnes per day. The waste generation is further divided by strata based on the ratio obtained from the Labour Force Survey 2010 (see ***Appendix 3***).

In order to obtain per capita waste generation rate for the ICI sector, the total waste generated daily is divided by the population.

- Per capita waste generation for the Industrial sector is 0.09 kg/capita/day
- Per capita waste generation for Commercial and Institution is 0.34 kg/capita/day

On average, the per capita waste generation for ICI sector is 0.43 kg/capita/day.

Overall, per capita waste generation in the urban area is relatively higher than the rate in the rural area. This holds true due to the influence of economic development and the degree of industrialisation. The degree of industrialisation in the urban area is greater than that of in rural area.

Table 23 shows the waste generation by ICI in Malaysia. The waste generation is estimated at 11,500 metric tonnes per day. The average ICI per capita waste generation is 0.41 kg/capita/day.

Table 21: Average Municipal Waste Generation by Industrial, Commercial and Institution in Peninsular Malaysia in 2012

PENINSULAR MALAYSIA						
	Urban		Rural		Total	
Population	16,991,419		5,577,926		**22,569,345**	
Waste Generation	**Waste (MT/day)**	**Per Capita (kg/capita/day)**	**Waste (MT/day)**	**Per Capita (kg/capita/day)**	**Waste (MT/day)**	**Per Capita (kg/capita/day)**
Industrial	1,564	0.09	521	0.09	2,086	0.09
Commercial and Institutions	5,965	0.35	1,622	0.29	7,587	0.34
Overall	**7,529**	0.44	**2,143**	0.38	**9,673**	0.43

Table 22: Average Municipal Waste Generation by Industrial, Commercial and Institution in Sabah and Sarawak in 2012

SABAH and SARAWAK						
	Urban		Rural		Total	
Population	3,133,551		2,631,239		**5,764,790**	
Waste Generation	**Waste (MT/day)**	**Per Capita (kg/capita/day)**	**Waste (MT/day)**	**Per Capita (kg/capita/day)**	**Waste (MT/day)**	**Per Capita (kg/capita/day)**
Industrial	125	0.04	68	0.03	193	0.03
Commercial and Institutions	1,187	0.38	451	0.17	1,638	0.28
Overall	**1,312**	0.42	**519**	0.20	**1,830**	0.32

***Table 23*:** Average Municipal Waste Generation by Industrial, Commercial and Institution in Malaysia in 2012

MALAYSIA						
	Urban		**Rural**		**Total**	
Population	20,124,970		8,209,165		**28,334,135**	
Waste Generation	**Waste (MT/day)**	**Per Capita (kg/capita/day)**	**Waste (MT/day)**	**Per Capita (kg/capita/day)**	**Waste (MT/day)**	**Per Capita (kg/capita/day)**
Industrial	1,689	0.08	590	0.07	2,279	0.08
Commercial and Institutions	7,152	0.36	2,072	0.25	9,224	0.33
Overall	**8,841**	0.44	**2,662**	0.32	**11,503**	0.41

Table 24 presents the waste generation by sub-sector of CI.

The waste generation rate for the CI sub-sectors is calculated based on the waste collected and weighed from the various sub-sectors. Wet market has the highest waste generation per kg per employee per day compared to all the other sectors.

Table 24: Waste Generation Rate by of Commercial and Institution Sub-sectors, in kg/employee/day

CI Sub sectors	Waste Generation
Business offices	1.07
Education	1.32
Health	2.18
Hotel	3.68
Public Administration	1.02
Restaurant	3.92
Transportation	1.56
Wet Market	11.87

8.3 Overall Waste Generation

As presented in the ***Table 25*** and ***Table 26,*** the overall waste generation in Peninsular Malaysia, i.e. combining household and ICI, is about 28,000 metric tonnes per day. Per capita waste generation ranges from 1.10 to 1.37 kg per person per day, with an average of 1.23 kg/capita/day.

It was also found that urban residents produce more waste as compared to their rural counterparts.

On average, the housing type group from Medium Cost Landed, High-Medium Cost High-rise and High Cost Landed produce more waste than that of Low Cost Landed and Low Cost High-rise.

Table 27 presents the overall waste generation for Malaysia.

The waste generation for the whole of Malaysia is approximately 33,000 metric tonnes per day, with per capita waste generation ranging from 1 to 1.33 kg per person per day across the strata and housing type, with an average of 1.17 kg/capita/day.

Overall, the urban residents generate more waste, 1.24 kg/capita/day as compared to their rural counterparts, 1.01 kg/capita/day.

On average, the housing type group from Medium Cost Landed, High-Medium cost high rise and High Cost Landed produce more waste than the Low Cost Landed and High-rise housing types.

***Table 25*: Overall Waste Generation from Households and ICI in Peninsular Malaysia**

URBAN			RURAL			OVERALL		
Population	**Per Capita (kg/capita/day)**	**Total (MT/day)**	**Population**	**Per Capita (kg/capita/day)**	**Total (MT/day)**	**Population**	**Per Capita (kg/capita/day)**	**Total (MT/day)**
16,991,419	**1.27**	**21,613**	**5,577,926**	**1.11**	**6,188**	**22,569,345**	**1.23**	**27,802**

Source: Waste Composition Study, 2012

***Table 26*: Overall Waste Generation from Households and ICI in Sabah and Sarawak**

URBAN			RURAL			OVERALL		
Population	**Per Capita (kg/capita/day)**	**Total (MT/day)**	**Population**	**Per Capita (kg/capita/day)**	**Total (MT/day)**	**Population**	**Per Capita (kg/capita/day)**	**Total (MT/day)**
3,133,551	1.04	**3,252**	**2,631,239**	0.79	2,076	**5,764,790**	0.92	5,328

Source: Waste Composition Study, 2012

Table 27: Overall Waste Generation from Households and ICI in Malaysia

URBAN			RURAL			OVERALL		
Population	**Per Capita (kg/capita/day)**	**Total (MT/day)**	**Population**	**Per Capita (kg/capita/day)**	**Total (MT/day)**	**Population**	**Per Capita (kg/capita/day)**	**Total (MT/day)**
20,124,970	**1.24**	**24,866**	**8,209,165**	**1.01**	**8,264**	**28,334,135**	**1.17**	**33,130**

Source: Waste Composition Study, 2012

Table 28 shows waste generation per capita by region. Klang Valley residents produce more waste, 1.35 kg/capita/day than the other regions whereas East Coast has the lowest waste generation rate 0.95 kg/capita/day.

Table 28: Waste Generation by Region

Region	Population	Per Capita (kg/capita/day)	Total (MT/day)
Northern	6,093,318	1.10	6,724
Klang Valley (KL and Selangor)	7,209,175	1.35	9,702
East Coast	4,076,395	0.95	3,862
Southern	5,190,457	1.28	6,657
Sarawak	2,471,140	1.04	2,571
Sabah	3,293,650	0.98	3,220
Total	**28,334,135**		**32,736**

Please note that there is a slight discrepancy in the total quantity of waste presented in ***Table 27*** and ***Table 28***. This slight difference is due to the number and characteristics of samples. As an example, the Klang Valley region consists of two LAs, DBKL and Majlis Perbandaran Klang. These two LAs are classified as urban areas and therefore the rural characteristics of Klang Valley were not captured. Thus, the estimation for Klang Valley is based on the urban samples only. However, the estimation based on the Housing Types and strata has wider coverage and more samples. The problem of limited data in each region's estimation is leveraged if the estimation is calculated in wider scope i.e. by housing types and strata.

9 RECYCLING RATE

9.1 Household Recycling Rate

As described in ***Section 7,*** the methodology for calculating household recycling rate is based on estimation of household recyclables and waste generated. Household recycling rate is the amount (weight) of recyclable items as a proportion of total solid waste generated at source, which can be represented as

$$\text{(HRR) Household recycling rate (\%)} = \frac{\sum (THC_h) \text{ Total household recyclables } (r_1)}{\sum (TWG_h) \text{ Total waste generated by household } (r_1+w_1)}$$

Where:

THC_h = total amount of recyclables segregated at source (household) for recycling (kg)
TWG_h = total amount of waste generated (kg) based on unit amount generation

The Household Recycling Practice Survey and Waste Composition Study form the base for the household recycling rate estimation.

Table 29 shows the household waste and recyclable materials Nationwide and in Peninsular Malaysia. The total recyclable materials retained by the total households in Peninsular Malaysia were about 1.8 million kg per day, whereas the total waste generated were about 18.1 million kg per day. The 2010 census reported 22.5 million in population in Peninsular Malaysia. In average, recyclable materials weight per capita is estimated about 0.08 kg/capita/day. The recycling rate for Peninsular Malaysia is estimated at about 10 per cent.

With the population in Sabah and Sarawak, the recycling rate in Malaysia is about 9.7 per cent, slightly lower than the recycling rate of Peninsular Malaysia. The decrease is due to the lower recycling rate in Sabah.

Table 30 presents the household recycling rate by region. The household recycling rate for the nation is 9.7 per cent. The East Coast region leads the way with the highest household recycling rate of 11.4 per cent followed by the Southern region with 10.6 per cent. The East Coast region has the highest household recycling rate due to high volume of recyclables materials retained and lowest waste generation. Sabah has the lowest household recycling rate compared to other regions.

***Table 29*: Quantity of Household Waste and Recyclable Materials Generated in 2012**

	Peninsular Malaysia		Sabah and Sarawak		Malaysia	
	Total (kg/day)	Generation Rate (kg/capita/day)	Total (kg/day)	Generation Rate (kg/capita/day)	Total (kg/day)	Generation Rate (kg/capita/day)
Recyclable materials retained by the household	1,821,735	0.08	245,911	0.04	2,101,129	0.07
Waste discarded	16,306,919	0.72	3,230,883	0.56	19,525,600	0.69
Waste generated (waste discarded + recyclables)	18,128,654	0.80	3,476,794	0.60	21,626,729	0.76
Recycling rate	10.0%		7.1%		9.7%	
Population (2010 Census)	22,569,345		5,764,790		28,334,135	

Table 30: Household Recycling Rate by Region, in per cent

Region	Selected LAs	Recycling rate	Overall Recycling Rate
Northern	Kangar	9.7	9.0
	Penang	11.0	
	Kubang Pasu	5.7	
	Tanjung Malim	3.0	
Klang Valley	Kuala Lumpur	10.4	10.0
	Klang	9.4	
East Coast	Kuantan	18.4	11.4
	Kota Bahru	15.7	
	Besut	4.4	
Southern	Jasin	13.2	10.6
	Johor Bharu	10.2	
	Kuala Pilah	11.5	
Sarawak	Samarahan	4.3	9.4
	Sibu	15.6	
	Miri	13.2	
Sabah	Beaufort	2.0	2.9
	Sandakan	3.7	
	Kota Kinabalu	4.5	
Malaysian Household Recycling rate			**9.7**

There are few proxy variables in classification of rural and urban areas. In this study, state capital or the main town is the main criteria for the classification. Of total 18 LA(s) in this study, 11 of them are classified as urban area whereas another 7 LA(s) are classified as rural area and is as presented in ***Table 3.***

Table 31 shows the Household Recycling Rate by Housing Type. The urban household recycling rate (10.6 per cent) is higher than the rural household recycling rate (7.3%). In Peninsular Malaysia, the recycling rate for the middle class group (those from Medium Income and Medium-High Income groups) is higher than other groups.

Table 31: Household Recycling Rate (RR) by Housing Type, in per cent

Region		Low Cost Landed	Low Cost High-rise	Medium Cost Landed	Medium-High Cost High-rise	High Cost Landed	Household RR
Peninsular Malaysia (PM)	Urban	8.6	11.6	10.0	12.3	11.8	10.6
	Rural	7.0	10.9	9.0	-	6.7	8.1
	Overall PM RR	**8.0**	**11.5**	**9.8**	**12.3**	**10.1**	**10.0**
Sabah and Sarawak (SS)	Urban	8.4	7.5	10.6	1.8	13.8	9.4
	Rural	4.9	7.7	2.6	-	4.3	4.3
	Overall SS RR	**6.2**	**7.6**	**7.1**	**1.8**	**9.4**	**7.1**
Malaysia	Urban	8.6	11.4	10.0	11.9	12.2	10.6
	Rural	6.7	8.3	8.0	-	6.3	7.3
	Overall Malaysia RR	**7.8**	**10.8**	**9.5**	**11.6**	**10.1**	**9.7**

9.2 Industrial Recycling Rate

The recycling rate for the industries is estimated based on the recyclables removed by the industry, only from the non-production portion of the total generated waste. This study does not take into account the production waste, i.e. waste generated during the manufacturing of their products, generated within the industry. The formula to calculate the industrial recycling rata is as below:

$$\text{(IndRR) Industrial recycling rate (\%) by industry sub-sectors} = \frac{\sum (THC_i) \text{ Total recyclables of non-production waste}}{\sum (TWG_i) \text{ Total non-production waste generated by Industries}}$$

Where:

THC = total amount of recyclables sorted at source for recycling (kg) for each sector
TWG = total amount of waste generated/computed based on unit amount generation for each sector

The non-production waste, recyclable materials and recycling rates by firm size are presented in ***Table 32***. The recycling rate for non-production waste was estimated by firm size and total number of employees in each firm size. The firm size was categorised as micro, small, medium and large firms where:

a) micro firms are firms with less than 5 employees,
b) small firms with 5 to 50 employees,
c) medium firms with 51 to 150 employees, and
d) large firms are those with more than 150 employees.

On average, the weight of recyclable materials per employee per day retained in micro firms was higher than the small, medium and large firms. But, at the same time the average waste generated per employee per day for micro firms was higher than the other size of firms.

Using the formula shown above, it was deduced that the recycling rate for micro firms is the lowest compared to other firm size. The recycling rate for large firms (25.8%) was higher than the micro (2.4%), small (5.3 per cent) and medium (11.9 %) firms. Overall, the recycling rate for Malaysian Industries sector was calculated to be 9.7 per cent.

Table 32: Industrial Non Production Waste, Recyclable Materials and Recycling Rate

	Micro	Small	Medium	Large	Overall
Recyclable materials retained by the Industries (kg/employee/day)	0.33	0.15	0.15	0.10	0.12
Waste discarded (kg/employee/day)	13.39	2.73	1.11	0.29	1.14
Waste generated (waste discarded + recyclables) (kg/employee/day)	13.72	2.88	1.26	0.37	1.26
Total Weight of Recyclable Materials, (kg/day)	17,665	36,623	45,471	121,345	221,103
Total Weight of Discarded Waste, (kg/day)	712,406	660,286	335,773	349,327	2,057,793
Total Weight of Generated Waste, (kg/day)	730,071	696,909	381,244	470,672	2,278,896
Recycling rate	2.4%	5.3%	11.9%	25.8%	9.7%
Number of employees – based on firm size*	53,193	242,184	303,531	1,213,452	1,812,360

*Source: * Economic Census 2011: Manufacturing, Dept of Statistics.*

9.3 Commercial and Institution Recycling Rate

The Commercial and Institutional Recycling Rate is estimated based on the weight of recyclables and total waste generated by Commercial and Institution.

$$\text{(CRR) Commercial and Institutional recycling rate (\%) by commercial sub-sectors} = \frac{\sum (THC_c) \text{ Total Commercial and Institutional recyclables}}{\sum (TWG_c) \text{ Total waste generated by Commercial \& Institutional}}$$

Where:

THC = total amount of recyclables sorted at source for recycling (kg) for each sector
TWG = total amount of waste generated/computed based on unit amount generation for each sector

Table 33 shows the recyclable materials and recycling rate of the Commercial and Institution (CI) which includes public administration, business offices, education, health, hotel, restaurant, transportation, wholesale and retail and wet markets.

On average, the recycling rate for CI is about 7.4 per cent. Recyclable materials per employee were estimated at 0.12 kg/employee/day, whereas waste generated per employee was estimated at 1.94 kg/employee/day.

In the survey sample, recyclable materials (mainly cardboard) per employee for hypermarkets (part of wholesale and retail trades) (0.8 kg/employee/day) was relatively high compared to other types of CI, so not to distort overall average, wholesale and retail trades has been removed from the estimation of recyclable materials per employee.

However, the weight of recyclable materials and waste discarded of wholesale and retail trades were estimated and added into the total weight of all selected CI for estimation of nation recycling rate in next section.

Table 33: Commercial and Institutional Waste, Recyclable Materials and Recycling Rate

	Total Weight excluding wholesale and retail trades but include hypermarket (kg/day)	Total Weight excluding wholesale and retail trades (kg/day)	Kg/employee/day[#]
Recyclable materials retained by the selected Commercial and Institutional	678,482	571,482	0.12
Waste discarded	8,545,993	8,438,993	1.82
Waste generated (waste discarded + recyclables)	9,224476	9,010,476	1.94
Recycling rate	-	7.4%	
Total Number of Employees working in the selected Commercial and Institutions*	-	4,640,523	

Source: Number of Employees from Economic Census 2011, Dept of Statistics

Note : [#] the estimation of kg/employee/day excludes wholesale and retail trades.

9.4 Overall Recycling Rate

The overall recycling rate is estimated based on the total recyclables from the household, industrial, commercial and institutions (ICI). The overall recycling rate also includes the recyclables collected by scavengers and total waste generated by household, industrial, commercial and institutions. As described in the earlier section, below is the formula for overall recycling rate.

$$\text{(TRR) Total recycling rate (\%)} = \frac{\sum \text{household recyclables} + \sum \text{ICI non production waste recyclables} + \sum \text{scavenged recyclables}^*}{\text{Total solid waste generated}^{**}}$$

9.4.1 Recycling Rate in Peninsular Malaysia

The recycling rate for Peninsular Malaysia for 2012, presented in ***Table 34***, is about ***10.8 per cent***. Of the total waste generated, estimated to be 27,801,612 kg/day (or about 27,800 metric tonnes /day), the recyclable materials extracted were about 3,000,897 kg/day (or about 3,000 metric tonnes /day). The recyclable materials retained by waste collection truck workers and scavengers were estimated based on secondary data.

Table 34: Recycling Rate in Peninsular Malaysia,

	Households	ICI	Overall at source	Waste Collection Truck Workers	Scaven-gers	Overall
Recyclable materials, in kg/day	1,821,735	760,427	2,582,162	406,693	12,042	3,000,897
Waste discarded, in kg/day	16,306,919	8,912,530	25,219,449	-	-	
Waste generated (waste discarded + recyclables) , in kg/day	18,128,654	9,672,958	27,801,612	-	-	27,801,612
Recycling rate, in per cent	10.0%	7.9%	**9.3%**	-	-	**10.8%**

Note:

1. *Projections are made based on the findings of Existing Practise on Solid Waste Recycling Survey of this study and population data published by DOS.*
2. *Estimation for waste collection truck workers was based on secondary data.*
3. *Estimation for scavenger was based on primary data and secondary data.*
4. *ICI - Industrial, Commercial and Institutions*

As shown in ***Table 35***, the average recyclables, materials retained in households in Peninsular Malaysia was about 0.08 kg/capita/day whereas for the ICI, the recyclable materials were about 0.03 kg/capita/day. The estimated recyclable materials collected by waste collection truck workers and scavengers were about 0.02 kg/capita/day. Overall, the average weight of recyclables material is 0.13 kg/capita/day.

Table 35: Recycling Details for Peninsular Malaysia, in kg/capita/day

	Households (a)	Industrial, Commercial and Institutions (b)	Waste Collection Truck Workers and Scavenger (c)	Overall (a+b+c)
Recyclable materials	0.08	0.03	0.02	0.13
Waste discarded	0.72	0.39	-	1.18
Waste generated	0.80	0.43	-	1.23

9.4.2 Recycling Rate in Sabah and Sarawak

The recycling rate for Sabah and Sarawak for 2012, presented in ***Table 36***, is about ***8.6 per cent***. Of the total waste generated, estimated to be 5,307,208 kg/day (or about 3,475 metric tonnes /day), the recyclable materials that was extracted about 456,519 kg/day (or about 450 metric tonnes /day). The recyclable materials retained by waste collection truck workers and scavengers were estimated based on secondary data.

Table 36: Recycling Rate in Sabah and Sarawak

	Households	ICI	Overall at source	Waste Collection Truck Workers	Scaven-gers	Overall
Recyclable materials, in kg/day	245,911	139,158	385,069	69,396	2,055	456,519
Waste discarded, in kg/day	3,230,883	1,691,256	4,922,139	-	-	
Waste generated (waste discarded + recyclables) , in kg/day	3,476,794	1,830,414	5,307,208	-	-	5,307,208
Recycling rate, in per cent	7.1%	7.6%	**7.3%**	-	-	**8.6%**

Note:

1. *Projections are made based on the findings of Existing Practise on Solid Waste Recycling Survey of this study and population data published by DOS.*
2. *Estimation for waste collection truck workers was based on secondary data.*
3. *Estimation for scavenger was based on primary data and secondary data.*
4. *ICI - Industrial, Commercial and Institutions*

As shown in ***Table 37***, the average recyclables, materials retained in households in Sabah Sarawak was about 0.04 kg/capita/day whereas for the ICI, the recyclable materials were about 0.02 kg/capita/day. The estimated recyclable materials collected by waste collection truck workers and scavengers were about 0.01 kg/capita/day. Overall, the average weight of recyclables material is 0.08 kg/capita/day.

Table 37: Recycling Details for Sabah and Sarawak, in kg/capita/day

	Households (a)	Industrial, Commercial and Institutions (b)	Waste Collection Truck Workers and Scavenger (c)	Overall (a+b+c)
Recyclable materials	0.04	0.02	0.01	0.08
Waste discarded	0.56	0.29	-	0.85
Waste generated	0.60	0.32	-	0.92

9.4.3 Recycling Rate in Malaysia

Table 38 shows the recycling rate and ***Table 39*** shows the recycling details in Malaysia. The recycling rate is ***10.5 per cent***.

Table 38: Recycling Rate in Malaysia

	Households	ICI	Overall at source	Waste Collection Truck Workers	Scaven-gers	Overall
Recyclable materials, in kg/day	2,101,129	899,585	3,000,714	476,089	14,097	3,490,899
Waste discarded, in kg/day	19,525,600	10,603,786	30,129,386	-	-	
Waste generated (waste discarded + recyclables) , in kg/day	21,626,729	11,503,372	33,130,100	-	-	33,130,101
Recycling rate, in per cent	9.7%	7.8%	**9.1%**	-	-	**10.5%**

Note:

1. *Projections are made based on the findings of Existing Practise on Solid Waste Recycling Survey of this study and population data published by DOS.*
2. *Estimation for waste collection truck workers was based on secondary data.*
3. *Estimation for scavenger was based on primary data and secondary data.*
4. *ICI - Industrial, Commercial and Institutions*

As shown in ***Table 39,*** the average recyclables, materials retained in households in Malaysia was about 0.07 kg/capita/day whereas for the ICI, the recyclable materials were about 0.03 kg/capita/day. The estimated recyclable materials collected by waste collection truck workers and scavengers were about 0.02 kg/capita/day. Overall, the average weight of recyclables material is 0.12 kg/capita/day.

Table 39: Recycling Details for Malaysia, in kg/capita/day

	Households (a)	**Industrial, Commercial and Institutions (b)**	**Waste Collection Truck Workers and Scavenger (c)**	**Overall (a+b+c)**
Recyclable materials	0.07	0.03	0.02	0.12
Waste discarded	0.69	0.37	-	1.06
Waste generated	0.76	0.41	-	1.17

10 WASTE COMPOSITION STUDY

The Tables and Figures in this chapter present the results of the Waste Composition Study for Household and Institutional, Commercial and Industrial (ICI) waste. The first section of this chapter presents the findings of the Household waste for Malaysia, Peninsular Malaysia, Urban/Rural, and the 6 zones, namely Northern, Southern, East Coast, Klang Valley, Sarawak and Sabah. This Section also presents results from the As Generated, As Discarded and As Disposed waste. The second section discusses the findings from the ICI sectors.

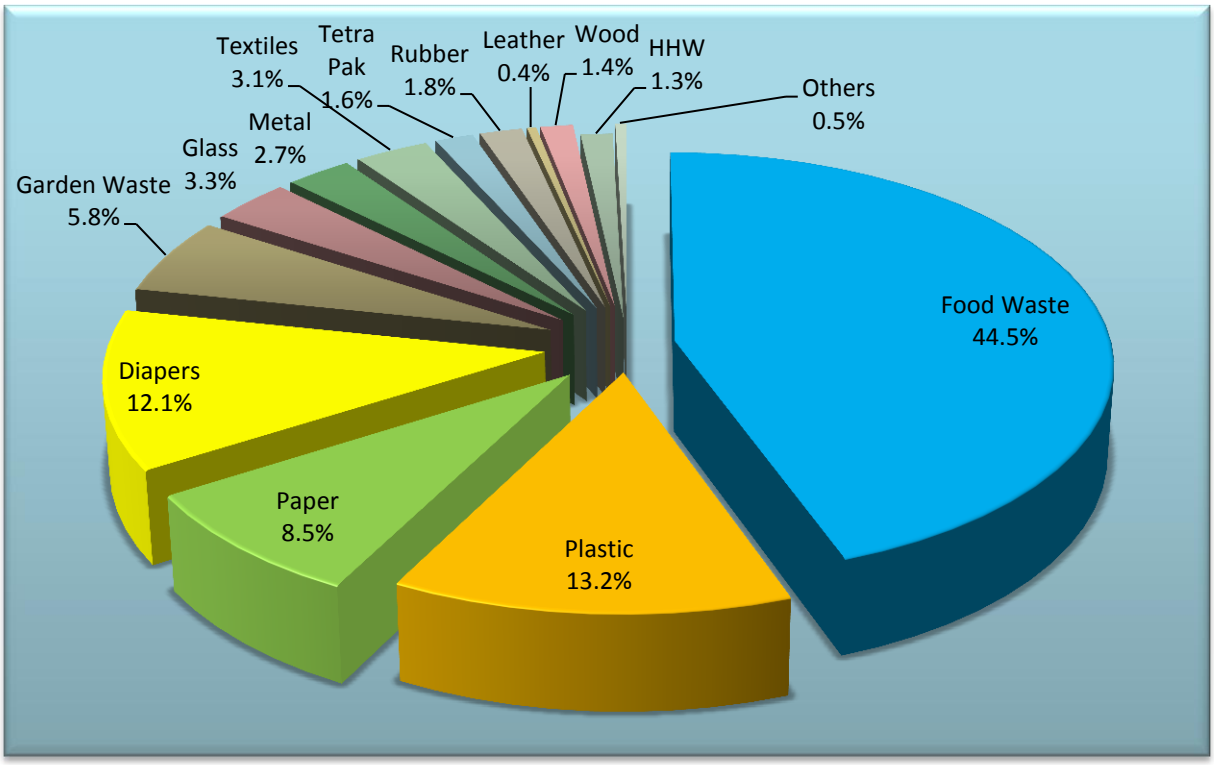
10.1 Overall Household Waste Composition

The waste composition data from the 18 Local Authorities (LAs) and number of households were used to develop the waste composition for the waste in Malaysia, Peninsular Malaysia and the 6 zones. The waste composition study data collection was by housing types, namely Low, Medium and High in each of the 18 LAs over a week cycle. The results for the week were averaged to obtain the waste composition result of each housing type of a LA.

This data was further aggregated into either national or regional, housing type or level of urbanisation by giving due weightage on the waste generation rate as well as the population in these 18 LAs. Consequently, the final waste composition for Malaysia would therefore incline towards the waste composition of the more populated urbanised areas, due to the higher waste quantities generated.

Figure 6 presents the average waste composition of the Municipal Solid Waste (MSW) generated in Malaysian Household.

Figure 6: Malaysian Household Waste Composition (As Generated)



HHW – Household Hazardous waste
Wood – Wood + Peel / Husk

The biggest component in the national waste composition is **food waste** constituting about 44.5 per cent. Plastics and paper were 13.2 per cent and 8.5 per cent respectively. The biggest deviation in the waste composition is the quantity of the waste component “Diapers” found in the waste. About 12.1 per cent of the waste contained disposable diapers and disposable feminine sanitary products. This is the consequence of the cheaper and more easily accessible diapers in the market.

Table 40 presents the breakdown of the waste components from all the "As Generated waste", all the "As Discarded" in the households and all the "As Disposed" at the Landfill in the country. It is assumed that the composition study conducted on the incoming waste at the landfill sites was primarily from the households.

Table 40: Waste Components Generated, Discarded and Disposed from Malaysian Households

	Waste Components	As Generated MT/day	As Discarded MT/day	As Disposed MT/day
Organics	Food Waste	9,685	8,563	8,492
	Garden Waste	1,252	1,240	1,445
	Wood	88	88	92
	Peel / Husk	206	217	248
Paper	Mixed Paper	310	286	273
	Newsprint / Old Newspaper	677	475	360
	Cardboard	841	697	567
Plastics	Polyethylene Terephthalate (PET)	538	463	374
	High-Density Polyethylene (HDPE)	774	610	604
	Polyvinyl Chloride (PVC)	107	92	90
	Low-Density Polyethylene (LDPE)	832	782	717
	Polypropylene (PP)	290	263	188
	Polystyrene (PS)	293	293	299
	Other Plastics	16	16	33
Glass	Glass Bottle	707	528	521
	Sheet Glass	12	30	59
Metals	Ferrous Metal	383	336	211
	Aluminium	197	160	85
	Other Non-Ferrous Metals	15	15	16
Household Hazardous Waste	Batteries	23	22	22
	Fluorescent Tube	56	48	48
	E-Waste	30	52	52
	Aerosol Cans	155	140	140
	Paint Container	20	20	20
Others	Tetra Pak	343	308	282
	Diapers	2,625	2,625	2,625
	Rubber	309	309	399
	Textiles	661	660	660
	Leather	84	85	99
	Porcelain / Ceramic/Stones	93	95	289
	Other Minor components	5	8	48
	Total	**21,627**	**19,526**	**19,358**

Food waste generated from the households daily is about 9,685 MT. This quantity reduces to 8,563 MT and 8,492 MT as the waste moves from the point of generation to point of disposal at the landfills. This reduction in the food waste is attributed to the rapid degradation of the waste over time and the release of the inherent moisture content as leachate. The second highest component in the Malaysian waste is the diapers totalling about 2,625 MT daily.

Using the information on the total number of newspaper printed in 2010 provided by the Audit Bureau of Circulations, Malaysia and the actual weight of the newspaper, it was determined that the total weight of all newspapers produced was approximately 1,100 MT per day. Assuming about 10% of this gets used for other purposes the average amount of newspaper waste generated daily is 990 MT. The above table shows that 677 MT of newspaper waste is generated from households, while the balance of 313 MT is from the ICI sector. The daily amount of 360 MT of newspaper from the households lands up at the disposal site. The difference in the amount of newspaper (317 MT/day) is the quantity collected by the recycling players from the households and goes back into the recycling sector.

It was also observed that there was an unexpected increase in quantity of porcelain/ceramic/stones by the time the waste reached the landfill. This could be caused by the contamination of the waste and collection methods used in areas where the waste is not placed in bins but on the ground.

Table 41 presents the average quantity of household waste generated by each person in a day based on the housing types.

The amount of food waste, garden waste, newspaper, HDPE and diapers generated is found to be increasing as the type of housing moves from low cost to high cost housing. The waste composition from each of the housing type includes both landed property and high rise buildings.

Table 41: Household Waste Composition for Low, Middle and High cost houses in grams/capita/day (As Generated)

Waste Components		Low cost	Medium cost	High cost
Organics	Food Waste	299.21	337.95	358.79
	Garden Waste	30.68	47.50	55.34
	Wood	3.52	3.39	1.98
	Peel /Husk	8.22	5.91	5.94
Paper	Mixed Paper	10.83	9.44	13.63
	Newsprint / Old Newspaper	23.51	33.49	39.95
	Cardboard	23.88	31.02	34.67
Plastics	Polyethylene Terephthalate (PET)	14.77	20.03	13.48
	High-Density Polyethylene (HDPE)	20.86	29.73	31.25
	Polyvinyl Chloride (PVC)	2.51	1.82	7.15
	Low-Density Polyethylene (LDPE)	28.44	28.80	27.76
	Polypropylene (PP)	10.07	10.49	7.98
	Polystyrene (PS)	8.34	10.83	12.04
	Other Plastics	0.50	0.77	0.27
Glass	Glass Bottle	22.59	24.91	26.26
	Sheet Glass	0.20	0.33	1.26
Metals	Ferrous Metal	13.55	12.52	13.83
	Aluminium	6.94	5.55	9.72
	Other Non-Ferrous Metals	0.27	0.07	1.56
Household Hazardous Waste	Batteries	0.57	0.50	2.08
	Fluorescent Tube	2.17	1.14	3.49
	E-Waste	1.08	0.71	1.92
	Aerosol Cans	5.59	4.85	6.04
	Paint Container	0.13	1.12	0.71
Others	Tetra Pak	11.21	9.64	14.59
	Diapers	78.94	93.79	106.53
	Rubber	12.08	13.41	14.51
	Textiles	22.78	22.98	21.36
	Leather	3.58	2.13	3.34
	Other Minor components	3.05	2.11	7.83

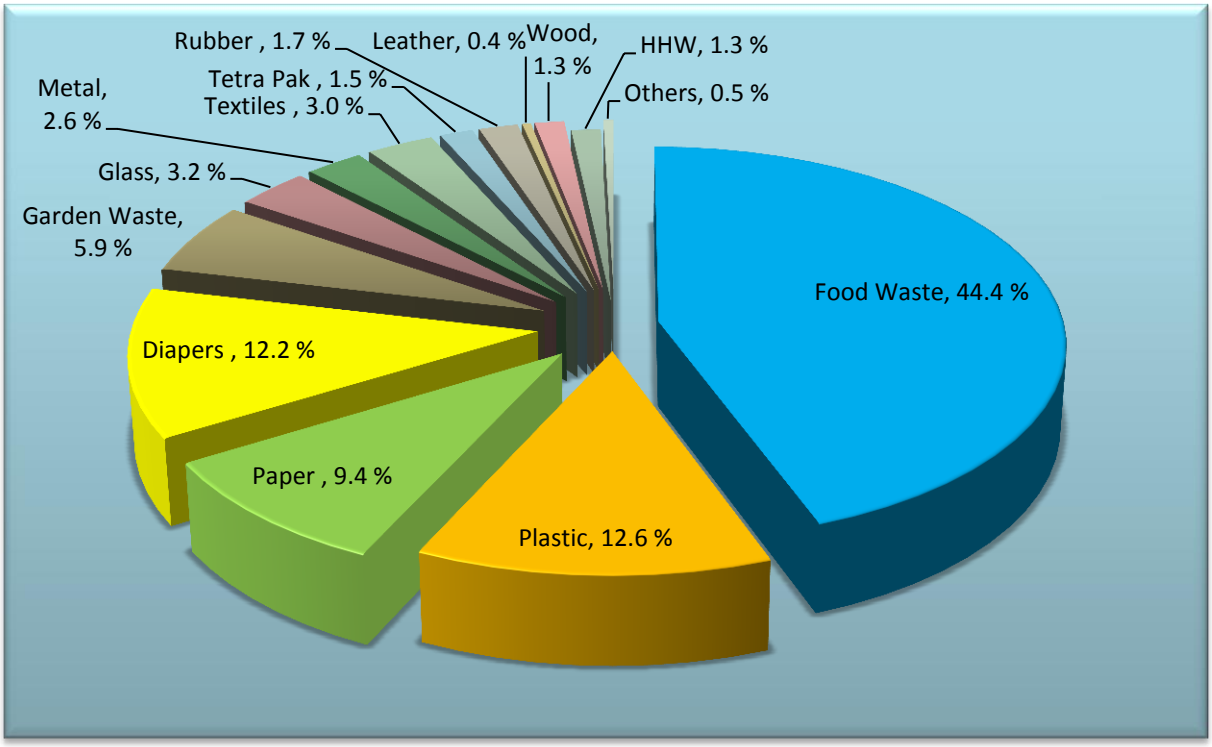
Table 42 presents the average quantity of Malaysian waste components for waste generated in the urban and rural households as defined in ***Table 3***. The amount of waste generated daily by a person in the urban area is approximately 0.8 kg. as compared to the rural area where it was found to be only 0.68 kgs. The major difference between the 2 groups, Rural and Urban, is the increase in Food waste showing with the increase in urbanisation, households waste more food.

Table 42: Comparison of the Malaysian Urban and Rural Household Waste (As Generated)

		Urban	Rural	Urban	Rural
		MT/day		grams/capita/day	
Organics	Food Waste	7,435.9	2,180.7	369.49	265.64
	Garden Waste	910.0	341.8	45.22	41.64
	Wood	67.3	20.7	3.35	2.52
	Peel / Husk	152.4	53.1	7.57	6.47
Paper	Mixed Paper	213.7	96.4	10.62	11.75
	Newsprint / Old Newspaper	477.7	199.5	23.74	24.30
	Cardboard	603.3	237.7	29.98	28.95
Plastics	Polyethylene Terephthalate (PET)	352.3	187.6	17.50	22.86
	High-Density Polyethylene (HDPE)	541.2	232.5	26.89	28.32
	Polyvinyl Chloride (PVC)	78.9	28.1	3.92	3.42
	Low-Density Polyethylene (LDPE)	575.1	257.1	28.57	31.32
	Polypropylene (PP)	220.1	69.9	10.93	8.51
	Polystyrene (PS)	182.6	110.8	9.07	13.50
	Other Plastics	4.7	12.6	0.23	1.54
Glass	Glass Bottle	516.5	190.4	25.67	23.19
	Sheet Glass	6.3	5.3	0.31	0.65
Metals	Ferrous Metal	262.5	120.5	13.04	14.68
	Aluminium	153.4	43.1	7.62	5.25
	Other Non-Ferrous Metals	6.7	4.5	0.34	0.54
Household Hazardous Waste	Batteries	16.6	6.2	0.83	0.76
	Fluorescent Tube	39.8	16.2	1.98	1.97
	E-Waste	22.5	7.8	1.12	0.95
	Aerosol Cans	118.4	36.6	5.88	4.46
	Paint Container	12.8	6.8	0.64	0.83
Others	Tetra Pak	250.7	91.8	12.46	11.18
	Diapers	1,928.3	697.3	95.82	84.95
	Rubber	288.9	92.2	14.36	11.23
	Textiles	473.2	188.1	23.51	22.91
	Leather	59.7	24.8	2.96	3.02
	Porcelain / Ceramic	60.7	32.3	3.02	3.93
	Other Minor components	5.1	0.7	0.26	0.09
	Total	16,037.3	5,593.1	796.9	681.33

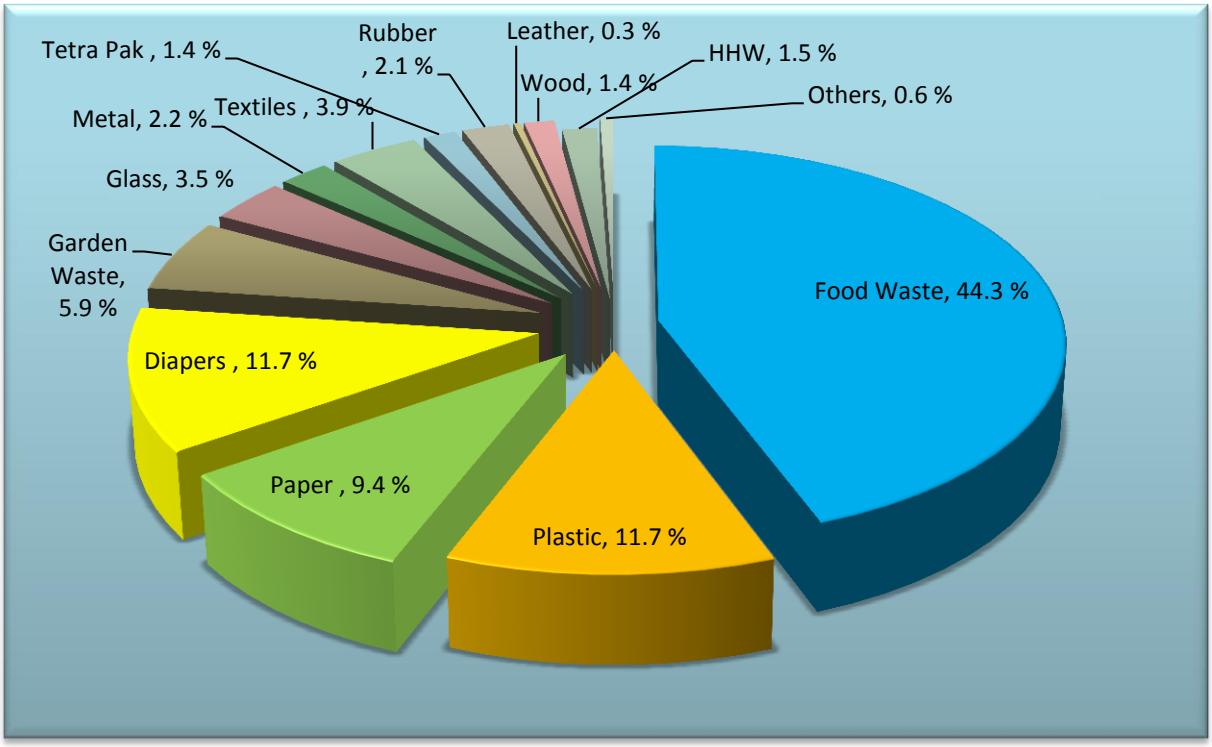
Figure 7 to ***Figure 13*** present the average waste composition of the Municipal Solid Waste generated in Households in Peninsular Malaysia, Klang Valley, East Coast, Northern Zone and Southern Zone, Sarawak and Sabah respectively. The biggest component in the waste is **food waste** which ranges between 44 per cent and 46 per cent except in the East Coast, Sarawak and Sabah where it was below 40 per cent. As seen in the average Malaysian waste, the quantity of **diapers** was 9.0 per cent to 13.0 per cent of the waste inside the household.

Figure 7: Peninsular Malaysia Household Waste Composition (As Generated)



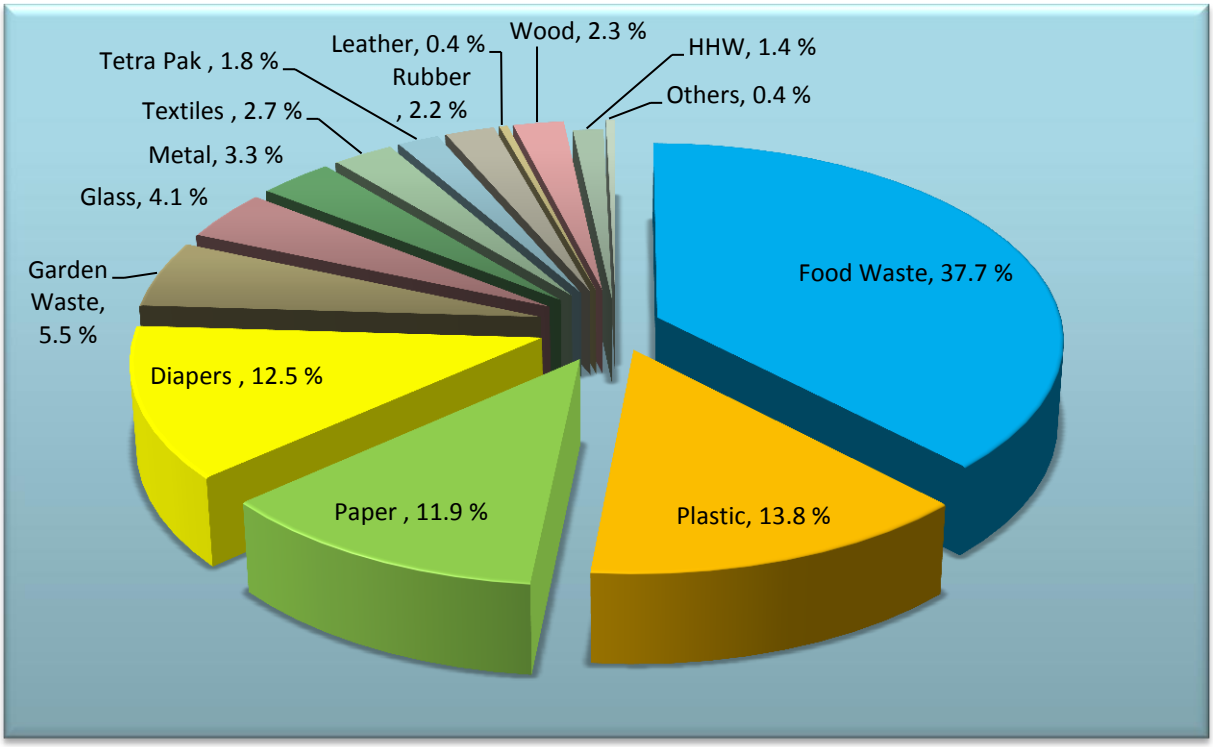
HHW – Household Hazardous waste
Wood – Wood + Peel / Husk

Figure 8: Klang Valley Household Waste Composition (As Generated)



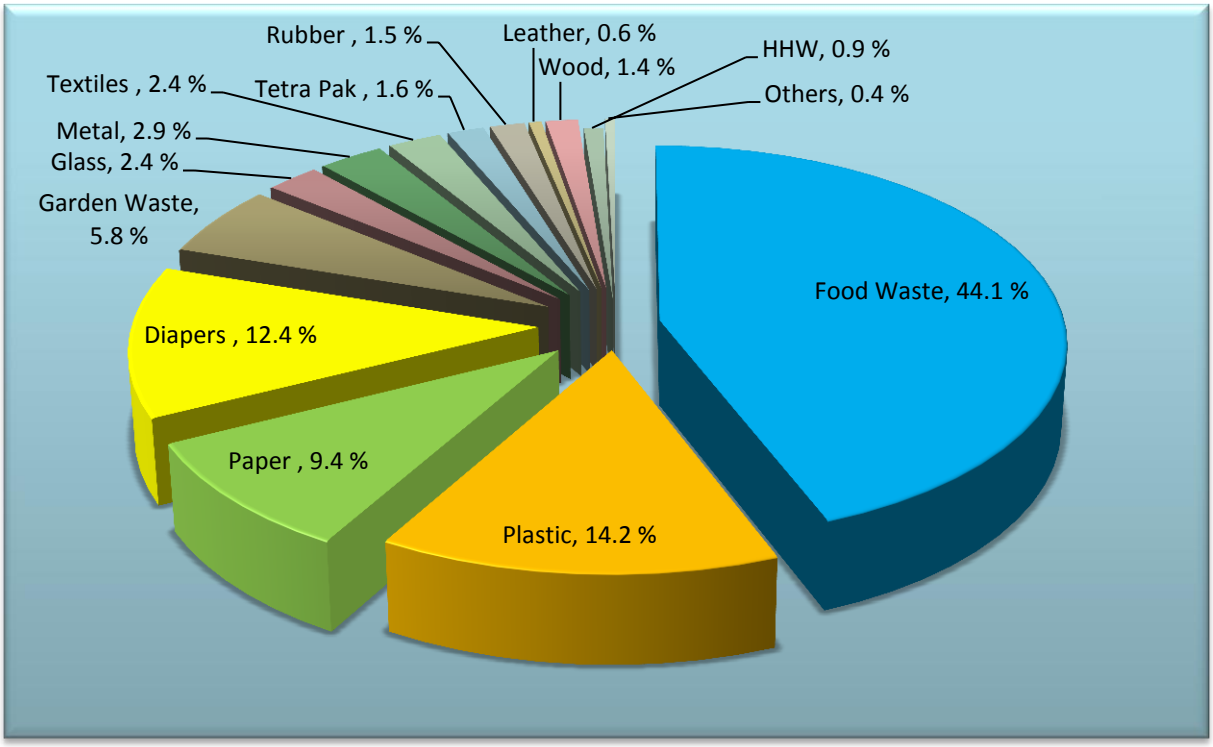
HHW – Household Hazardous waste
Wood – Wood + Peel / Husk

Figure 9: East Coast Household Waste Composition (As Generated)



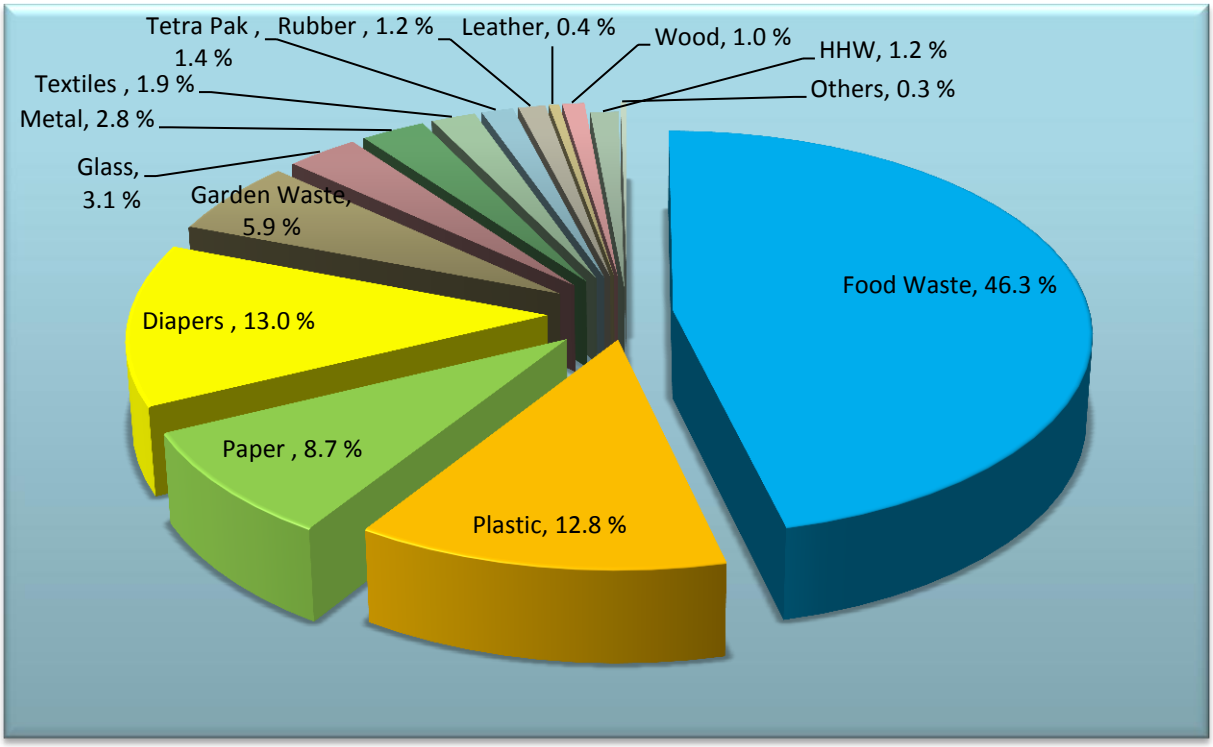
HHW – Household Hazardous waste
Wood – Wood + Peel / Husk

Figure 10: Northern Zone Household Waste Composition (As Generated)



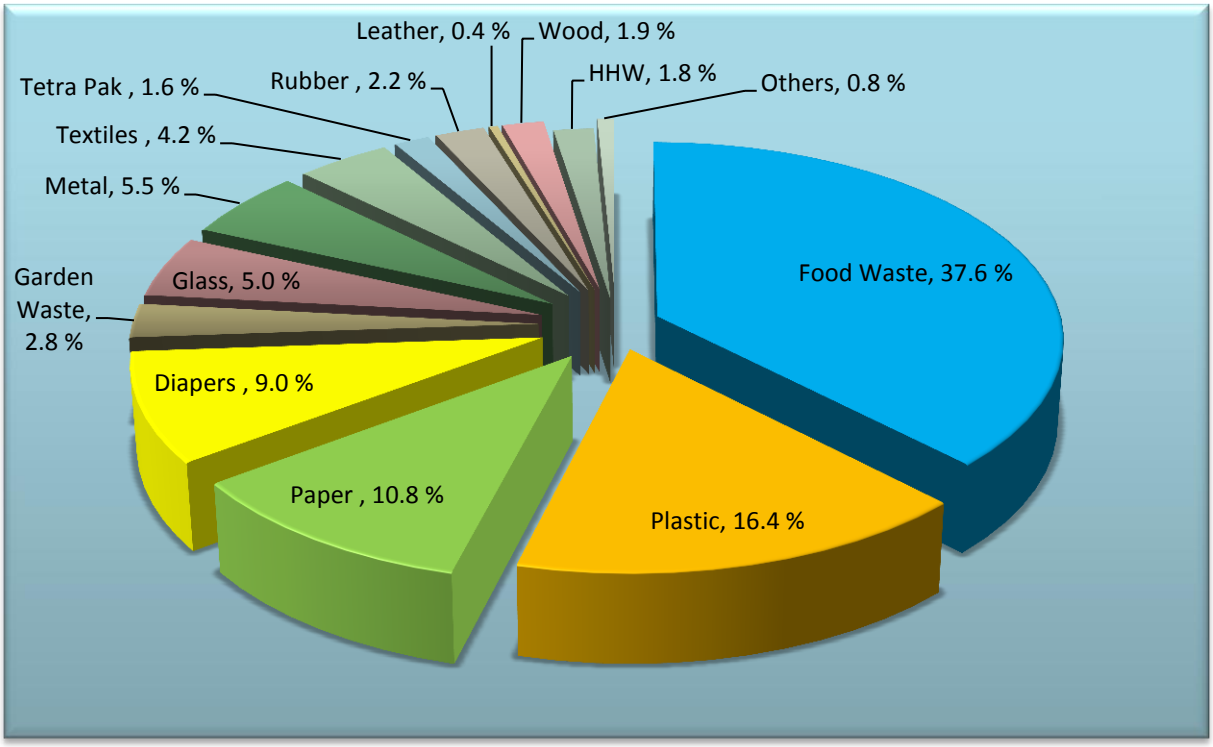
HHW – Household Hazardous waste
Wood – Wood + Peel / Husk

Figure 11: Southern Zone Household Waste Composition (As Generated)



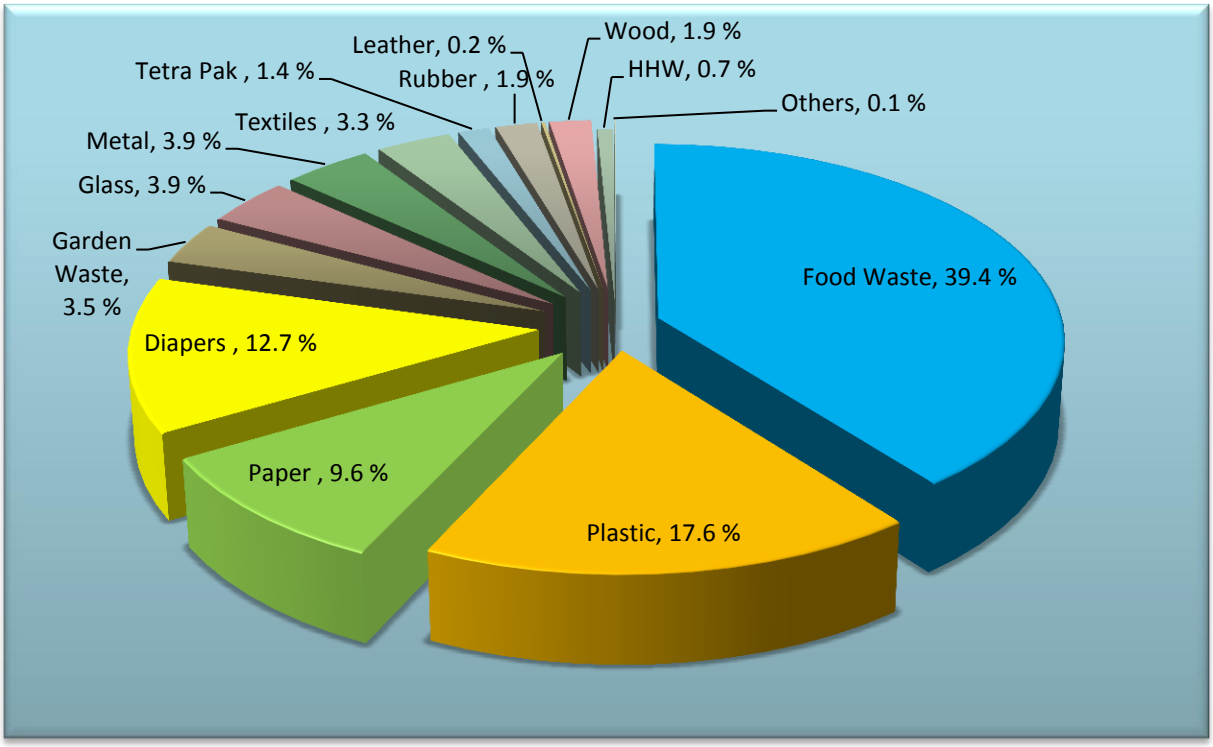
HHW – Household Hazardous waste
Wood – Wood + Peel / Husk

Figure 12: Sarawak Household Waste Composition (As Generated)



HHW – Household Hazardous waste
Wood – Wood + Peel / Husk

Figure 13: Sabah Household Waste Composition (As Generated)



HHW – Household Hazardous waste
Wood – Wood + Peel / Husk

Table 43 presents the average quantity of household waste generated by each person in a day based on the 6 zones. The amount of food and garden waste, newspaper, HDPE and noticeably diapers generated by one person was highest in the Klang Valley followed by Southern Zone (which comprises of the states of Negeri Sembilan, Melaka & Johor).

Table 43: Breakdown of Household Waste Components generated by each person for six Regions, in grams/capita/day

	Waste Components	Northern	Southern	Klang Valley	East Coast	Sarawak	Sabah
Organics	Food Waste	307.51	405.82	416.21	204.27	238.44	225.35
	Garden Waste	40.51	52.06	55.42	29.63	17.57	19.88
	Wood	2.41	2.23	4.71	3.01	5.06	1.52
	Peel / Husk	7.60	6.20	8.01	9.21	6.70	9.10
Paper	Mixed Paper	15.52	13.43	8.69	12.74	10.34	7.53
	Newsprint / Old newspaper	25.41	32.27	41.92	27.02	27.09	22.31
	Cardboard	24.38	30.73	38.03	24.86	31.24	25.01
Plastics	PET	21.29	18.18	19.11	12.70	15.34	19.17
	HDPE	22.38	31.71	33.35	17.32	31.44	28.23
	PVC	4.46	2.07	3.44	3.17	1.47	3.23
	LDPE	27.18	35.85	32.13	24.30	31.82	27.84
	Polypropylene (PP)	9.45	13.79	11.13	7.29	10.87	5.95
	Polystyrene (PS)	12.17	10.02	10.39	10.16	13.26	15.68
	Other Plastics	2.13	0.82	-	-	-	0.48
Glass	Glass Bottle	16.23	27.08	32.64	21.00	31.40	21.97
	Sheet Glass	0.56	0.43	0.29	1.17	0.37	0.16
Metals	Ferrous Metal	14.59	15.44	12.72	13.35	22.21	15.16
	Aluminium	5.18	8.72	7.76	4.68	12.91	6.21
	Other Non-Ferrous Metals	0.41	0.47	0.44	-	0.05	1.14
Household Hazardous Waste	Batteries	0.32	0.39	1.51	0.46	1.46	0.14
	Fluorescent Tube	2.32	2.43	2.48	0.30	1.23	0.42
	E-Waste	0.07	0.54	2.12	1.68	0.32	0.29
	Aerosol Cans	3.12	5.26	7.87	4.59	8.31	3.19
	Paint Container	0.13	1.94	0.54	0.29	-	-
Other Waste Components	Tetra Pak	11.41	12.07	13.52	10.02	10.02	7.94
	Diapers	86.35	113.73	109.93	67.49	57.36	72.59
	Rubber	10.74	10.23	19.73	11.93	13.99	10.61
	Textiles	16.74	16.78	37.01	14.66	26.73	19.15
	Leather	3.91	3.94	2.84	2.04	2.45	0.93
	Porcelain / Ceramic	2.40	2.31	5.47	1.56	4.79	0.35
	Fine	0.62	-	0.03	0.60	-	-

10.2 ICI Waste Composition

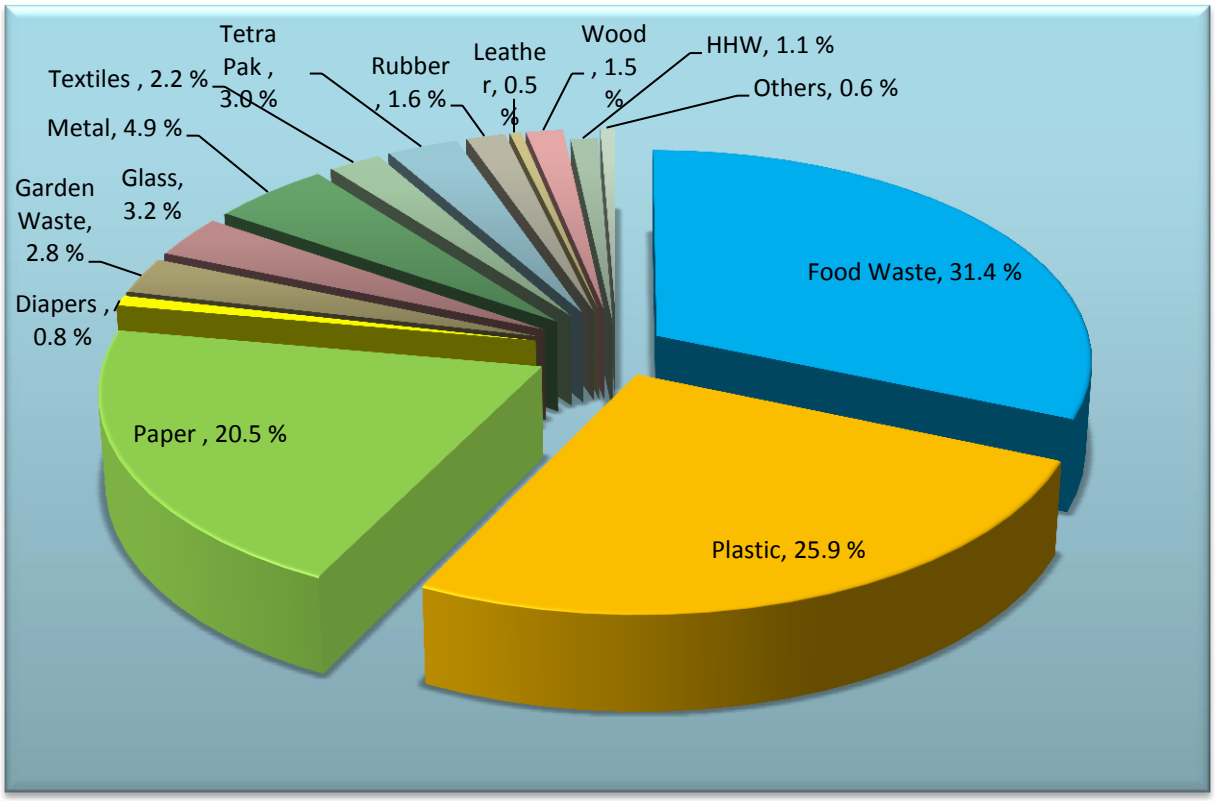
This section presents the results of the waste composition study for the ICI sectors.

10.2.1 Malaysia ICI Waste Composition

The waste composition data from industries, commercial and institutional in the 18 LAs were used to develop the ICI waste composition for Malaysia.

Figure 14 below presents the average waste composition of the Municipal Solid Waste (MSW) generated in Malaysian ICI. The biggest component in the waste is Food waste.

Figure 14: Malaysia ICI Waste Composition

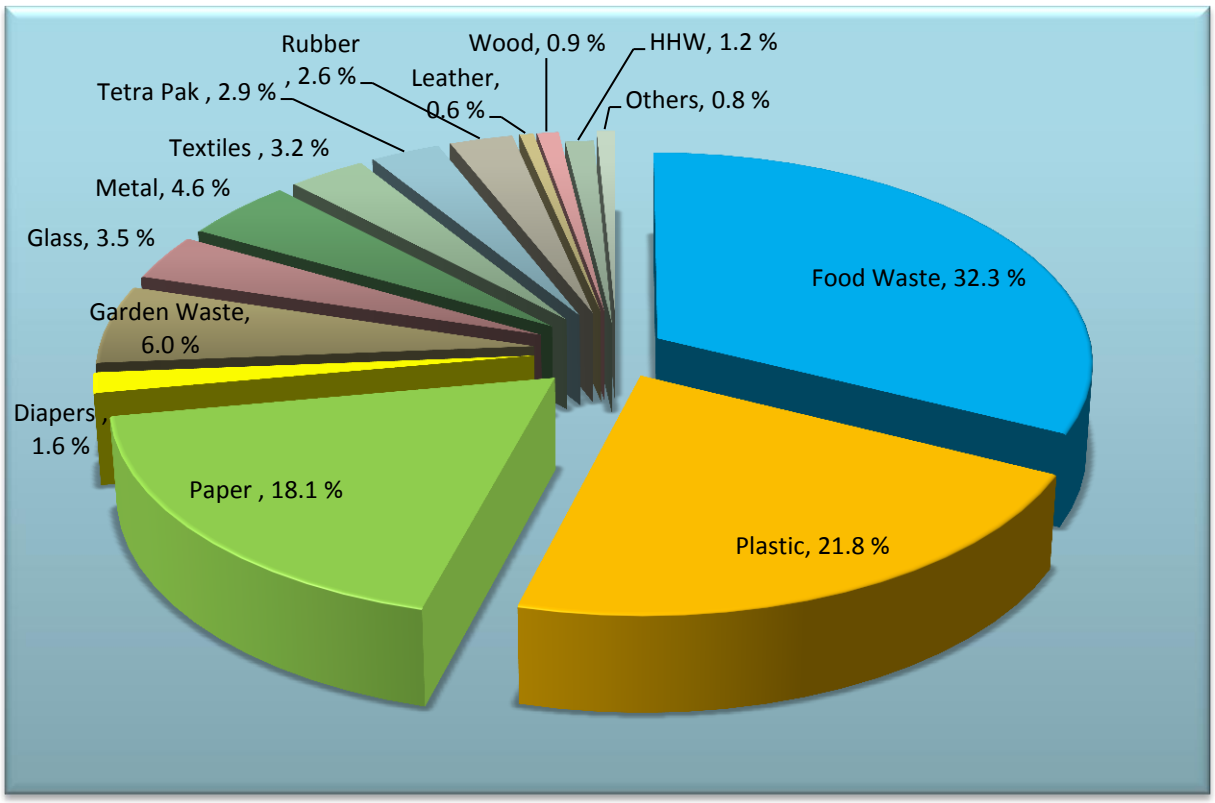


10.2.2 Institutional Waste Composition

The main Institutional sector comprised of the following categories; government offices, schools, college, universities, polytechnics, hospitals, clinics, and public transportation facilities.

Figure 15 presents the average composition of the waste collected from the various institutions in Malaysia. Food Waste was recorded to be the highest average with an average of 32 per cent followed by plastics at 22 per cent and paper at 18 per cent.

Figure 15: Composition of Institutional Waste for Malaysia



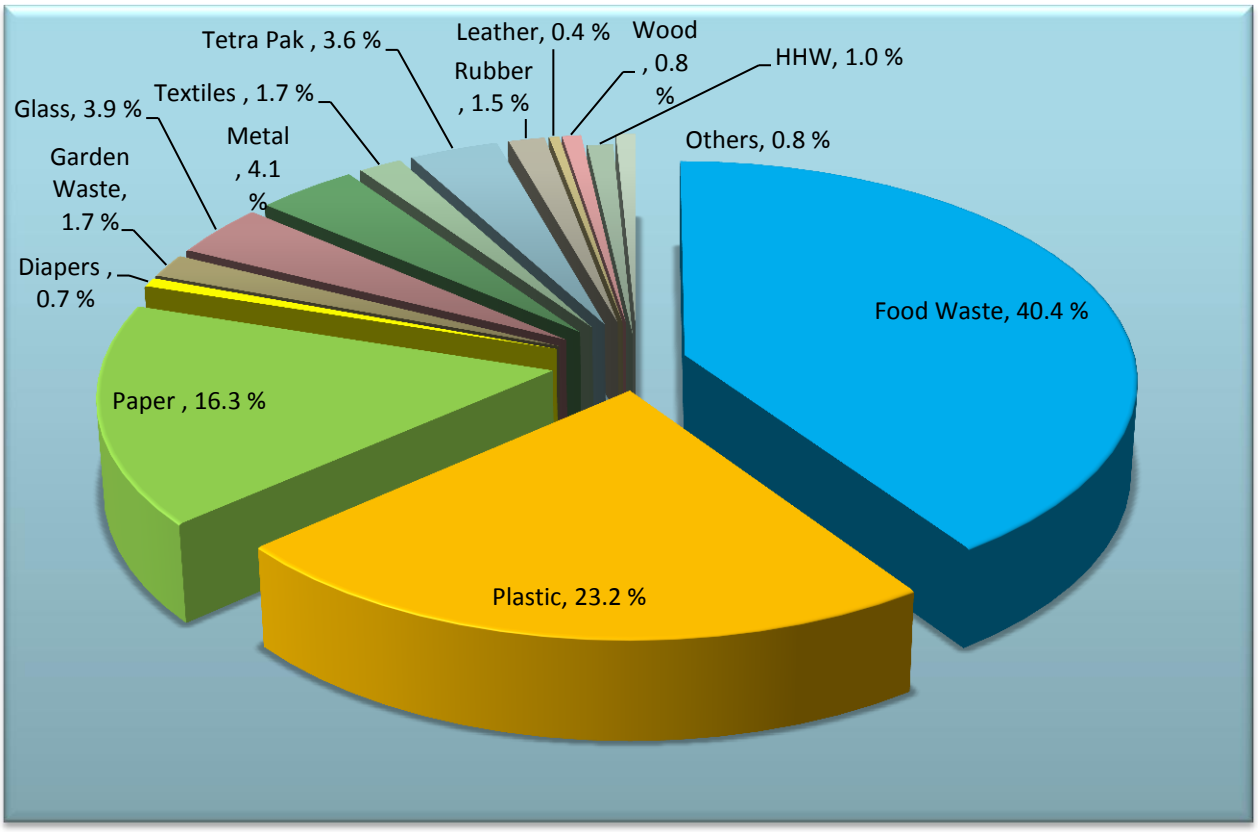
10.2.3 Commercial Waste Composition

The Commercial sector comprises of the following categories:

- Markets
- Supermarkets
- Shopping complexes
- Hotels
- Food courts
- Restaurants
- Business lots

Figure 16 presents the average composition of the waste collected from the various Commercial facilities in Malaysia. Food Waste was the highest component with an average of 40 per cent followed by plastics at 23 per cent and paper at 16 per cent.

Figure 16: Composition of Commercial Sector Waste for Malaysia



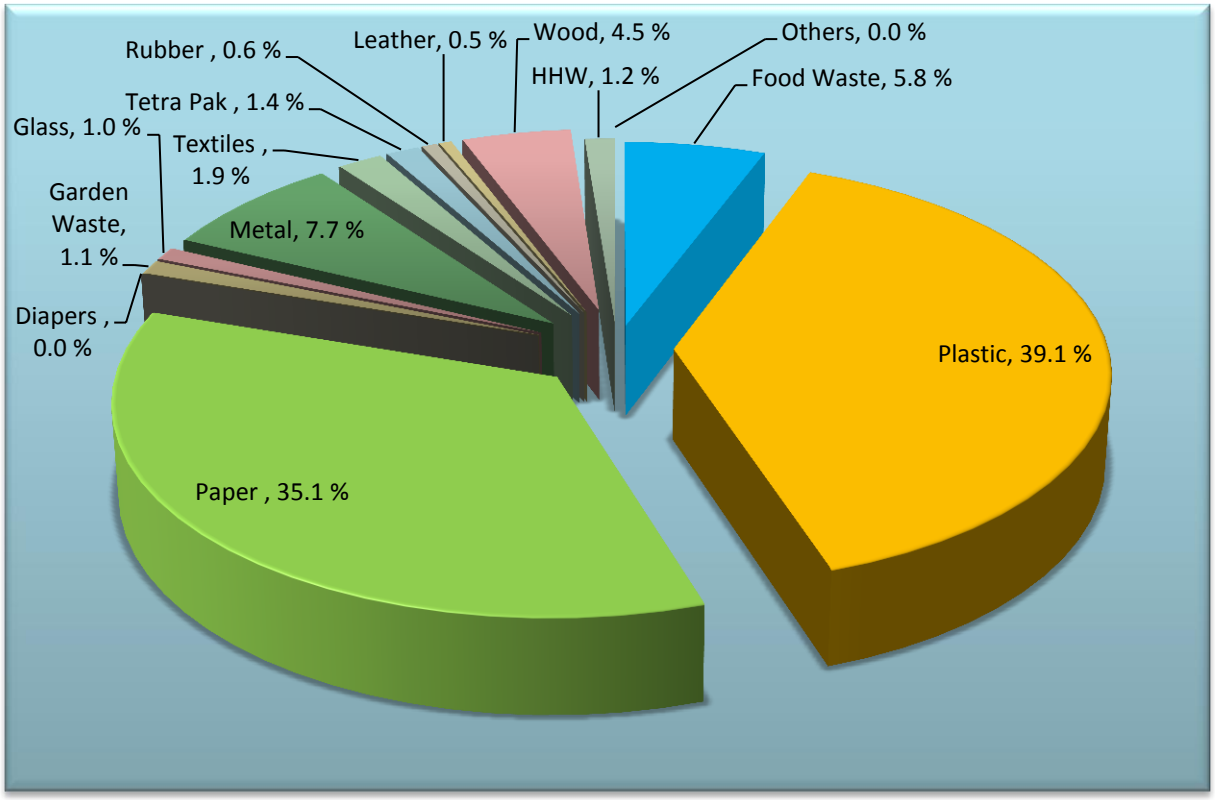
10.2.4 Industrial Waste Composition

The waste samples were taken from various Industrial sectors which included:

- Food and beverages
- Textile apparel
- Chemical
- Petrochemical
- Plastic products
- Electrical and electronics products
- Fabricated metal
- Basic metal and non-metallic mineral products
- Paper and paper products
- Wood and products of wood

Figure 17 presents the Average Composition of the waste collected from the various industries in Malaysia. For industrial waste, the highest components were plastics at 39 per cent and paper at 35 per cent. Food waste comprised of only 6 per cent of the total waste.

Figure 17: Average Composition of Industrial Waste in Malaysia



10.3 Recyclables in the As Disposed Waste

Table 44 presents the amount of selected recyclable material present in the incoming waste at the landfill or the Transfer Station. The total quantity of recyclable material is estimated to be 6,500 MT of which the plastics fraction makes up almost 45%.

Table 44: Quantity of Recyclable Material found in the As Disposed Waste

Recyclable Components	Quantity in the As Disposed waste	
	MT/day	percentage of total waste
Mixed Paper	418	1.41%
Newsprint / Old Newspaper	551	1.86%
Cardboard	868	2.93%
Polyethylene Terephthalate (PET)	573	1.93%
High-Density Polyethylene (HDPE)	925	3.12%
Low-Density Polyethylene (LDPE)	1098	3.70%
Polypropylene (PP)	288	0.97%
Glass Bottle	798	2.69%
Ferrous Metal	323	1.09%
Aluminium	130	0.44%
Other Non-Ferrous Metals	24	0.08%
E-Waste	80	0.27%
Paint Container	31	0.10%
Tetra Pak	432	1.46%
	6,539	22.05%

10.4 Hazardous Material

During the sorting activity, some hazardous waste was observed in the MSW. The quantity of the hazardous waste from Peninsular Malaysia, Sarawak and Sabah is presented in ***Table 45***.

Table 45: Percentage of Hazardous Material found in the MSW

Hazardous Material	Household Generated, %	Household Generated, MT/day
Peninsular Malaysia	1.31%	235.5
Sarawak	1.78%	28.4
Sabah	0.71%	13.8

The items commonly found during the sorting activities of MSW in the 18 sites are as follows:-

- Batteries – Alkaline batteries, Ni-Cd/Li-ion rechargeable batteries, small lead batteries.
- Fluorescent Tube / bulbs – mostly broken.
- E waste – Electronic components like printed circuit boards, computer parts, radio, CD/DVD players and parts.
- Aerosol cans including insect repellent spray, detergent, household chemical containers and cans.
- Paint spray cans and containers.
- Medical waste – cough syrup bottles, swabs, a few syringes (with and without needles), some expired pills.
- Motor service waste – oil and air filters, plugs, oil and grease containers.
- Others – asbestos sheet, fire extinguishers.

Although the amount of this type of waste was small, the presence of these items in the waste stream was noted and should be removed systematically. Most of these types of wastes originate from the households and shop-lots. Some of these could however, be removed from the waste stream by having collection centres and buy back systems.

11 WASTE CHARACTERISATION STUDY

The Tables and Figures in this chapter present the results of the waste characterisation study for Household and ICI waste. The first section presents the findings of the Household waste for Malaysia. This Section also presents results from the As Generated, As Discarded and As Disposed waste. The second section discusses findings from the ICI sector. The ***Section 11.3*** presents the results from the individual waste component analysis.

11.1 Household Waste Characterisation

The field samples taken from the households were analysed for its moisture content, calorific value and Nitrogen, Phosphorus and Potassium (NPK) values. Apart from these, proximate and ultimate analysis was also conducted to get the various constituents in the samples. The following section discusses the findings from these analyses.

11.1.1 Moisture Content

The average Moisture content of the household samples from various groupings is as presented in ***Table 46***. The average moisture content for the generated waste varied from 52 per cent to 54 per cent for the household waste in urban areas while the average moisture content for the generated waste varied from 42 per cent to 47 per cent for rural household waste. The moisture in the waste is clearly increasing as the waste moves from the point of generation to the point of disposal. This can be attributed to increase of food content with the reduction in recyclable material and the precipitation.

Table 46: Moisture Content - Malaysian Household MSW, in per cent

	Urban Household			Rural Household			Malaysian Average
	Low Cost	Medium Cost	High Cost	Low Cost	Medium Cost	High Cost	
As Generated	53.84	52.30	51.95	43.92	46.96	42.03	52.10
As Discarded	56.53	59.13	58.87	48.18	50.35	47.01	57.34
As Disposed	59.65			60.55			59.45

11.1.2 Proximate Analysis

The Proximate analysis was carried out to obtain the Fixed Carbon, Ash Content and Volatile Matter of the combustible fraction of the household waste sample. The average proximate analysis results for the As Discarded and As Disposed waste is presented in ***Table 47***.

Table 47: Average Proximate Analysis Results for Malaysian As Discarded and As Disposed Waste in per cent, wet basis (n=54)

	As Discarded	As Disposed
Moisture Content	57.34	59.45
Volatile Matter Content	22.79	20.79
Fixed Carbon Content	11.48	11.10
Ash Content	8.39	8.65

Note: Non-combustible fraction of the waste removed before analysing the sample

11.1.3 Ultimate Analysis

The Ultimate analysis was carried out to obtain the elementary components of Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur and Organic Chlorine present in the combustible fraction of the waste sample. The major chemical constituents of the As Discarded and As Disposed waste are presented in ***Table 48***. These results are shown on wet basis.

Table 48: Average Ultimate Analysis Results for Malaysian As Discarded and As Disposed Waste in per cent, wet basis (n=54)

	As Discarded	As Disposed
Moisture Content	57.34	59.45
Carbon Content	21.57	17.36
Sulphur Content	0.05	3.35
Hydrogen Content	4.29	5.89
Nitrogen Content	1.37	1.05
Oxygen Content	7.47	5.89
Organic Chlorine Content	0.06	0.04
Ash Content	7.85	6.96

Note: Non-combustible fraction of the waste removed before analysing the sample

11.1.4 Metals

The minor chemical constituents of Metals, of the As Discarded and As Disposed waste samples are presented in ***Table 49***. These results are shown on wet basis.

Table 49: Average Heavy Metal results of the As Discarded and As Disposed Waste in ppm, wet basis (n=54)

	As Discarded	As Disposed
Mercury	0.084	0.092
Vanadium	2.859	3.590
Chromium	37. 46	46.58
Manganese	15.17	21.97
Iron	269.34	318.27
Cobalt	0.30	0.53
Copper	6.46	5.92
Zinc	18.50	19.35
Arsenic	0.18	0.66
Silver	0.41	0.66
Cadmium	0.29	2.38
Lead	1.43	1.98
Aluminium	143.65	148.23
Magnesium	56.98	88.30
Nickel	2.49	1.94

11.1.5 Bulk Density

The average Bulk Density of the As Discarded and As Disposed waste samples measured at the Landfill/Dumpsite are presented in ***Table 50***.

***Table 50*:** Average Bulk Density measurements As Discarded and As Disposed Waste in kg/m^3, (n=54,108)

	As Discarded	As Disposed
Bulk Density	185.33	202.54

11.1.6 Calorific Value

The average Higher Heating Value or also known as Calorific Value of the As Discarded and As Disposed waste samples analysed at the laboratory are presented in ***Table 51***.

Table 51: Average Calorific Value Results As Discarded and As Disposed Waste (n=54,108)

	As Discarded	As Disposed
Higher Heating Value, HHV_{dry} dry basis, kJ/kg (kcal/kg)	21,671 (5,176)	21,185 (5,060)
Lower Heating Value, LHV_{wet} wet basis, kJ/kg (Kcal/kg)	6,950 (1,660)	6,325 (1,511)

11.1.7 NPK and Biodegradability

The average Nitrogen, Phosphorus and Potassium content of the organic fraction of the dry As Disposed waste samples analysed at the laboratory are presented in ***Table 52.***

Table 52: Average NPK value of the organic fraction of the Waste in per cent, dry basis (n=108)

NPK	As Disposed
Total Nitrogen	3.88
Phosphorous (P_2O_5)	3.46
Potassium (K_2O)	2.42

Biodegradability is an important parameter when using treatment techniques such as composting. If a large fraction of the solid waste is not biodegradable, then this fraction will have to be disposed off by other means if composting is the primary mode of treatment. The potential biodegradability of the waste samples were determined using the estimated percentage of degradation of the individual components, as presented in ***Table 53***, of the waste sample as recommended by Aarne Vesilind *et al*. in his book “Solid Waste Engineering”.

Table 53: Potential Biodegradability of Each Waste Component

Waste Components	Bio Fraction
Food Waste	0.82
Garden Waste	0.72
Paper	0.5
Plastics	0
Textile	0.5
Rubber & Leather	0.5
Wood	0.7
Glass	0
Ferrous Metal	0
Aluminium	0
Other non-Ferrous Metal	0
Miscellaneous inorganic	0.8
Other Material	0.5

Source: Solid Waste Engineering, Aarne Vesilind *et al*.

Using the data provided in the above table, the average waste composition of the As Disposed Waste was used to compute the biodegradability of the sample.

The average biodegradability of Malaysian waste calculated from 54 samples was found to be 61.2 per cent with a median value of 61.4 per cent.

11.2 ICI Waste Characterisation

The field samples taken from the ICI were analysed for its moisture content and calorific values. Apart from these, proximate and ultimate analysis was also conducted to get the various constituents in the samples. The following section discusses the findings from these analyses.

11.2.1 Moisture Content

The average Moisture content of the ICI samples from various categories are presented in ***Table 54.*** The average moisture content varies from 47 per cent to 54 per cent.

Table 54: Moisture Content - Malaysian ICI Waste (n=54)

Institutional	Commercial	Industry	Overall ICI Sector
50.49%	54.19%	47.02%	51.75%

11.2.2 Proximate Analysis

The Proximate analysis was carried out to obtain the Fixed Carbon, Ash Content and Volatile Matter of the combustible fraction of the ICI waste samples. The average proximate analysis results for the various sectors are presented in ***Table 55***.

Table 55: Average Proximate Analysis Results for Malaysian ICI Sector Waste, in per cent, Wet basis (n=54)

	Institutional	Commercial	Industry	Overall ICI Sector
Moisture Content	50.49	54.19	47.02	51.75
Volatile Matter Content	27.74	25.10	28.84	26.57
Fixed Carbon Content	13.07	12.91	14.60	13.28
Ash Content	8.70	7.80	9.55	8.40

Note: Non-combustible fraction of the waste removed before analysing the sample

11.2.3 Ultimate Analysis

The Ultimate analysis was carried out to obtain the elementary components of Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur and Organic Chlorine present in the combustible fraction of the ICI waste sample. The major chemical constituents of the ICI Sector waste are presented in ***Table 56***. These results are shown on wet basis.

Table 56: Average Ultimate Analysis Results for ICI sector waste, in per cent, wet basis (n=54)

	Institutional	Commercial	Industry	Overall ICI Sector
Moisture Content	50.49	54.19	47.02	51.75
Carbon Content	24.49	23.09	26.26	24.11
Hydrogen Content	5.30	4.72	5.31	5.00
Oxygen Content	9.33	8.68	9.83	9.09
Nitrogen Content	1.39	1.29	1.54	1.37
Organic Chlorine Content	0.07	0.05	0.10	0.07
Total Chlorine Content	0.16	0.13	0.31	0.17
Sulphur Content	0.12	0.05	0.09	0.08
Ash Content	8.65	7.80	9.54	8.36

Note: Non-combustible fraction of the waste removed before analysing the sample

11.2.4 Metals

The minor chemical constituents of metals, of the ICI waste samples are presented in ***Table 57.*** These results are shown on wet basis.

Table 57: Average Heavy Metal results of the ICI Waste in ppm, wet basis (n=54)

	Institutional	Commercial	Industry	Overall ICI Sector
Mercury	0.127	0.112	0.174	0.127
Vanadium	1.895	1.425	0.382	1.371
Chromium	24.59	22.16	16.86	21.94
Manganese	10.80	6.77	5.71	7.71
Iron	172.02	163.17	146.73	163.17
Cobalt	0.79	0.47	0.17	0.51
Copper	6.83	3.74	3.77	4.59
Zinc	10.52	7.99	15.59	10.06
Arsenic	0.76	0.44	0.28	0.50
Silver	0.30	0.31	0.33	0.31
Cadmium	1.04	0.57	0.23	0.64
Lead	1.47	1.67	1.52	1.59
Aluminium	128.93	90.90	184.79	118.27
Magnesium	22.31	27.30	56.38	31.22
Nickel	2.80	2.22	1.71	2.29

Note: Non-combustible fraction of the waste removed before analysing the sample

11.2.5 Bulk Density

The average Bulk Density of the ICI sector waste samples are presented in ***Table 58.***

Table 58: Bulk Density measurements of the ICI Waste, in kg/m^3 (n=54)

	Institutional	Commercial	Industry	Overall ICI Sector
Bulk Density	137.09	145.18	101.56	134.38

11.2.6 Calorific Value

The calorific value, also known as higher heating value, is analysed on a dry basis. The average higher heating value of the ICI samples from various categories are presented in ***Table 59***.

Table 59: Average Calorific Value of the ICI Waste (n=54)

	Institutional	Commercial	Industry	Overall ICI Sector
Higher Heating Value, HHV_{dry} dry basis, kJ/kg (kcal/kg)	21,192 (5,061)	20,542 (4,906)	20,757 (4,958)	20,765 (4,960)
Lower Heating Value, LHV_{wet} wet basis, kJ/kg (kcal/kg)	8,165 (1,950)	7,121 (1,701)	8,755 (2,091)	7,727 (1,846)

11.3 Individual Waste Component Analysis

Apart from analysis of the co-mingled waste samples from the various sectors, 17 individual waste components extracted from 5 disposal sites were also analysed for their major and minor chemical constituents. Components which are inert or metals were not analysed.

Table 60 presents the Proximate Analysis, Ultimate Analysis and the Calorific Value of the individual waste components of the As Disposed Samples from the disposal sites.

Table 61 presents the Metal analysis of the individual waste components of the As Disposed Samples from the disposal sites.

Table 60: Proximate, Ultimate analysis and Calorific Value of the Individual Components

	Moisture content	Proximate Analysis			Ultimate Analysis					Calorific Value		
	Moisture content, %	Volatile Matter, wet basis %	Fixed Carbon, wet basis %	Ash Content, wet basis %	Carbon Content, wet basis %	Hydrogen Content, wet basis %	Oxygen Content, wet basis %	Nitrogen Content, wet basis %	Sulphur Content, wet basis %	Higher Heating Value dry,kJ/kg	Lower Calorific Value wet,kJ/kg	Lower Calorific Value wet, kcal/kg
Food	82.00	14.30	1.54	2.16	7.88	1.20	5.60	1.09	0.05	12,427	229	55
Garden	30.85	50.46	11.14	7.55	30.70	3.01	26.88	0.81	0.20	17,522	11,356	2,712
Mixed Paper	54.57	34.51	3.70	7.22	21.63	3.20	12.39	0.79	0.20	20,536	7,988	1,908
Newsprint	22.73	74.33	1.03	1.90	37.78	6.50	29.50	1.35	0.23	16,209	11,953	2,855
Cardboard	12.17	72.53	7.36	7.94	37.39	7.15	33.18	1.61	0.56	16,466	14,148	3,379
Tetra Pak	14.70	71.20	7.33	6.78	38.41	6.39	32.21	1.20	0.32	14,884	12,323	2,943
PET	5.69	92.46	0.93	0.92	79.37	8.06	4.95	0.88	0.12	33,755	31,678	7,566
HDPE	5.65	91.64	1.30	1.41	76.24	9.26	6.40	0.74	0.30	34,706	32,584	7,783
PVC	7.29	79.78	3.77	9.17	69.58	7.30	4.17	1.17	1.33	32,143	29,607	7,072
LDPE	44.69	50.40	0.96	3.95	40.62	6.14	3.72	0.74	0.14	29,924	15,443	3,688
PP	24.52	61.93	6.45	7.10	49.46	7.14	9.99	1.65	0.14	30,620	22,498	5,373
PS	10.32	88.19	0.29	1.20	67.79	8.37	10.33	1.42	0.58	31,725	28,180	6,731
Diapers	76.69	19.91	1.72	1.68	9.93	2.26	9.10	0.26	0.08	25,434	4,049	967
Textile	53.80	37.86	7.31	1.03	25.39	3.19	15.83	0.56	0.21	18,185	7,079	1,691
Rubber	2.96	87.76	0.92	8.36	66.58	5.14	13.51	0.99	2.47	23,092	22,323	5,332
Leather	4.66	81.54	4.86	8.95	58.74	8.64	16.56	1.53	0.93	26,337	24,977	5,966
Wood	15.92	72.07	10.89	1.11	43.65	6.52	31.34	1.21	0.25	20,092	16,488	3,938

- Non-combustible fraction of the waste removed before analysing the sample

Table 61: Metal Analysis of the Individual Components, in ppm

	Mercury	Vanadium	Chromium	Manganese	Iron	Cobalt	Copper	Zinc	Arsenic	Silver	Cadmium	Lead	Aluminium	Magnesium	Nickel
Food	0.005	0.081	5.46	13.91	31	0.07	0.63	2.95	0.067	0.100	0.010	0.077	-	9.20	2.88
Garden	0.018	0.837	4.68	92.71	226	0.20	3.69	17.15	1.218	0.188	0.030	0.851	-	35.89	0.22
Mixed Paper	-	0.796	59.22	19.20	137	0.62	7.38	109.69	0.760	0.205	0.177	0.245	-	23.59	1.14
Newsprint	0.022	1.412	57.89	35.99	535	0.32	9.68	16.93	0.524	0.349	0.082	2.108	-	39.41	1.18
Cardboard	0.033	1.447	12.55	44.23	174	0.57	15.71	14.78	0.566	0.848	0.051	0.263	-	45.32	0.64
Tetra Pak	0.036	0.616	18.52	29.25	4,597	1.07	2.57	75.87	0.679	0.587	0.206	0.092	3,262	45.12	19.20
PET	0.034	0.986	134.06	6.21	2,706	0.34	6.19	200.20	1.173	0.504	0.106	2.490	-	51.17	2.90
HDPE	0.023	1.347	90.00	1.23	148	5.03	2.84	368.04	0.351	0.504	4.057	0.900	-	50.33	2.96
PVC	0.022	1.396	87.49	1.82	141	7.32	1.94	358.41	0.295	0.536	3.197	0.510	-	51.43	3.75
LDPE	0.029	0.698	108.88	4.14	1,019	0.52	2.44	149.89	1.034	0.878	0.046	3.094	-	30.31	1.77
PP	0.027	1.632	75.16	1.59	122	2.82	3.30	271.74	0.257	0.456	1.096	0.507	-	42.89	0.59
PS	-	1.322	6.78	37.56	231	1.05	3.12	33.88	1.343	0.500	0.084	0.737	-	49.12	1.45
Diapers	-	0.358	1.76	0.46	32	0.10	0.43	9.74	0.093	0.135	0.070	0.669	-	12.14	0.13
Textile	0.017	0.235	69.49	2.52	89	0.08	0.96	11.66	0.455	0.222	0.030	0.877	3,225	24.61	0.23
Rubber	0.037	6.121	-	30.89	841	1.43	227.44	1,714.35	1.432	0.398	0.670	1.461	2,069	41.79	2.68
Leather	0.048	8.345	-	35.71	1,139	2.79	278.44	2,188.07	2.059	0.473	0.040	1.770	2,541	51.19	3.04
Wood	0.044	0.281	50.84	3.13	78	0.37	3.95	13.48	0.309	0.264	0.045	1.130	3,455	44.31	0.84

- Non-combustible fraction of the waste removed before analysing the sample

12 RECYCLING SURVEY RESULTS

12.1 Household Survey

12.1.1 Introduction

This section discusses the household survey results. A total of 4,258 households were visited provided information for the Recycling Survey. The survey covered:

- 917 in Northern region
- 670 households in the Central Zone/ Klang Valley Region
- 495 in East Coast and 690 in the Southern region.
- 2,772 households from the Peninsular
- 676 from Sarawak
- 810 from Sabah

The distribution of interviewed households for each region was weighted by the household population distribution of the Local Authorities. Of a total of 4,258 households interviewed, about 67.8% practice recycling, whereas about 32.2% of the total household interviewed did not practice any form of recycling.

The Distribution of the respondents, by region is presented in ***Table 62***.

Table 62: Distribution of Respondents and Recycling Practice by Region

Number of Households interviewed	Central Zone	East Coast	Northern	Southern	Peninsular Malaysia	Sarawak	Sabah	Malaysia
Those who separate their waste	435 (64.9%)	238 (48.1%)	611 (66.6%)	487 (70.6%)	**1771 (63.9%)**	532 (70.6%)	582 (71.9%)	**2885 (67.8%)**
Those did not separate waste	235 (35.1%)	257 (51.9%)	306 (33.4%)	203 (29.4%)	**1001 (36.1%)**	144 (29.4%)	228 (28.1%)	**1373 (32.2%)**
Total No. of Households Interviewed (n)	670 (100%)	495 (100%)	917 (100%)	690 (100%)	**2772 (100%)**	676 (100%)	810 (100%)	**4258 (100%)**

The rest of this section discusses some of the key survey results.

12.1.2 Reasons for Practising Recycling at Home

About 67.8 per cent of the respondents reported they practiced recycling at home. Overall, about 34.7 per cent or one third of them said that "money" or financial incentive was the main motivator. The respondents will sell the accumulated recyclables for financial gain. While there were variations across the regions, about half of Sabah households said that this was the main reason for recycling.

The second most important reason was environmental protection with about 32 per cent of all households citing this reason. Almost 48 per cent of households in the East Coast gave this reason.

The third reason was also altruistic – they did it for charity. Almost 20 per cent of all households gave this reason. The proportion of households that cited this reason in the Northern region and Central Zone / Klang Valley was higher than the average.

The fourth reason was, interestingly, "upon request" by friends or relatives or by collectors and street pickers. Such networks were strongest in the Klang Valley and East Coast.

The reasons cited for recycling by the respondents, by region is presented in ***Table 63***.

Table 63: Reasons for Recycling, in per cent

Reasons for recycling	Northern	Central Zone	East Coast	Southern	Peninsular	Sarawak	Sabah	Total
Money	25.8	35.9	16.0	34.5	29.4	35.0	50.7	34.7
Environmental protection	35.3	24.7	47.9	29.6	32.8	41.1	21.8	32.1
Upon request by collectors, street pickers, friends and relatives	6.7	15.4	13.9	9.0	10.5	8.1	11.1	10.1
For charity	29.2	21.9	17.6	20.3	23.4	13.0	13.3	19.5
For cleanliness	1.6	1.2	2.9	5.5	2.8	0.4	0.2	1.8
Others	1.3	0.9	1.7	1.0	1.2	2.4	2.9	1.8
Number of respondents (n)	609	434	238	487	1,768	531	578	2,877

Note: 8 households did not respond

For urban respondents in Peninsular Malaysia, the most important reason for recycling was because of:

a) environmental protection (29.8%)
b) charity (29.7%)
c) money incentive (26.1%)

However, the percentage gaps of these three most important reasons were relatively close.

For rural respondents in Peninsular Malaysia, similar to the urban respondents, the most important reason is for:

a) environmental protection (36.5%)
b) money incentive (36.5%)
c) charity (9.6%)

The results show that both urban and rural respondents were concerned about the impact of solid waste to the environmental protection. However, apart from the reasons of environmental protection and money incentives, urban respondents indicated recycling for charity was relatively equally important whereas the rural respondent's results suggested that recycling for charity was less important.

The reasons cited for recycling by the respondents, by strata is presented in ***Table 64***.

Table 64: Reasons for Recycling by Strata, in per cent

Recyclables	Peninsular Malaysia		Sabah & Sarawak		Malaysia	
	Urban	Rural	Urban	Rural	Urban	Rural
Money	26.1	36.5	42.8	45.3	33.3	38.7
Environmental protection	29.8	39.4	28.4	44.2	29.2	40.6
Upon request by collectors, street pickers, friends and relatives	9.9	11.6	11.0	2.8	10.4	9.4
For Charity	29.7	9.6	14.2	7.7	23.0	9.2
For cleanliness	3.6	0.9	0.3	0.0	2.2	0.7
Others	0.8	2.0	3.2	0.0	1.9	1.5
Number of respondents (n)	1217	551	928	181	2145	732

Note: 8 households did not respond

Table 65 shows reasons for recycling by housing type. In Peninsular Malaysia, most of the respondents from low cost landed and high rise indicated the money incentive was the most important reason for recycling, whereas most of the medium and high cost landed respondents said environment protection was the most important reason. It is noted that for respondents from high rise residential, either low cost or medium-high cost high rise, recycling for charity was the most important reason. This may be due to the commonality of the recycling bin placed by the charity organisation in the compound of high rise building.

Table 65: Reasons for Recycling by Housing Type, in per cent

		Low Cost Landed	Low Cost High-rise	Medium Cost Landed	Medium-High Cost High-rise	High Cost Landed
Peninsular Malaysia	Money	39.5	29.6	30.9	22.1	22.0
	Environmental protection	31.9	26.3	34.3	28.2	39.5
	Upon request by collectors, street pickers, friends and relatives	12.2	9.6	12.1	6.7	9.4
	For Charity	13.4	29.6	18.4	41.0	24.6
	For cleanliness	0.9	4.2	3.2	2.1	2.9
	Others	2.1	0.6	1.1	-	1.6
	Number of respondents (n)	329	334	528	195	382
Sabah & Sarawak	Money	47.8	44.7	41.6	51.6	37.4
	Environmental protection	34.3	30.5	28.7	20.0	36.6
	Upon request by collectors, street pickers, friends and relatives	7.0	9.1	11.5	17.9	6.2
	For Charity	7.5	11.7	14.7	10.5	17.7
	For cleanliness	0.0	0.5	0.3	0.0	0.4
	Others	3.5	3.6	3.2	0.0	1.6
	Number of respondents (n)	201	197	373	95	243
Malaysia	Money	42.6	35.2	35.3	31.7	28.0
	Environmental protection	32.8	27.9	32.0	25.5	38.4
	Upon request by collectors, street pickers, friends and relatives	10.2	9.4	11.9	10.3	8.2
	For Charity	11.1	23.0	16.9	31.0	21.9
	For cleanliness	0.6	2.8	2.0	1.4	1.9
	Others	2.6	1.7	2.0	-	1.6
	Number of respondents (n)	530	531	901	290	625

Note: 8 households did not respond

Of the total interviewed households, about 32.2 per cent of the total households did not practice recycling (see ***Table 62***). ***Table 66*** shows the reasons for not recycling by region.

Of all households that did not practice recycling, more than one-third of the respondents gave the excuse that they had "no time" to recycle. This was clearest in the Klang Valley (43%) for Peninsular Malaysia and Sabah in East Malaysia (54%).

About one-fifth or 21 per cent of all households "don't see a need" to recycle. However, this survey result is not evenly distributed across the regions. For instance, only 7.5 per cent of households in Sabah felt this way. Interestingly 31 per cent of households in the East Coast gave the same excuse.

The third important reason was the lack of recycling facilities or services. About 18 per cent of all households indicated this to be the case. Again, this result was not evenly distributed across the regions. Almost 25 per cent of households in the Sabah said "no facility/service" was available in their area, while in the Klang Valley and Southern Region, less than 10 per cent stated this as a reason.

Another reason given was that there was "no space in the house", which was about 10 per cent of all households. This means that as more and more households move into high rise accommodation, it is important to ensure that facilities or services for recycling are provided outside or near to these homes. Just below 5 per cent of all households needed an incentive to recycle.

The reasons cited for not recycling by the respondents, by region is presented in ***Table 66*** while ***Table 67*** presents the reasons given for not recycling by strata.

Table 66: Reasons for Not Recycling, in per cent

Reasons for not Recycling	Northern	Central /Klang Valley	East Coast	Southern	Peninsular	Sarawak	Sabah	Total
No time	32.4	42.6	18.3	32.5	**31.2**	45.8	53.9	**36.5**
Don't see a need	14.4	25.5	31.1	33.5	**25.2**	13.2	7.5	**21.0**
No facility /service	24.5	9.4	21.8	3.4	**16.0**	22.9	25.4	**18.3**
No space in house	6.2	12.3	13.2	10.3	**10.3**	14.6	7.0	**10.2**
No volume	14.7	2.1	3.9	9.4	**7.9**	0.7	1.8	**6.1**
No incentive	3.9	8.1	8.2	2.5	**5.7**	1.4	2.2	**4.7**
Others	3.9	0.0	3.5	8.4	**3.8**	1.4	2.2	**3.3**
Number of respondents (n)	**306**	**235**	**257**	**203**	**1001**	**144**	**228**	**1373**

Table 67: Reasons for Not Recycling by Strata, in per cent

Reason for recycling	Peninsular Malaysia		Sabah & Sarawak		Malaysia	
	Urban	Rural	Urban	Rural	Urban	Rural
No time	36.4	20.1	52.2	43.3	41.4	23.8
Don't see a need	23.6	28.5	6.7	25.0	18.3	27.9
No facility/service	12.5	23.2	26.9	11.7	17.1	21.4
No space in house	11.8	7.1	10.9	5.0	11.5	6.8
No volume	5.2	13.6	1.9	1.7	3.6	12.5
No incentive	6.2	4.6	0.3	6.7	4.8	4.2
Others	4.3	2.8	1.0	6.7	3.2	3.4
Number of respondents (n)	**678**	**323**	**312**	**60**	**990**	**383**

Table 68 shows the reasons for not recycling by housing type. In general, most of the respondents from medium-high cost high rise and high cost landed stated they did not practice recycling because they do not have the time to do so, whereas for respondents from low cost landed, most of them do nothing as they did not see a need to recycle.

Table 68: Reasons for Not Recycling by Housing Type, in per cent

		Low Cost Landed	Low Cost High-rise	Medium Cost Landed	Medium-High Cost High-rise	High Cost Landed
Peninsular Malaysia	No time	19.9	32.1	30.3	36.9	37.7
	Don't see a need	28.6	20.8	27.3	21.3	25.0
	No facility/service	19.9	17.9	13.7	13.1	15.6
	No space in house	9.2	20.2	7.7	13.1	5.7
	No volume	8.2	4.2	9.2	2.5	11.5
	No incentive	8.2	1.8	7.7	8.2	2.9
	Others	6.1	3.0	4.1	4.9	1.6
	Number of respondents (n)	**196**	**168**	**271**	**122**	**244**
Sabah & Sarawak	No time	13.0	33.0	22.8	50.0	22.4
	Don't see a need	40.7	44.0	58.4	0.0	55.2
	No facility/service	18.5	14.7	4.7	50.0	5.2
	No space in house	11.1	6.4	10.7	0.0	12.1
	No volume	7.4	1.8	0.0	0.0	1.7
	No incentive	3.7	0.0	1.3	0.0	1.7
	Others	5.6	0.0	2.0	0.0	1.7
	Number of respondents (n)	**54**	**109**	**149**	**2**	**58**
Malaysia	No facility/service	24.4	36.8	40.2	36.3	41.1
	No time	27.8	15.2	21.4	21.0	22.5
	No space in house	18.4	23.8	16.9	13.7	16.9
	Don't see a need	11.2	18.1	6.7	13.7	5.6
	No incentive	7.2	2.5	6.4	2.4	9.6
	No volume/do not cook	8.0	1.8	5.0	8.1	2.6
	Others	6.0	1.8	3.3	9.6	1.7
	Number of respondents (n)	**250**	**277**	**420**	**124**	**302**

12.1.3 Most Effective Ways to Further Promote Waste Minimisation and Recycling

In general, majority of the respondents across the region selected the method of "raise awareness on recycling" (mean scores: 2.42) as the most effective ways to promote recycling and waste minimisation. The second important way is "strict enforcement of the law or regulations" (mean score: 2.02). The results indicate that making recycling a habit should come from "inside", rather than be imposed from outside with stricter enforcement of health and safety regulations and imposition of penalties. (These may be more related to littering than enforced recycling. e.g. RM500 fine for throwing rubbish on the road etc.). However, there is a problem with law enforcement overall with reference to littering also i.e. laws are not enforced. ***Table 69*** presents the most effective way to further promote waste minimisation and recycling, by region.

Table 69: Most Effective Ways to Further Promote Waste Minimisation and Recycling by Region

Description	Northern	Central	East Coast	Southern	Peninsular Malaysia	Sarawak	Sabah	Malaysia
	Mean Score (3=most effective → 1=least effective)							
Raise awareness on recycling	2.48	2.36	2.23	2.41	2.39	2.36	2.53	2.42
Strict enforcement of the law or regulations	2.14	2.00	1.78	1.90	2.00	2.18	1.91	2.02
Introduce incentives (example: buy back)	1.96	1.80	1.81	1.96	1.90	1.92	1.87	1.90
Introduce penalties if don't recycle	1.71	1.81	1.70	1.68	1.73	1.82	1.69	1.73
Set up more recycling facilities	1.86	1.97	2.08	1.93	1.94	1.80	1.72	1.88
Door to door collection of recyclables	1.68	1.66	1.90	1.75	1.73	1.96	1.82	1.79
Others	2.10	1.83	2.50	1.78	1.96	1.75	-	1.88

Table 70 presents the most effective ways to further promote waste minimisation and recycling, by strata. Overall, both urban and rural respondents ranked the method of "raise awareness on recycling" as the most effective ways to further promote waste minimisation and recycling.

Table 71 presents the most effective ways to further promote waste minimisation and recycling, by housing type.

For housing type, there is no significant difference for the reason for recycling across the housing type. Raise awareness on recycling is selected as the most effective way to further promote waste minimisation and recycling, followed by “Strict enforcement of the law or regulations”.

Table 70: Most Effective Ways to Further Promote Waste Minimisation & Recycling by Strata

Description	Peninsular Malaysia		Sabah & Sarawak		Malaysia	
	Urban	Rural	Urban	Rural	Urban	Rural
	Mean Score (3=most effective → 1=least effective)					
Raise awareness on recycling	2.36	2.48	2.44	2.58	2.39	2.50
Strict enforcement of the law or regulations	2.02	1.97	2.08	1.75	2.05	1.91
Introduce incentives(example: buy back)	1.88	1.94	1.93	1.71	1.90	1.89
Introduce penalties if don't recycle	1.73	1.73	1.76	1.50	1.75	1.66
Set up more recycling facilities	1.95	1.91	1.73	1.92	1.87	1.91
Door to door collection of recyclables	1.77	1.65	1.88	1.98	1.81	1.72
Others	2.00	1.83	1.87	1.00	1.91	1.63

Table 71: Most Effective Ways to Further Promote Waste Minimisation and Recycling by Housing Type

Ways to Further Promote Waste Minimisation		Low Cost Landed	Low Cost High-rise	Medium Cost Landed	Medium-High Cost High-rise	High Cost Landed
		Mean Score (3= most effective → 1=least effective)				
Peninsular Malaysia	Raise awareness on recycling	2.40	2.35	2.40	2.34	2.45
	Strict enforcement of the law or regulations	2.01	2.01	1.95	2.12	1.98
	Introduce incentives(example: buy back)	1.88	1.94	1.94	1.77	1.90
	Introduce penalties if don't recycle	1.81	1.70	1.81	1.64	1.64
	Set up more recycling facilities	1.83	1.96	1.92	2.07	1.96
	Door to door collection of recyclables	1.80	1.78	1.68	1.70	1.70
	Others	2.00	2.00	2.11	1.29	2.60
Sabah & Sarawak	Raise awareness on recycling	2.56	2.53	2.47	2.10	2.49
	Strict enforcement of the law or regulations	2.09	1.89	2.00	1.90	2.18
	Introduce incentives(example: buy back)	1.77	1.70	1.96	2.30	1.85
	Introduce penalties if don't recycle	1.67	1.80	1.67	1.86	1.75
	Set up more recycling facilities	1.70	1.93	1.75	1.84	1.71
	Door to door collection of recyclables	1.99	1.71	1.95	1.78	1.94
	Others	1.89	1.89	1.60	-	2.00
Malaysia	Raise awareness on recycling	2.45	2.42	2.43	2.26	2.46
	Strict enforcement of the law or regulations	2.04	1.97	1.97	2.04	2.08
	Introduce incentives(example: buy back)	1.84	1.86	1.95	1.99	1.87
	Introduce penalties if don't recycle	1.75	1.74	1.73	1.75	1.70
	Set up more recycling facilities	1.78	1.95	1.85	2.03	1.88
	Door to door collection of recyclables	1.86	1.75	1.78	1.72	1.78
	Others	1.91	1.92	1.79	1.29	2.16

In terms of increasing the facilities for recycling, another method that has yet to be tried on a national scale is to have an additional day where only recyclables are collected. Hence, households were asked whether they would support this service in three ways –

- Would they be willing to separate the recyclable materials
- Would they be willing to pay for this service
- Whether they expected payment for the recyclables

The responses to these questions are tabulated in Tables, ***Table 72, Table 73*** and ***Table 74***. Surprisingly, households did not want to pay for the additional service. Almost half or 48 per cent of them said that they are willing to separate the recyclables (thus indicating minimum support). 31 per cent or almost one third said that they would be willing to separate only if they are paid for them. Less than 10 per cent said that they would be willing to pay for this service. About 5 per cent were not willing to separate but were willing to pay for this service. Hence, 15 per cent of households were willing to pay for the service. About 5 per cent of households said that they did not support this service.

Table 72: Support Additional Day for Collection of Recyclables by Region, in per cent

Type of support	Northern	Central	East Coast	Southern	Peninsular Malaysia	Sarawak	Sabah	Malaysia
Willing to pay for add service and also separate the recyclables	6.4	14.3	7.6	5.8	8.3	15.6	9.1	9.8
Willing to pay for service and but not willing to separate	2.6	10.3	10.1	4.3	6.0	3.6	6.7	5.7
Not willing to pay for add service but willing to separate	53.5	40.7	45.0	43.8	46.6	51.4	49.7	48.1
Not willing to pay for add service but collector pay	33.9	23.7	34.5	40.7	33.3	24.9	32.4	31.6
Do not support this service	3.6	11.0	2.9	5.3	5.8	4.5	2.1	4.8
Number of respondents (n)	611	435	238	486	1770	531	581	2882

Note: 3 households did not respond

More than half of total urban respondents in Peninsular Malaysia (52.3%) are not willing to pay for the additional service but they are willing to separate the recyclables, whereas for rural respondents, most of them (50.2%) are not willing to pay for the additional service and also not willing to separate the recyclables for free. The results show that most of the rural respondents will separate the recyclables items if collectors buy them.

Table 73: Support Additional Day for Collection of Recyclables by Strata, in per cent

Type of support	Peninsular Malaysia		Sabah & Sarawak		Malaysia	
	Urban	Rural	Urban	Rural	Urban	Rural
Willing to pay for the additional service and also separate the recyclables	9.9	4.7	11.2	17.7	10.5	7.9
Willing to pay for the additional service and but not willing to separate	5.6	6.9	4.6	8.3	5.2	7.2
Not willing to pay for the additional service but willing to separate	52.3	33.9	52.6	39.8	52.4	35.3
Not willing to pay for the additional service, but willing to separate only if collectors buy them	25.7	50.2	28.7	29.3	27.0	45.0
Do not support the additional service	6.5	4.3	2.9	5.0	4.9	4.5
Number of respondents (n)	**1218**	**552**	**931**	**181**	**2149**	**733**

Note: 3 households did not respond

Table 74 shows the survey result of support additional day for collection of recyclables by housing type. There is no difference across the housing type on the view of the additional day for collection of recyclables. Most of them are not willing to pay for the additional service but willing to separate the recyclables.

Table 74: Support Additional Day for Collection of Recyclables by Housing Type, in per cent

	Type of support	Low Cost Landed	Low Cost High-rise	Medium Cost Landed	Medium-High Cost High-rise	High Cost Landed
Peninsular Malaysia	Willing to pay for additional service & also separate recyclables	6.1	7.5	7.8	13.3	9.1
	Willing to pay for additional service and but not willing to separate	4.2	3.9	5.5	8.2	8.9
	Not willing to pay for additional service but willing to separate	41.5	51.2	48.4	56.1	39.4
	Not willing to pay for additional service, but willing to separate only if collectors buy them	43.0	29.6	33.0	16.3	37.3
	Do not support the additional service	5.2	7.8	5.3	6.1	5.2
	Number of respondents	330	334	527	196	383
Sabah & Sarawak	Willing to pay for additional service & also separate recyclables	6.4	7.7	9.0	12.0	14.7
	Willing to pay for additional service and but not willing to separate	4.7	4.5	5.4	7.9	6.9
	Not willing to pay for additional service but willing to separate	44.9	53.4	49.4	54.1	41.6
	Not willing to pay for additional service, but willing to separate only if collectors buy them	38.5	28.6	32.3	21.2	32.1
	Do not support the additional service	5.5	5.8	3.9	4.8	4.8
	Number of respondents (n)	**530**	**532**	**901**	**292**	**627**
Malaysia	Willing to pay for additional service & also separate recyclables	6.4	7.7	9.0	12.0	14.7
	Willing to pay for additional service and but not willing to separate	4.7	4.5	5.4	7.9	6.9
	Not willing to pay for additional service but willing to separate	44.9	53.4	49.4	54.1	41.6
	Not willing to pay for additional service, but willing to separate only if collectors buy them	38.5	28.6	32.3	21.2	32.1
	Do not support the additional service	5.5	5.8	3.9	4.8	4.8
	Number of respondents (n)	**530**	**532**	**901**	**292**	**627**

Note: 3 households did not respond

12.1.4 Types of Recyclable Materials Retained for Recycling

Most of the households retained more than one type of recyclable materials for recycling. ***Table 75*** shows that about 76 per cent of total households retained old newspaper for recycling. Other paper products that were retained include: coloured paper, black and white paper, and cardboard.

At the same time, almost half of the total households kept aside aluminium cans for recycling whereas only about 39 per cent of total households retained PET plastic bottles for recycling. For glasses, 16 per cent of total households said that they retained clear glass for recycling and another 4 per cent retained coloured glass for recycling. Only a very small percentage of households retained cooked or uncooked food for recycling (used as feed for livestock).

Table 75: Types of Recyclable Items retained by Household, in per cent

Recyclables	Central	East Coast	Northern	Southern	Peninsular Malaysia	Sarawak	Sabah	Total
Aluminium can	44.4	28.2	31.3	40.7	36.6	78.4	66.7	50.4
Black & white paper	12.9	17.6	9.3	20.1	14.3	30.6	14.8	17.4
Cardboard	13.1	10.9	18.5	16.2	15.5	25.4	13.1	16.8
Coloured paper	17.7	16.8	18.2	22.4	19.0	26.9	10.8	18.8
Cleared glass	17.2	26.1	12.9	19.9	17.7	23.9	7.0	16.7
Coloured glass	1.6	0.4	1.0	4.7	2.1	12.8	5.3	4.7
Metal can	22.5	22.7	17.0	25.3	21.4	19.5	9.3	18.6
Old newspaper	84.4	69.3	84.5	85.0	82.6	77.8	54.8	76.1
Non-PET plastic	21.1	13.4	15.4	26.5	19.6	15.8	4.8	15.9
PET plastic	44.1	40.3	51.2	51.5	48.1	28.0	20.1	38.8
Cooked food	9.7	31.9	6.5	15.2	13.1	9.2	12.0	12.2
Uncooked food	0.7	3.8	0.7	9.9	3.6	7.3	1.5	3.9
Others	0.2	0.8	2.0	0.8	1.1	0.4	3.1	1.4

Note: Some households retained more than one type of recyclable materials for recycling.

Table 76 presents the composition of the recyclable material collection from each region. In terms of composition of recyclable materials, on average, about two thirds of the total retained recyclable materials in a household are old newspaper. Inclusion of other forms of paper products would increase retention by the households of the paper products to 75 per cent. The recycling rate for old newspaper in the Klang Valley and the Northern Region (both 80%) are the highest. While it is comparatively lower in Sabah (42%), Sarawak (53%) and the East Coast states (56%).

Table 76: Recyclables Composition by Region, in per cent

Recyclables	Central	East Coast	Northern	Southern	Peninsular Malaysia	Sarawak	Sabah	Total
Aluminium can	2.1	1.2	0.9	1.8	1.6	9.1	18.2	4.4
Black & white paper	2.5	3.4	2.5	3.2	2.8	3.1	4.9	3.1
Cardboard	2.1	1.8	3.1	1.9	2.3	4.5	6.1	3.0
Coloured paper	3.6	1.9	3.3	2.4	2.9	3.1	3.8	3.0
Cleared glass	1.3	6.1	1.1	1.1	1.8	2.4	1.8	1.9
Coloured glass	0.1	0.0	0.2	0.3	0.2	1.1	1.1	0.4
Old newspaper	80.3	56.5	80.2	64.8	72.3	53.3	42.3	66.2
Metal can	1.2	3.1	1.6	3.3	2.2	2.4	1.9	2.2
Non-PET plastic	0.6	0.4	1.0	1.3	0.9	0.8	0.5	0.8
PET plastic	2.5	2.1	2.7	3.2	2.7	1.6	4.7	2.7
Uncooked food	0.3	2.6	0.1	5.3	2.2	7.6	0.7	3.0
Cooked food	3.2	20.6	2.8	10.2	7.6	10.6	12.8	8.6
Others	0.1	0.1	0.6	1.1	0.6	0.6	1.3	0.7

12.1.5 Destination of Recyclable Materials Collected or Traded

The most common methods to "dispose" the recyclable materials are:

a) "sell to private recyclers or collectors"
b) "given free" to recyclers or collectors"

Overall, two thirds of households sold their recyclables whereas another 40 per cent of total households gave away the recyclables "for free". And 16 per cent of households had other channels of recycling.

Table 77 shows the how the recyclables reach their destination. There are distinct ways in which recycling is being done for the various types of recyclables. For items that have monetary value, there is an extensive network of private recyclers and collectors who are quite efficient in their system of collecting items that are valuable. Such items would be the paper and paper products, plastic and metal (including aluminium).

For items that have little or no commercial value (glass, food), the main way is either to give it away or through other means (probably for animal feed). As can be seen, about one-third goes through the "give away for free" route.

Table 77: Destination of Recyclables by Region, in per cent

Type of destination	Northern	Central	East Coast	Southern	Sarawak	Sabah
Sell to private recycles/collectors	28.4	34.0	33.0	56.6	46.5	46.2
Take and sell to nearest buy-back centre	16.0	15.7	10.3	3.5	10.4	16.3
Taken by recyclers/ collectors/waste collection truck with no payment	39.3	33.9	36.0	22.3	16.0	20.3
Take to nearest drop off point/ centre(no payment)	11.1	12.5	7.5	9.1	18.1	7.8
Others	5.2	3.9	13.3	8.5	8.9	9.5

Note: Answer was provided in multiple choices, e.g. one household may gave away the recyclables for free and may also sold their recyclables to different canter.

12.2 Industry Survey

12.2.1 Introduction

This section describes the recycling practices of industries by looking at the percentage of:

a) respondents that practice recycling,
b) the total weight of recyclables generated by Malaysian industries according to industrial type and firm size,
c) the composition of recyclables in Malaysian industries and
d) the percentage contribution of different industries towards the recycling of each recyclables types and the prices of recyclables.

This section first examines the recycling practices of non-production waste (municipal waste) and the second, recyclables from production waste.

12.2.2 Percentage of Respondents that Recycle

A total of 1013 industrial establishments were approached in this survey with 73 per cent of the respondents practicing recycling while 27 per cent do not. The 73 per cent that practice recycling comprises of respondents that recycle both municipal and production waste (27%), respondents that recycle only municipal waste (24%), respondents that recycle only production waste (13%) and respondents that claim to practice recycling but do not have information about the recyclables (9%) as shown in ***Figure 18***. Tables**,** ***Table 78*** and ***Table 79*** show a breakdown of the respondents and their recycling practices according to industry type and firm size respectively.

Figure 18: Recycling practices of respondents in percentages (n=1,013)

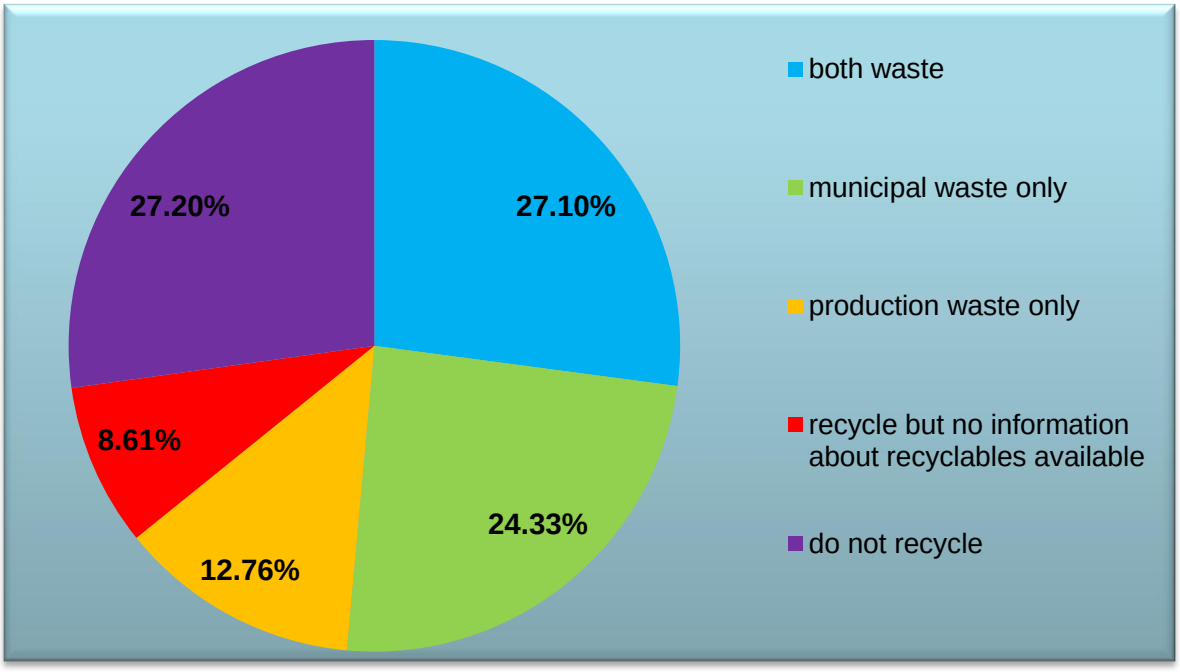


Table 78 : Distribution of respondents sampled in the industry survey according to industry type and their recycling practices, in per cent (n=1013)

Industry categories	Both waste	Municipal solid waste only	Production waste only	Recycle but no information available	Do not recycle	Total
Food and beverage	11.2	24.1	4.7	16.1	21.1	16.6
Textile and Apparel	4.3	8.6	2.3	5.7	7.6	6.1
Fabricated metal	15.5	2.4	20.9	17.2	10.5	11.8
Basic metal	8.7	2.9	11.6	1.1	3.6	5.6
Machinery, motor vehicles and transport equipment	7.6	6.5	10.9	8.0	6.5	7.5
Electrical and electronic products	11.9	7.3	5.4	10.3	6.2	8.3
Wood and wood based products *	6.9	6.9	9.3	1.1	12.0	8.1
Paper and paper products	6.5	5.7	11.6	3.4	2.2	5.5
Chemical, petrochemical and plastic products	15.5	15.5	14.7	21.8	14.2	15.6
Non-metallic mineral product	6.9	9.0	3.9	3.4	10.2	7.6
Others	5.1	11.0	4.7	11.5	5.8	7.2
Total respondents (n)	**277**	**245**	**129**	**87**	**275**	**1013**

* - product of wood and cork, manufacture of articles of straw and plaiting materials, furniture

Table 79: Distribution of respondents sampled in the industry survey according to firm size and their recycling practices, in per cent (n=1013)

Firm size	Both waste	Municipal solid waste only	Production waste only	Recycle but no information available	Do not recycle	% of Total Respondents
Micro	4.0	11.8	14.0	9.2	9.1	9.0
Small	50.9	55.1	62.0	55.2	54.5	54.7
Medium	18.4	20.8	14.0	18.4	18.5	18.5
Large	26.7	12.2	10.1	17.2	17.8	17.9
Total respondents (n)	**277**	**245**	**129**	**87**	**275**	**1013**

12.2.3 Reasons for not practicing recycling

Reasons for not practicing recycling amongst industries were examined as shown in ***Table 80***. Most industries ranked "No time", "No reason" and "Do not see a need" as the main reasons for not practising recycling. Only the electrical and electronics industry had ranked "Not enough volume of recyclables" as a rank 1 reason. The breakdown of different reasons according to industries may suggest different needs of industry types for encouraging more recycling practices.

Figure 19 shows the composition of recyclables generated from municipal solid waste of Malaysian Industries. 60 per cent of the recyclables generated originates from paper with 27 per cent being cardboard, 23 per cent being black and white paper, 6 per cent newspaper and about 4 per cent being coloured paper. 37 per cent of the recyclables are other recyclables which include metals (apart from metal cans), wood pallets and other packaging while plastics contribute about 3 per cent of the total recyclables. The remaining recyclables types contribute about 0.3 per cent of the total recyclables generated.

Figure 19: Composition of recyclables of Malaysian industries based on weight of recyclables

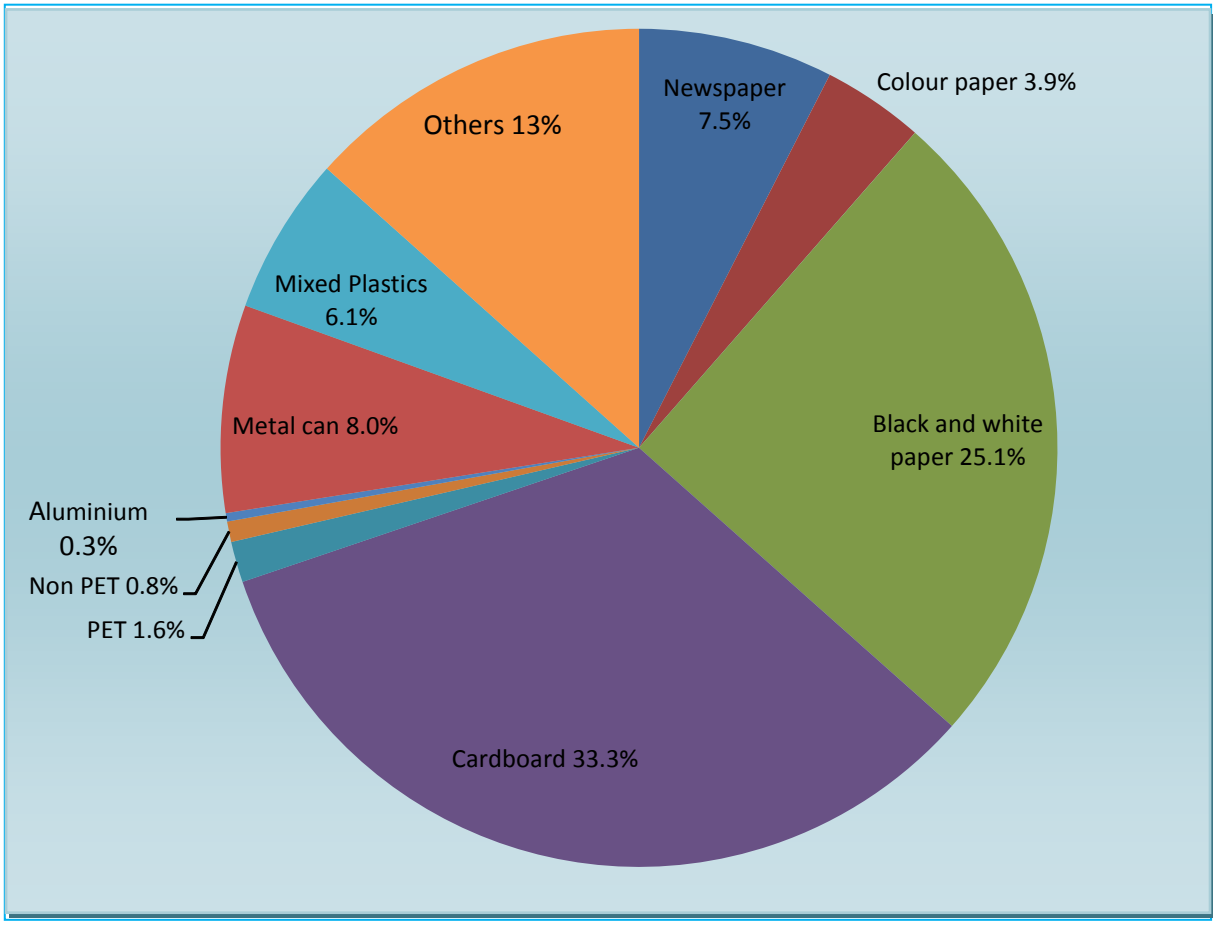


Table 80: Ranking of reasons for not practicing recycling for different industry types (n=275)

Industry category	Reason Rank 1	Reason Rank 2	Reason Rank 3	Reason Rank 4	Reason Rank 5	n
Basic metal	No time (33%)	No facility/service (22%); Not enough volume of recyclables (22%); No reason (22%)				9
Chemical, petrochemical and plastic products	Don't see a need (28%)	No reason (23%)	No time (21%)	No facility/service (12%)		43
Electrical and electronic products	Not enough volume of recyclables (24%); No reason (24%)		Don't see a need (18%)	No facility/service (12%); No time (12%)		17
Fabricated metal	Don't see a need (30%)	No reason (26%)	No facility/service (19%); No Time (19%)			27
Food and beverage	No time (30%)	No facility/service (18%)	Don't see a need (14%); No reason (14%)		Not enough volume of recyclables (13%)	56
Machinery, motor vehicles and transport equipment	No time (29%); Don't see a need (29%)		No reason (24%)			17
Non-metallic mineral product	Don't see a need (25%); No reason (25%)		No time (14%)	No facility/service (11%)		28
Paper and paper product	Don't see a need (33%); No reason (33%)	No time (17%); Not enough volume of recyclables (17%)				6
Textile and Apparel	No time (24%); No reason (24%)		Don't see a need (19%)	Reuse, own used (14%)		21
Wood and wood based products *	No time (49%)	No facility/service (14%)	No space in premises (11%); Don't see a need (11%)			35
Others	No time (25%); No reason (25%)		Don't see a need (19%); Not enough volume of recyclables (19%)			16

** - of wood and cork, manufacture of articles of straw and plaiting materials, furniture*

As shown in ***Figure 20***, there are certain recyclables that are mainly generated by specific industries. For example, the paper and paper product industry generates about 70 per cent of the black and white paper recycled though there are 8 other industries that contribute to the total amount of black and white paper generated. There are approximately 7-8 industries that recycle all papers, cardboard, aluminium cans and plastics as shown by their contributions in ***Figure 20***. In comparison, coloured glass is only recycled by 3 industries namely the food and beverage, textile and apparel and machinery, motor vehicles and transport equipment industries.

12.2.4 Recyclables generated by Malaysian industries according to firm size

Table 81 shows the total weight and the breakdown of the weight according to types of recyclables generated by different sized Malaysian industrial firms. In total, 221,103kg is generated per day. 65 per cent of this total originates from large firms that have more than 150 staff followed by small firms that have more than 5 but less than 50 staff contributing 16 per cent of the total recyclables generated daily. Medium sized firms that have more than 50 staff but less than 150 contribute 14 per cent of the total recyclables generated daily from municipal waste of industries while micro sized firms with less than 5 staff contribute 5 per cent of the total (***Figure 21***).

Table 81: Total weight of recyclables generated per day (kg/day) by Malaysian industries according to firm size and types of recyclables

Type of recyclables	Micro	Small	Medium	Large	Total
Aluminium can	163	459	15	73	710
Black and white paper	671	4,976	6,929	42,893	55,469
Cardboard	12,416	8,733	23,143	29,228	73,521
Clear glass	39	2	6	-	48
Coloured glass	-	5	-	-	5
Coloured paper	340	5,072	920	2,346	8,678
Metal can	54	12,080	3,898	1,674	17,706
Mixed Plastics	222	1,480	2,503	9,262	13,466
Newspaper	2,047	1,949	7,504	5,157	16,657
Non PET	19	40	47	1,644	1,750
PET	254	434	461	2,331	3,480
Others	1,440	1,393	43	26,735	29,612
Total recyclables generated per day (kg/day)	**17,665.1**	**36,622.6**	**45,470.7**	**121,345.2**	**221,103.5**
Number of Employees	53,193	242,184	303,531	1,213,452	1,812,360

Figure 20: Percentage contribution of different industry types toward the total weight of recyclables

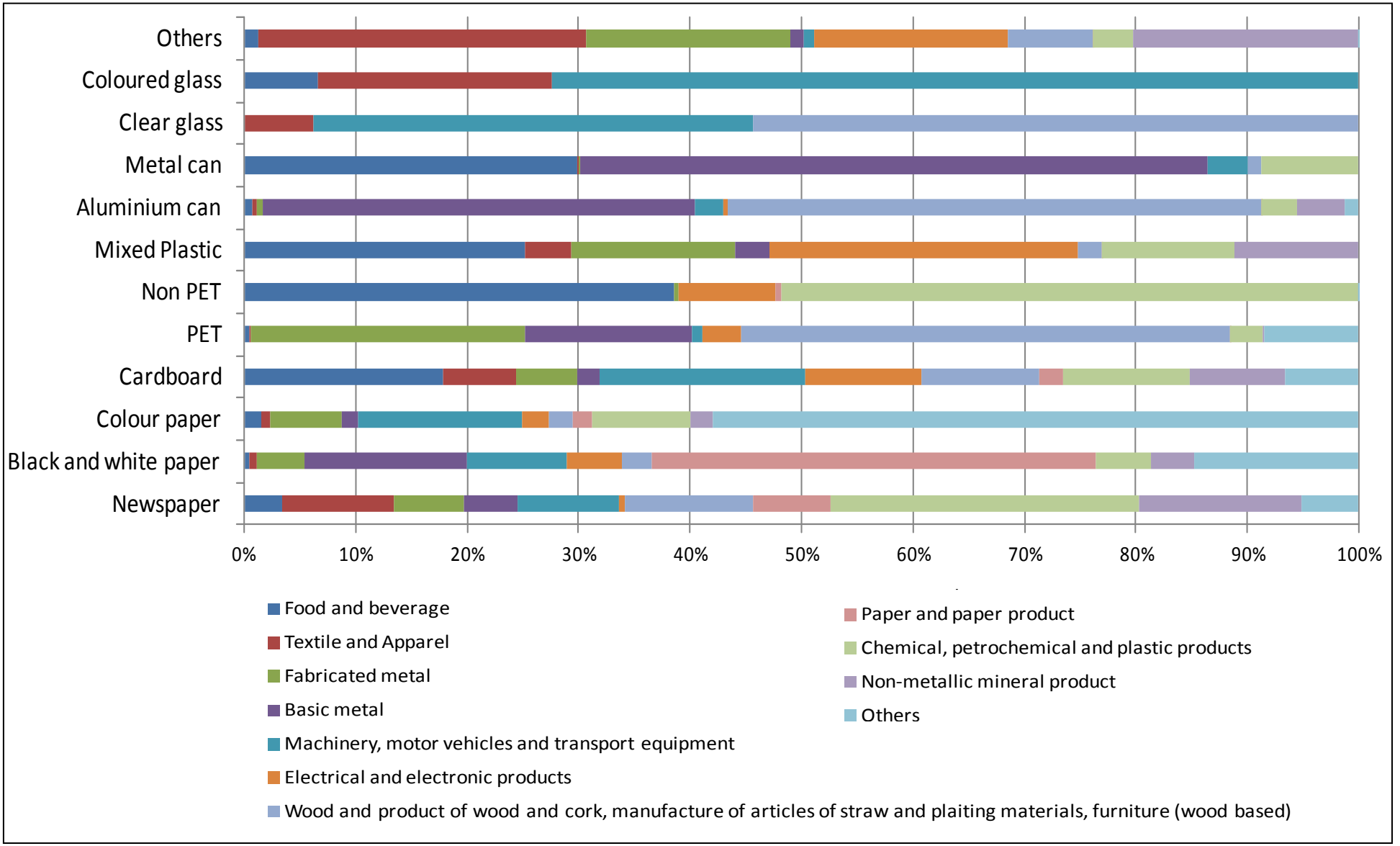
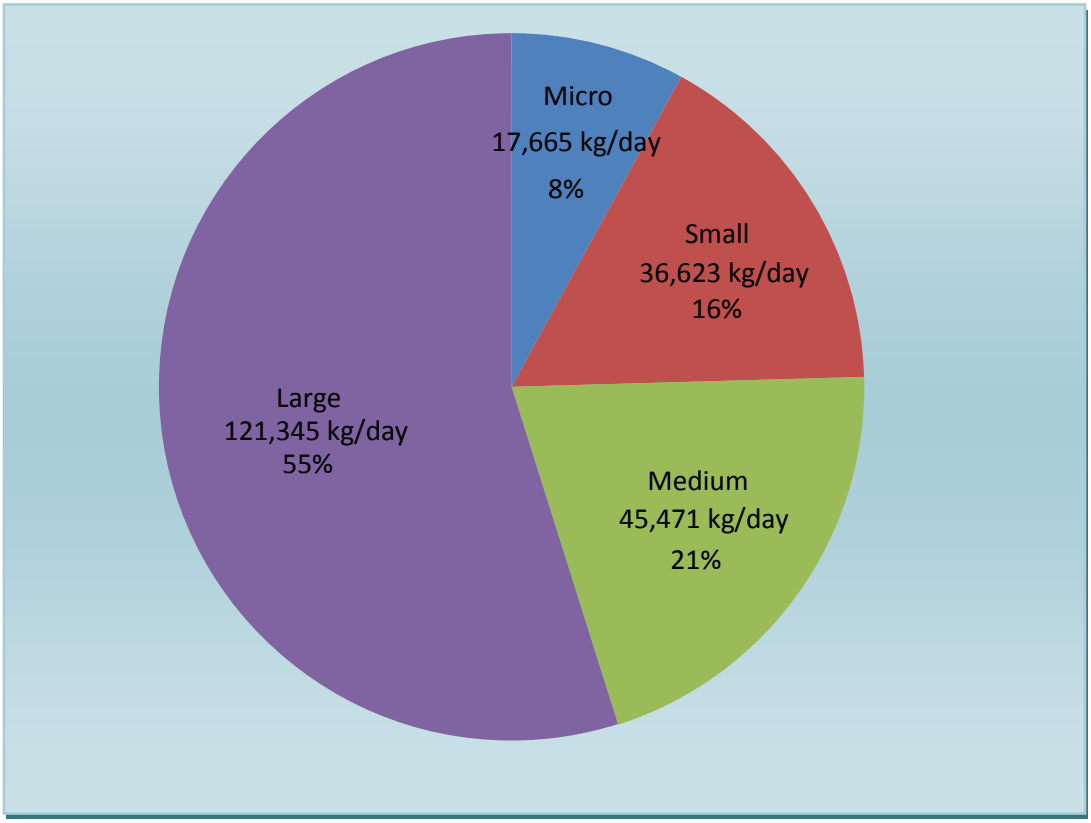


Figure 21: The percentage contribution of different sized industrial firms toward the total weight generated by Malaysian industries



Looking at the percentage contribution of different sized firms to the amount of recyclables generated according to types of recyclables in ***Figure 22,*** large firms contribute the most to recycling of papers, plastics and other recyclables. Aluminium cans, metal cans and coloured glass is recycled mainly by small firms while micro firms contribute most to the recycling of clear glass.

12.2.5 Price range of recyclables generated from municipal waste of Malaysian industries

Table 82 shows the price ranges for different types of recyclables generated from municipal waste of Malaysian Industries. The inter-quartile range (IQR) indicates the price range in which 50 per cent of the samples lie in between. While paper generally is sold at RM0.20-0.30/kg, cardboard obtains a higher price of RM0.35/kg. Plastics generally have higher prices than paper with the IQR being between RM0.20-0.50/kg for PET plastics and RM0.25 to 0.70/kg for Non-PET plastics. Aluminium cans obtain a higher price between RM 2.35-3.80/kg and metal cans obtain a price of RM0.55 – 0.83/kg. Other recyclables also obtain different prices depending on the items as shown below. When the prices are examined at regional levels, the prices of papers and plastics are lower in Sabah and Sarawak compared to the Peninsula Malaysian regions as shown in ***Table 83***.

Figure 22: Percentage contribution of different sized firms toward the total weight of recyclables

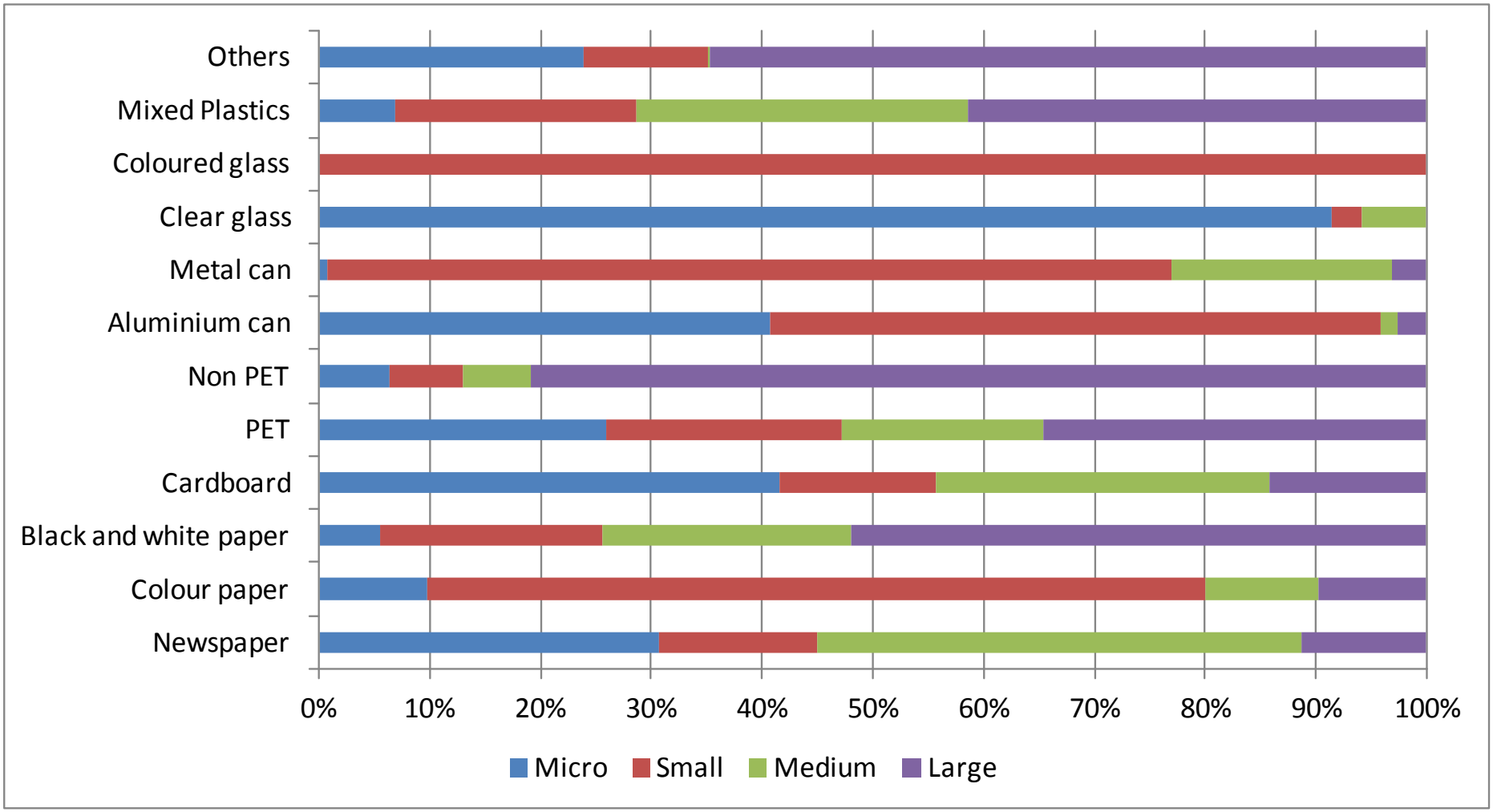


Table 82: Price ranges for different recyclables generated from municipal waste of Malaysian industries, in RM/kg

Types of recyclables	Min	Max	Average	Median	IQR (50%of samples)
Aluminium can	0.40	5.00	2.84	3.30	2.35 - 3.80
Black and white paper	0.02	1.00	0.27	0.25	0.20 - 0.30
Cardboard	0.10	0.70	0.29	0.30	0.20 - 0.35
Clear glass	0.1	0.4	0.25	0.25	--
Coloured glass	0.40	0.40	0.40	0.40	--
Colour paper	0.03	0.70	0.24	0.25	0.20 - 0.30
Metal can	0.2	1.5	0.74	0.65	0.55 - 0.83
Newspaper	0.05	0.80	0.23	0.20	0.20 - 0.30
Non PET	0.05	1.15	0.48	0.55	0.25 - 0.70
PET	0.05	1.30	0.40	0.40	0.20 - 0.50

Other recyclables	Min	Max	Average	Median	IQR (50% of samples)
E-waste	0.30	0.30	0.30	0.30	--
Guni (Gunny sack)	0.20	0.20	0.20	0.20	--
HDPE/PVC/PP/ABS/PS	0.10	15.87	2.15	0.50	0.14 - 1.30
Mixed metals	0.60	1.10	0.83	0.83	--
Mixed papers	0.15	1.00	0.35	0.30	0.25 - 0.40
Plastic stretch film, plastic foam films, plastic bags, plastic sheets	0.05	1.60	0.56	0.40	0.28 - 0.80
Scrap metal (Ferrous)	0.05	25.00	4.16	0.90	0.41 - 1.28
Used Oils	0.74	0.80	0.77	0.77	--
Wood	0.01	20.00	2.83	1.10	0.30 - 1.80
Others (cloth gloves, rubber, yarn waste)	3.33	3.33	3.33	3.33	--

Table 83: Price ranges of recyclables according to region, in RM/kg

Region	Min	Max	Average	Median	Mode	IQR (50%of samples)
Newspaper						
Central	0.10	0.80	0.26	0.20	0.20	0.20 - 0.30
Northern	0.08	0.40	0.25	0.20	0.20	0.20 - 0.30
Sabah	0.10	0.15	0.11	0.10	0.10	0.10
Sarawak	0.05	0.45	0.20	0.20	0.20	0.18 - 0.20
Southern	0.12	0.40	0.26	0.25	0.20	0.20 - 0.34
Coloured paper						
Central	0.08	0.70	0.26	0.25	0.20	0.20 - 0.30
Northern	0.05	0.40	0.25	0.23	0.20	0.20 - 0.30
Sabah	0.03	0.10	0.05	0.03	0.03	0.03 - 0.10
Sarawak	0.05	0.10	0.08	0.07	--	--
Southern	0.12	0.43	0.27	0.27	0.30	0.20 - 0.33
Black and White paper						
Central	0.05	1.00	0.27	0.25	0.20	0.20 - 0.30
Northern	0.10	0.80	0.30	0.25	0.20	0.20 - 0.35
Sabah	0.02	0.15	0.11	0.10	0.10	0.10 - 0.15
Sarawak	0.05	0.70	0.27	0.30	0.30	0.20 - 0.30
Southern	0.12	0.43	0.29	0.30	0.30	0.21 - 0.39
Cardboard						
Central	0.10	0.70	0.29	0.30	0.30	0.20 - 0.33
Northern	0.20	0.50	0.31	0.30	0.30	0.23 - 0.40
Sabah	0.10	0.50	0.28	0.20	0.20	0.20 - 0.40
Sarawak	0.10	0.50	0.25	0.25	0.10	0.10 - 0.35
Southern	0.12	0.43	0.29	0.30	0.30	0.22 - 0.33
PET						
Central	0.10	0.90	0.42	0.40	0.20	0.20 - 0.50
Northern	0.05	2.00	0.80	0.65	0.50	0.43 - 1.20
Sabah	0.50	0.50	0.50	0.50	0.50	--
Sarawak	0.05	0.20	0.12	0.10	0.10	0.09 - 0.16
Southern	0.12	0.70	0.36	0.30	0.30	0.17 - 0.60

Table 83: Price ranges of recyclables according to region, in RM/kg (Cont'd)

Region	Min	Max	Average	Median	Mode	IQR (50%of samples)
Aluminium can						
Central	0.60	4.00	1.42	1.05	--	0.68 - 3.30
Northern	0.70	3.00	1.85	1.85	--	--
Sabah	0.80	4.50	3.23	3.80	3.80	3.00 - 3.80
Sarawak	2.20	3.80	3.22	3.30	3.30	3.00 - 3.40
Southern	0.80	5.00	2.40	1.90	--	0.80 - 4.50
Metal can						
Central	0.20	0.70	0.53	0.60	0.6	0.30 - 0.68
Northern	0.70	0.70	0.70	0.70	--	--
Sabah	--	--	--	--	--	--
Sarawak	1.50	1.50	1.50	1.50	--	--
Southern	0.40	1.22	0.81	0.81	--	--

12.2.6 Recyclables from Production Waste of Malaysian Industries

A total of 5,365,466.45 kilograms of recyclable material is generated out of the production waste of the Malaysian industries per day in 2012. Of this total, 29.3 per cent of the recyclables were ferrous metals, 22.5 per cent wood pallets and wooden frames, 20 per cent biomass, 8 per cent plastics, 6.5 per cent cardboard or corrugated boxes and 5.7 per cent papers. The remainder comprised of non-ferrous metals (4.2%), food waste (3.5%), other recyclables (2%) and glass (0.4%). The biomass primarily consists of the husks "*kulit padi*" and oil palm empty fruit bunches "*tandan kelapa sawit".*

Figure 23 presents the Composition of recyclables removed from production waste of Malaysian Industries.

Figure 23: Composition of recyclables removed from production waste of Malaysian Industries

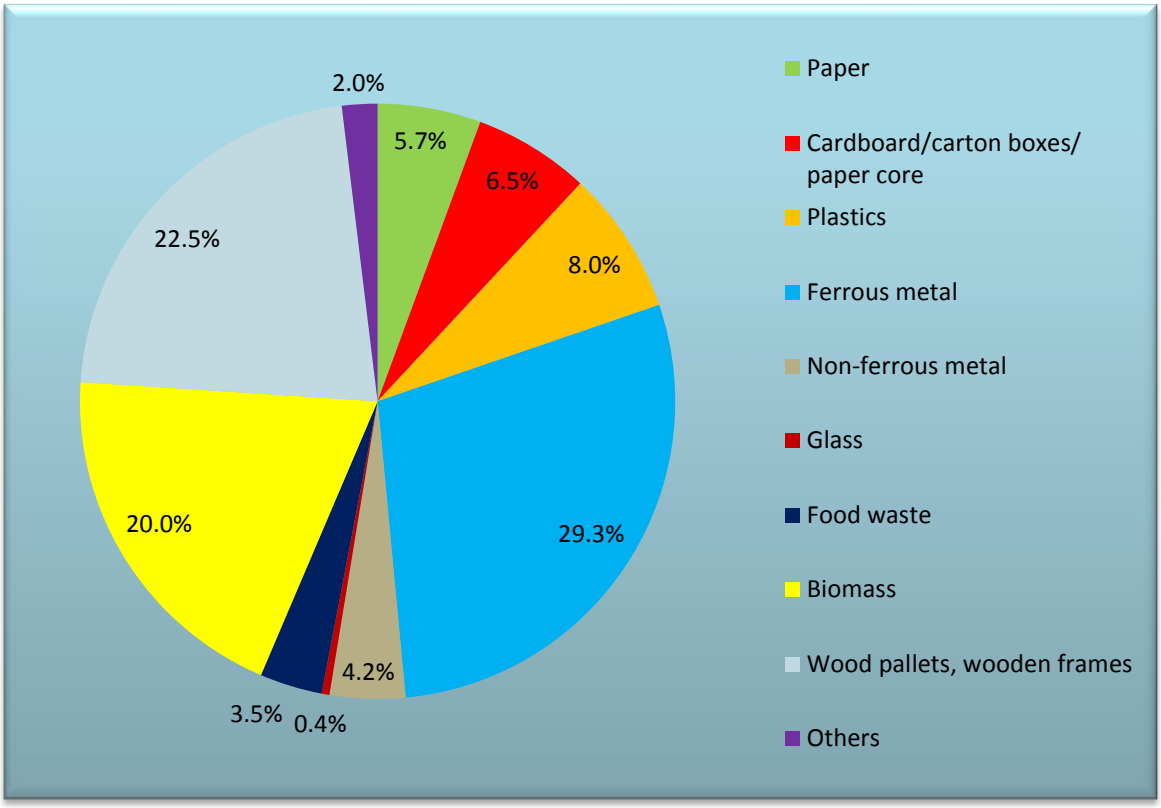
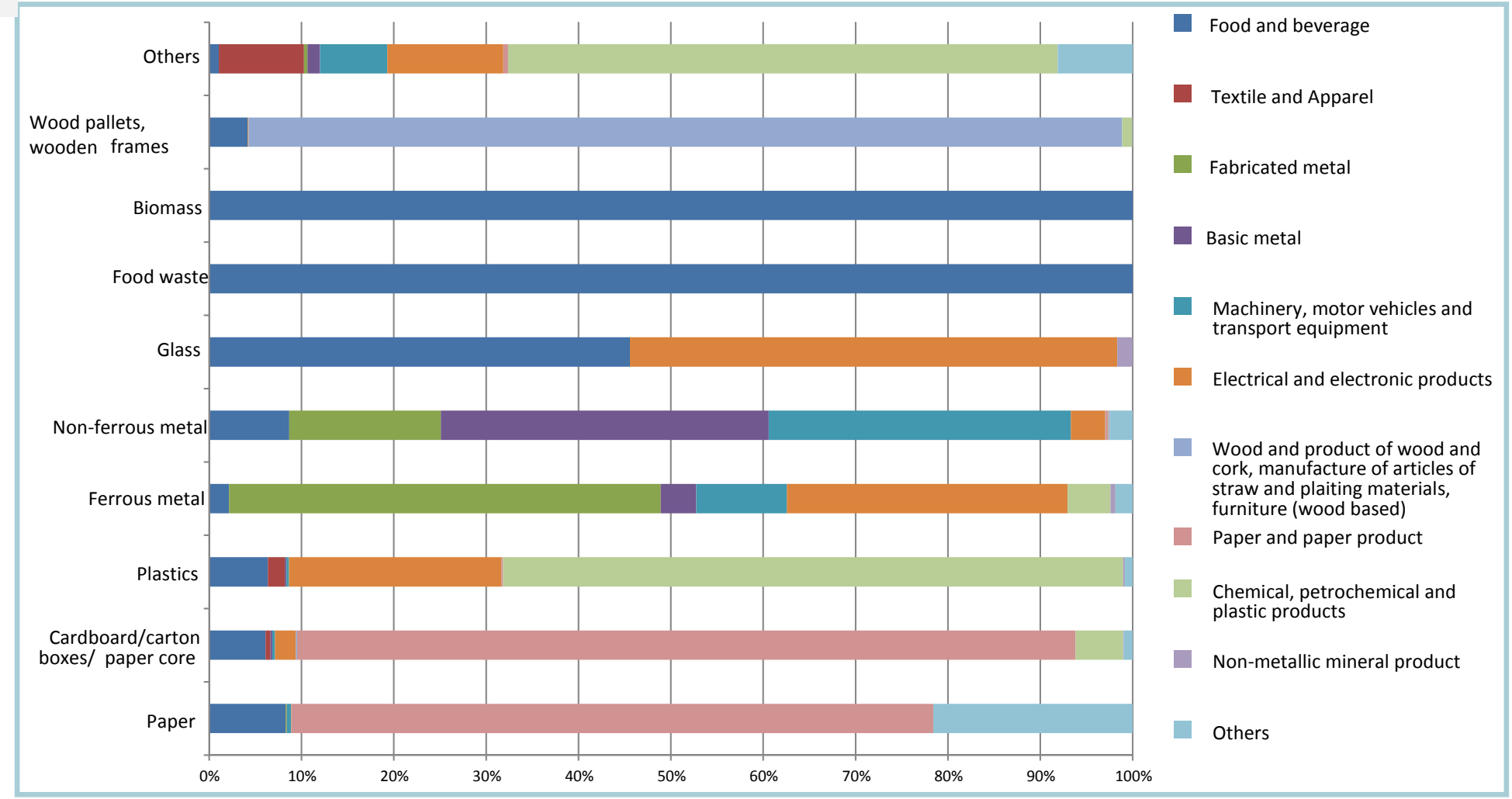


Figure 24 shows the percentage contribution of various industries to different recyclables generated from production waste of Malaysian industries. Food waste and biomass are solely from the Food and Beverage industry. Glass is recycled largely by the food and beverage industry, as well as the electronics and electrical industry. Paper and cardboard is recycled largely by the paper and paper products industry. Plastics and other materials are recycled mainly by the chemical, petrochemical, plastics and pharmaceutical products industry. The fabricated metal industry recycles the highest amount of ferrous metals, followed by the electrical and electronics industries. Non-ferrous metals, on the other hand, are largely recycled by the basic metals industry followed by the machinery, motor vehicles and transport equipment industries.

Figure 24: Percentage contribution of different industrial sectors toward types of recyclables removed from the production waste



12.3 Commercial and Institutions Survey

12.3.1 Introduction

This section of the report discusses the commercial and institutions survey results. A total of 794 Commercial and Institutions (CI) were surveyed. The key survey results are discussed in the following sections.

12.3.2 Survey Results

The survey covered 794 commercial enterprises and institutions. It was found that only 538 firms/agencies/organisations (67.8%) practiced recycling in their premises, whereas 256 firms/agencies/organisations (32.2%) do not recycle waste (Refer ***Table 84)***. Among all CI contacted, transportation hubs/stations had the highest percentage of un-recycled waste, followed by sundry/retail stores, government offices, and clinics (Refer ***Table 85)***.

Table 84: Distribution of Commercial and Institutions Respondents by Participating in Recycling

Commercial and Institutions		Practice recycle		Do not recycle		Total respondents	
		n	%	n	%	n	%
Wholesale and retail (exclude wet market	Sundry/Retail store	13	40.6	19	59.4	32	100
	Supermarket	25	86.2	4	13.8	29	100
	Hypermarket	14	87.5	2	12.5	16	100
	Convenience store	18	90.0	2	10.0	20	100
Transport sector. (stations)	Airport	3	50.0	3	50.0	6	100
	Train station	2	33.3	4	66.7	6	100
	Bus terminal	14	41.2	20	58.8	34	100
	Ferry terminal	1	50.0	1	50.0	2	100
Hotels	Hotels	42	89.4	5	10.6	47	100
Restaurants	Food outlet/coffee shop	53	74.6	18	25.4	71	100
Health	Clinic	29	58.0	21	42.0	50	100
	Hospital	20	83.3	4	16.7	24	100
Private offices in office complex	Private offices in office complex	59	62.1	36	37.9	95	100
Government offices	Government office	68	57.1	51	42.9	119	100
Education	School	40	69.0	18	31.0	58	100
	College	23	74.2	8	25.8	31	100
	University	11	78.6	3	21.4	14	100
Wet market	Wet market (stall)	91	74.6	31	25.4	122	100
Others	Others	12	66.7	6	33.3	18	100
Grand Total		538	67.8	256	32.2	794	100

The main recyclable material for private offices is newspaper whereas for wholesale and retail sector (excluding wet market), their main recyclables is cardboard. For wet markets, their main recyclable material is raw food. For restaurant, cooked food and aluminium cans were the two major recyclable materials.

Table 85: Composition of recyclables of Malaysian Commercial and Institutions based on weight of recyclables, in per cent

Waste Composition	Wholesale and retail (exclude wet market)	Transports (stations)	Hotels	Restaurants	Health	Private offices in office complex	Government offices	Education	Wet market	Others
Newspaper	1.51	57.4	47.1	3.4	28.2	95.7	30.5	20.0	1.1	44.2
Colour paper	0.00	11.1	11.0	0.1	15.3	2.9	2.3	15.6	0.4	30.7
Black and white paper	2.42	10.5	6.7	0.1	6.9	0.9	58.3	34.8	0.0	14.2
Cardboard	92.25	10.4	13.9	8.2	33.1	0.3	6.4	9.4	19.0	9.8
PET	0.62	3.2	12.6	10.2	4.3	0.0	0.6	11.3	0.1	0.0
Non PET	0.00	0.0	0.6	0.6	7.7	0.0	0.1	0.2	0.5	0.2
Aluminium can	0.00	7.3	4.5	22.9	2.6	0.3	0.6	8.1	0.1	0.5
Metal can	0.01	0.0	3.0	16.1	1.8	0.0	0.1	0.3	0.0	0.3
Clear glass	0.00	0.0	0.1	7.0	0.0	0.0	0.0	0.3	0.0	0.0
Coloured glass	0.00	0.0	0.1	7.2	0.0	0.0	0.8	0.0	0.0	0.0
Cooked food	0.00	0.0	0.3	24.0	0.0	0.0	0.0	0.0	0.3	0.0
Raw food	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78.6	0.0
Others	3.19	0.0	0.0	0.4	0.0	0.0	0.2	0.0	0.0	0.0
Total	100	100	100	100	100	100	100	100	100	100

Note: Others for wholesale and retail, mainly mix plastics

12.4 Recycling Players Survey

12.4.1 Introduction

This section discusses the results from the recycling players' survey. The survey was divided into two components:

- Recycling player 1 (RP1) which involved the street picker and scavenger
- Recycling player 2 (RP2) which involved the drop-off centre, middle man, buy back centre and recyclers

The details of the two components are tabulated in the ***Table 86*** below.

Table 86: Types of recycling players

Recycling Player 1, RP1	Recycling Player 2, RP2
Door-to-door collector	Drop off centre
Street collector	Middle man
Waste collection workers	Junk shop who deals recyclables
Scavengers	Buy back centres
	Recycler (End user or buyers of recyclable materials)

The data on the Recycling Players are presented in ***Appendix 4***.

The total number of respondents for each category of recycling players is shown in ***Table 87***.

The RP1 survey was carried out at the landfills, streets, and with known recycling players. Both RP1 and RP2 were interviewed face-to-face, and via telephone interview with some RP2. The RP2 list was compiled from the *Directori Kitar Semula*, recycling players introduced by contacts, internet search, and on the ground listing exercise. At least 700 recycling players of the category RP2 were contacted for the survey. Some contact numbers listed in the phone directory were found to be no longer in service, whilst some on the list refused to be interviewed. The final number of respondents under recycling players, RP2, that were successfully interviewed was 225. The list of RP2 is presented in ***Appendix 5.***

***Table 87*:** Number of Respondents for each category of recycling players

Region	Number of Respondents									Total
	RP1					RP2				
	Door-to-door collector	Street collector	Waste collection worker	Scavenger	Sub Total	Drop off centre	Trader, Buy-back centre, etc.	Recycler	Sub Total	
Northern	14	20	2	5	**41**	8	21	37	**66**	**107**
Central	2	19	-	1	**22**	3	23	23	**49**	**71**
East Coast	6	17	1	9	**33**	1	6	13	**20**	**53**
Southern	7	1	-	22	**30**	7	15	20	**42**	**72**
Sarawak	4	20	-	8	**32**	2	15	10	**27**	**59**
Sabah	-	17	7	13	**37**	0	17	4	**21**	**58**
Total	**33**	**94**	**10**	**58**	**195**	**21**	**97**	**107**	**225**	**420**

12.4.2 Collection Method

There are three common methods to collect recyclable items from the sources, these could be:

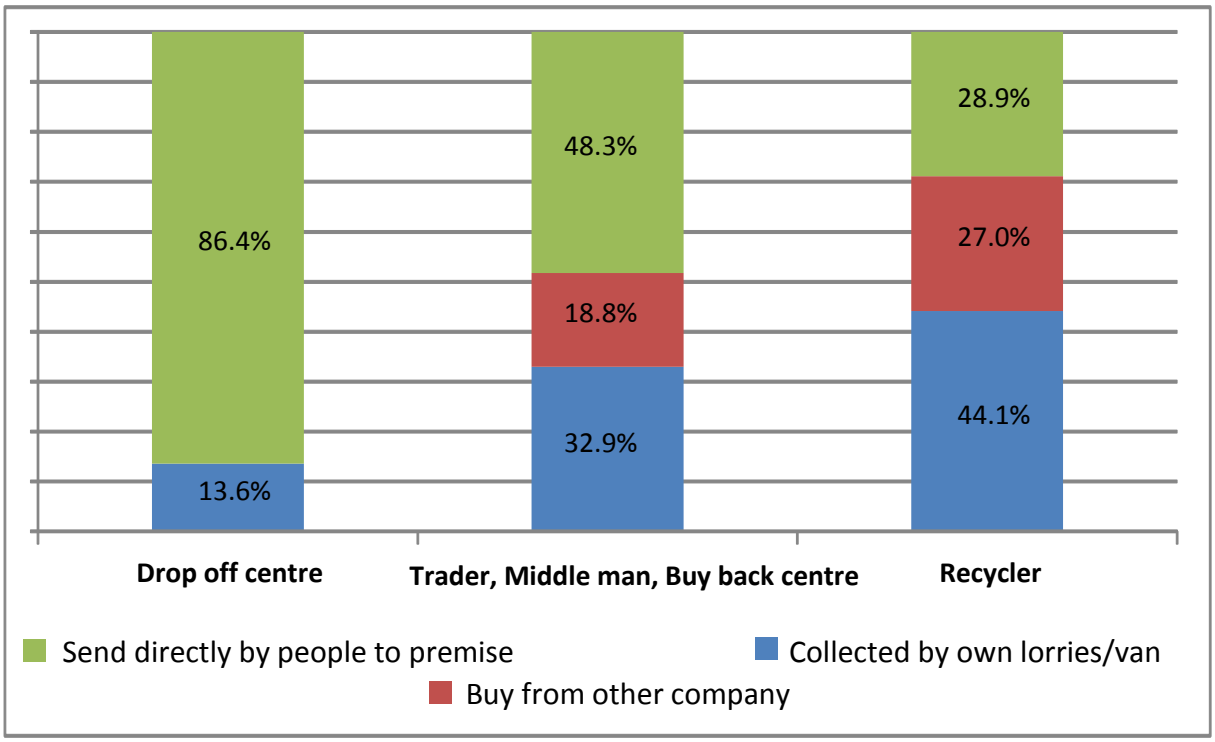
- Collection by own organisation's lorries/vans
- Collection by another company selling recycling materials to buy back centre/recycler
- Direct individual delivery to recycling drop-off centre

For the drop-off centre, about 86 per cent of the recyclables were delivered directly by people to the centres while the remaining 14 per cent was collected by vans/lorries (***Figure 25***). Some charity associations conducted recycling campaigns to collect recyclables from public.

The most common collection method for middle men, junk and buy-back centres was by directly buying from individual customers who sold the recyclables to them (49%), followed by door-to-door collections made by vans/lorries (33%), and other collectors/companies (e.g. street-pickers, scavengers, etc.) (19%).

For the recyclers, most of the recyclables were bought from other collectors/companies (44%), followed by individual direct delivery to their premises (29%), and lastly door-to-door collection by vans/lorries (27%).

Figure 25: Collection Method Used by Recycling Players in Malaysia

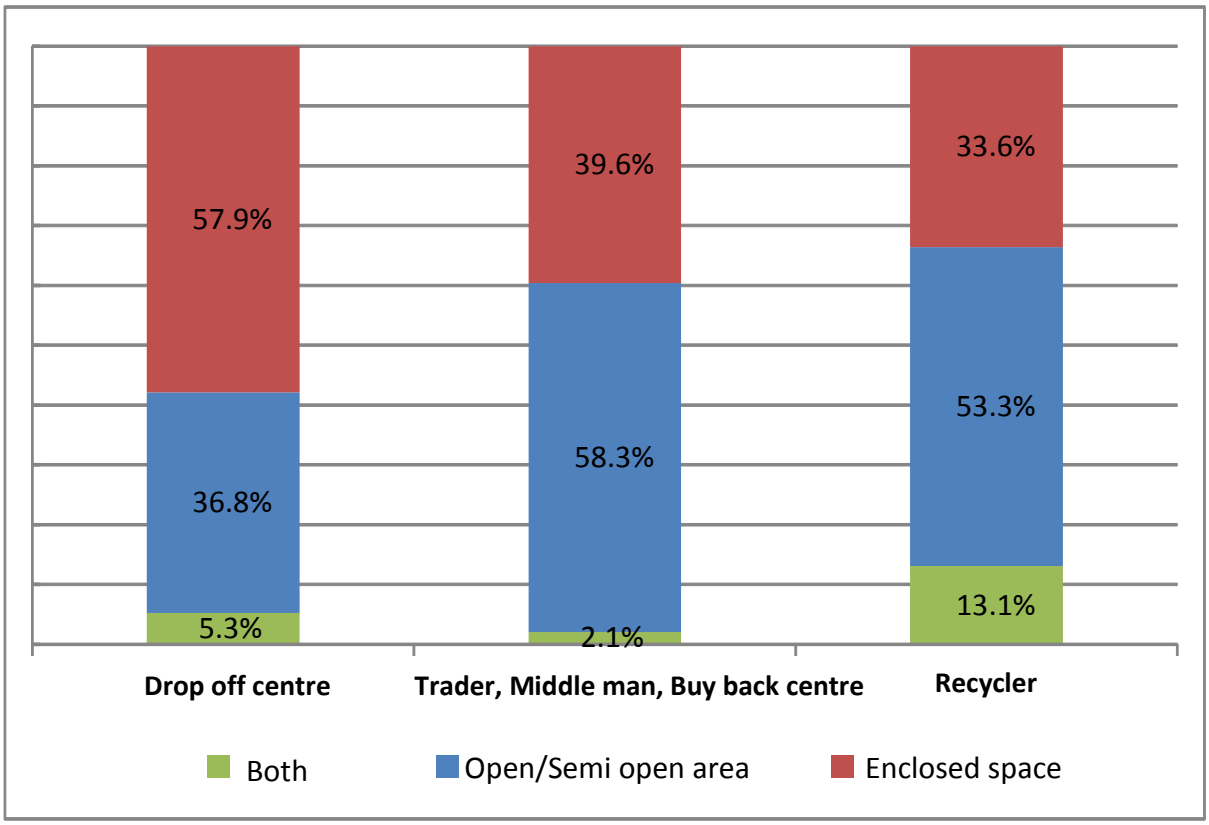


12.4.4 Storage Method

The recycling players store the collected recyclables either in open/semi open areas or enclosed spaces. The survey shows most of RP1 (street collectors, waste collection workers and scavengers) store their recyclables in open areas; some of them will sell these immediately after making the collection.

A majority of the drop-off centres and recyclers stored their recyclables in enclosed places while most middle men, junk shops and buy-back centres kept their recyclables in open areas, either in an open field, shed with/without walls, under a canopy, canvas, in containers, a roofed-place or bin as showed in ***Figure 26***.

Figure 26: Storage method practised by Recycling Players in Malaysia



12.4.5 Collection Points

Majority of the traders, middle men and buy back centres (61%) have one collection point to buy the recyclables. This may indicate that most traders, middle men, and buy back centres are small scale. The number of collections points in the various regions is as presented in ***Table 88.***

Table 88: Number of Collection Points Provided by Trader/Middle Men/Buy Back Centre, in per cent

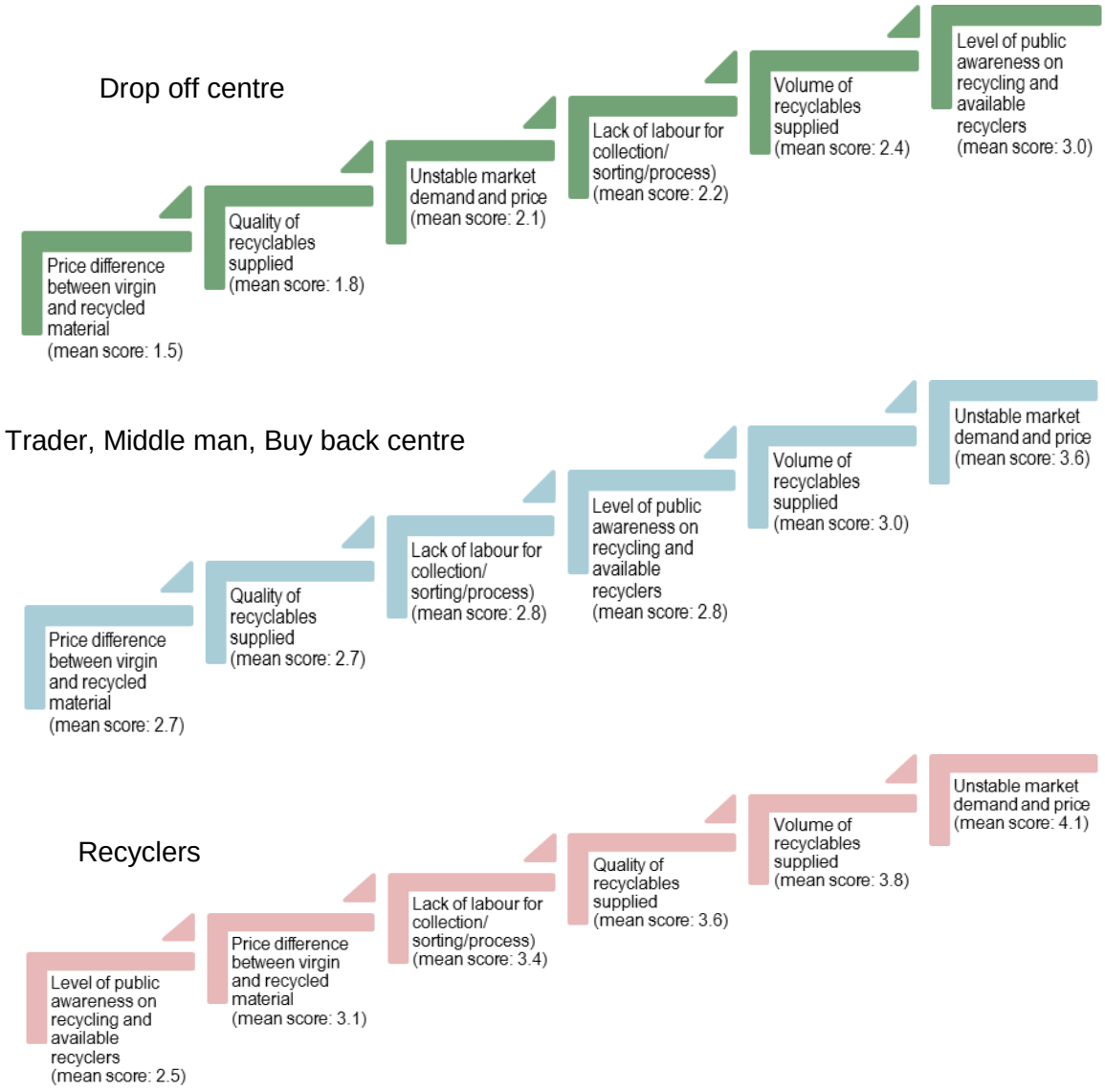
Number of Collection Points	Northern	Central	East Coast	Southern	Sarawak	Sabah	Total
1	89.5	38.8	100.0	92.9	66.7	6.7	61.2
2 - 5	10.5	27.8	-	7.1	33.3	40.0	21.3
6 - 10	-	16.7	-	-	-	33.3	10.0
11 and above	-	16.7	-	-	-	20.0	7.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

12.4.5 Factors Affecting the Recycling Activity

Figure 27 Shows how respondent recycling players from different categories perceived the factors that could affect recycling activities in their company or organisation. Respondents were asked to rate the importance of each factor listed in the questionnaire. RPs with drop off centres, thought the level of public awareness of recycling and availability of recyclers to buy the recyclables was the most important factor. The second most important factor that may affect recycling activity is the volume of recyclables capable of being collected (or supplied by the public).

For the traders, middle men and buy back centres, the most important factor affecting their recycling activity is an unstable market demand and, hence, price instability. Similarly for drop off centres, the second most important factor was the volume of collectable recyclables.

Figure 27: Factors that may affect recycling activity



Recyclers also rated unstable market demand and price as the most important factor affecting their recycling activity, and cited the volume of collectable recyclables as the second most important factor. They saw the level of public awareness on recycling as the least important factor affecting recycling activity.

Compared to the drop off centre, the recycling activities carried out by the traders, middle men, buy back centres and recyclers, are more market driven. Unstable market demand and price of recyclables has caused the group to be sceptical about expanding or continuing their recycling activity or businesses.

12.4.5 Type of Recyclables Collected by Recycling Players

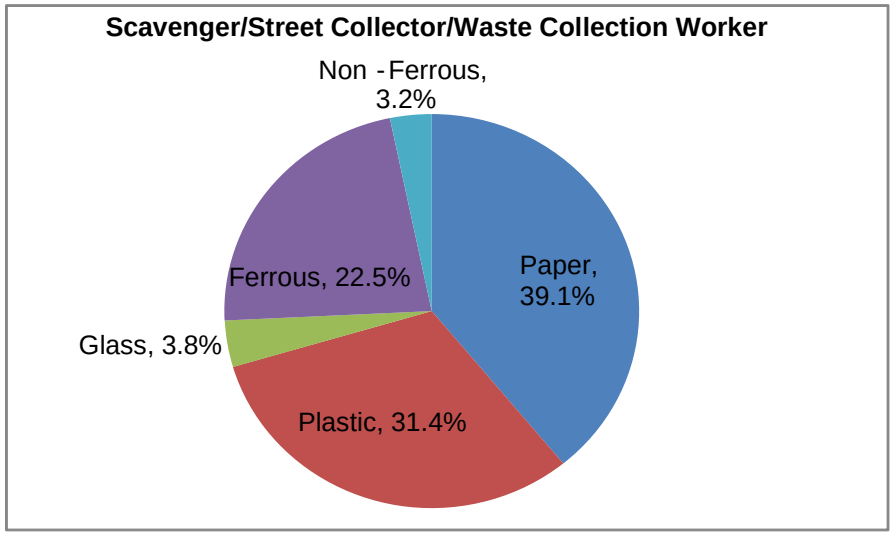
Figure 28 shows the distribution of type of recyclable items collected by recycling player respondents. For group of RP1 (Scavengers/street collectors/waste collection workers), the most collected recyclable items was paper (39.1%), followed by plastic (31.4%) and ferrous (22.5%). Glass (3.8%) and non-ferrous (3.2%) materials are the items least collected by the RP1 group.

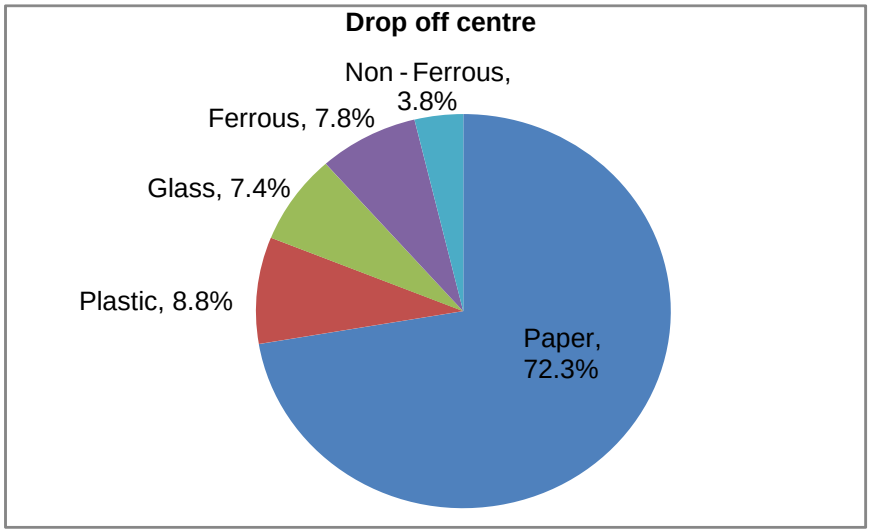
Compared to other types of recycling players, the drop-off centres have the highest percentage of paper recyclable items, followed by ferrous items. This shows that most people give away paper products for recycling for free to the drop off centres.

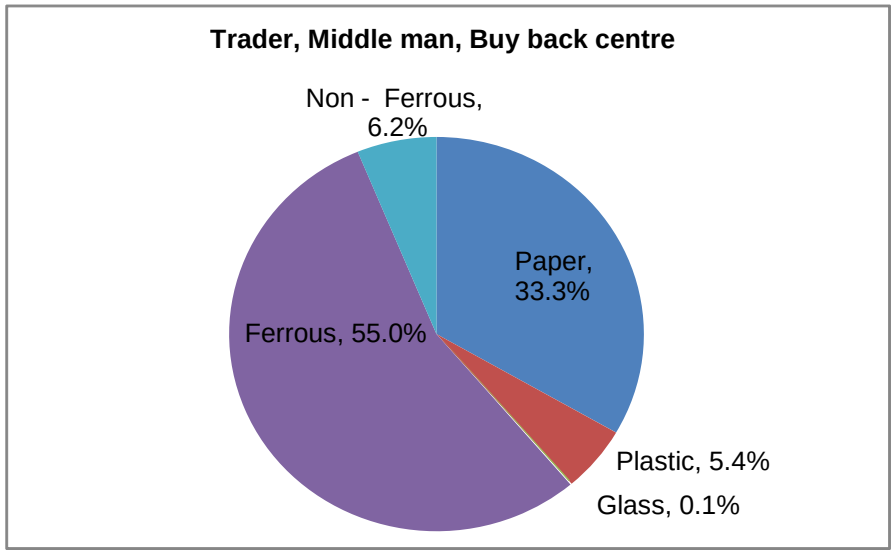
Ferrous items are the type most collected (54.7%) by the traders, middle men and buy back centres, followed by paper (33.5%). The survey shows that a very minimal volume of glass (0.02% of total recyclable materials) was collected by them.

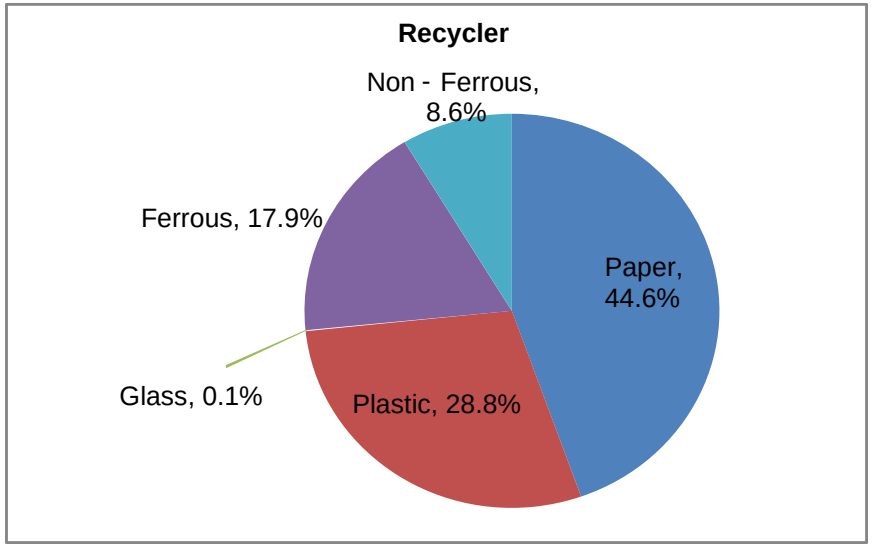
For recyclers, paper (44.6%) is the most collected recyclable material followed by plastics (28.8%).

Figure 28: Type of recyclables collected by Recycling Players in Malaysia









12.5 Material Flow

The following section presents the recyclable materials flow from household and ICI to the recycling players, and from recycling players to other RPs.

Five main recyclable materials discussed are:

- Paper
- Plastics
- Glass
- Ferrous and non-ferrous materials

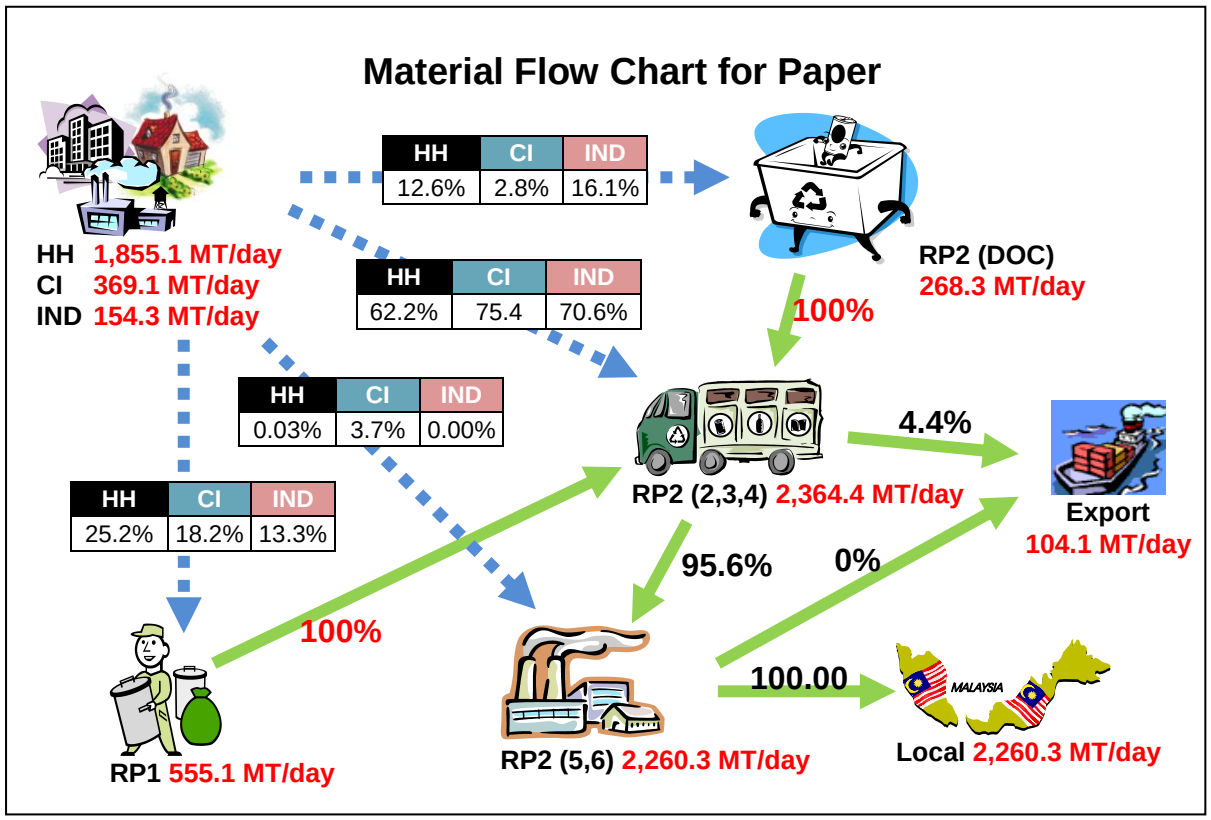
The weight of recyclable materials referred to in the following section, relate to the weight of recyclable materials retained in households and ICI for recycling.

12.5.1 Paper

Figure 29 shows the material flow chart for paper in Malaysia. The flow chart shows that about 25 per cent of the papers from households are left outside of their houses to be collected by RP1, 12 per cent are sent to drop-off centres, while 62 per cent are sold to traders, middle men and buy-back centres. Less than one per cent of the recyclable paper products were sold to recyclers directly.

As in households, most of the papers from the commercial and institutional sector, (CI) (75%) and industries (71%) were sold to traders, middle men and buy-back centres. It was assumed that all the collected papers from RP1 and drop off centres, were sold to traders and middle men. About 4 per cent of the waste paper material collected and/or received by the trader, middle men and buy-back centres are exported, while 96 per cent are sold to local recyclers for processing.

Figure 29: Material flow chart for paper in Malaysia



Note:

HH denotes 'Household', CI denotes 'Commercial and Institution', IND denotes 'Industry',

RP1 denotes 'Recycling Player 1: Door-to-door Collector, Street Collector, Waste collection worker & Scavenger',

RP2 DOC denotes 'Recycling Player 2: Drop off Centre', RP2 (2,3,4) denotes 'Recycling Player 2:Trader, Middle Man, Junk shop and etc' and RP2 (5,6) denotes 'Recycling Player 2: Recycler'

12.5.2 Plastic

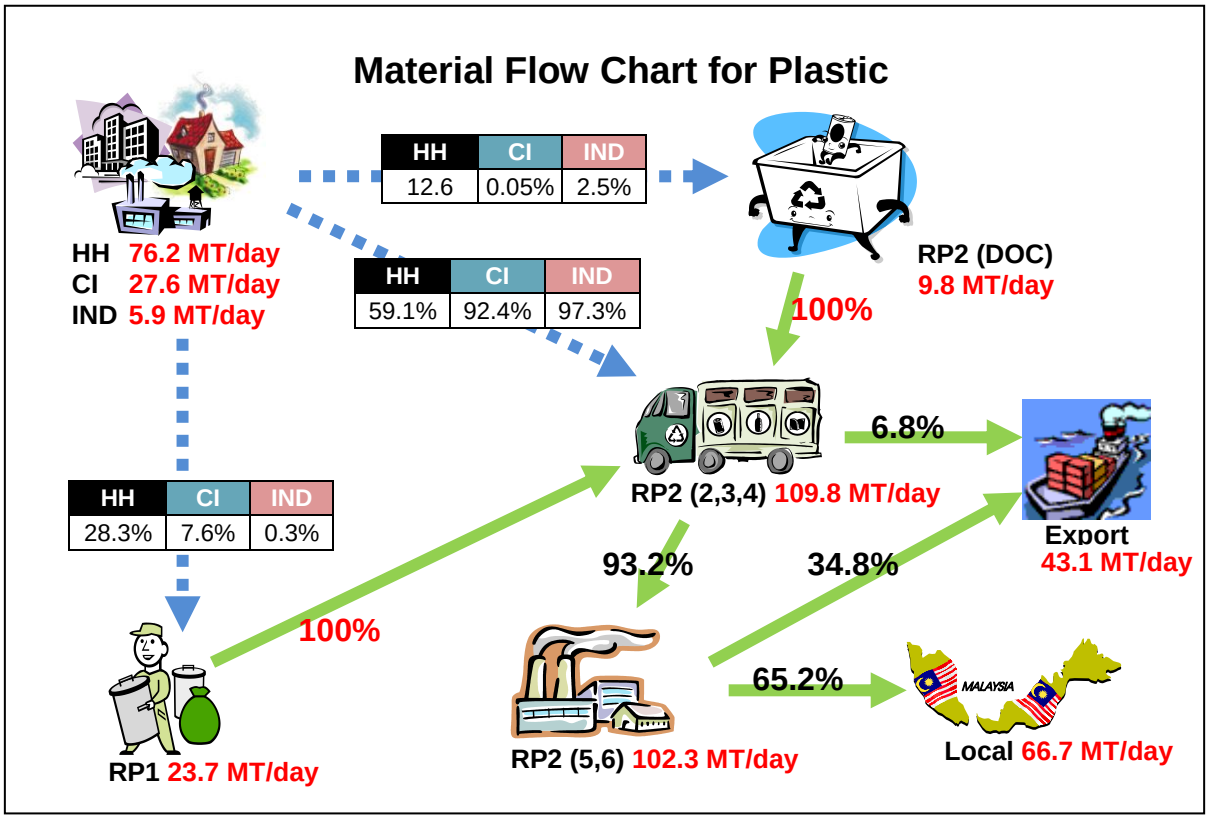
As presented in ***Figure 30***, the most common way for households to handle their plastic recyclables was:

a) to sell them to the traders, middle men or buy-back centres (59.1%),
b) leaving these outside their houses for door-to-door collectors or waste collection workers (28.3%) and
c) sending them to drop-off centres (12.6%).

The CI handled their plastic recyclables by:

a) selling plastic to traders, middle men and buy-back centres (92.4%),
b) leaving it to street-pickers or waste collection workers (7.6%) and
c) less than one per cent sent their plastics to drop-off centres.

Figure 30: Material flow chart for plastic in Malaysia



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For Industries, plastic recyclables were:

a) sold to traders, middle men and buy-back centres (97.3%),
b) sent to drop-off centres (2.5%) and
c) collected by street-pickers or waste collection workers (0.26%).

Overall, 93.2 per cent of plastics collected by traders, middle men and buy-back centres were sold to recyclers for further processing, and the remaining 6.8 per cent exported. For RP2 (5,6), about one third (34.8%) of recycled plastics were exported and 65.2 per cent of processed plastic was used locally (***Figure 30***).

12.5.3 Glass

As shown in ***Figure 31,*** the most common way for households to handle their glass recyclables was:

a) to sell them to the traders, middle men or buy-back centres (47.1%),
b) leaving these outside their houses for door-to-door collectors (42%) and

c) sending them to drop-off centres (10.9%)

The CI handled their glass recyclables by:

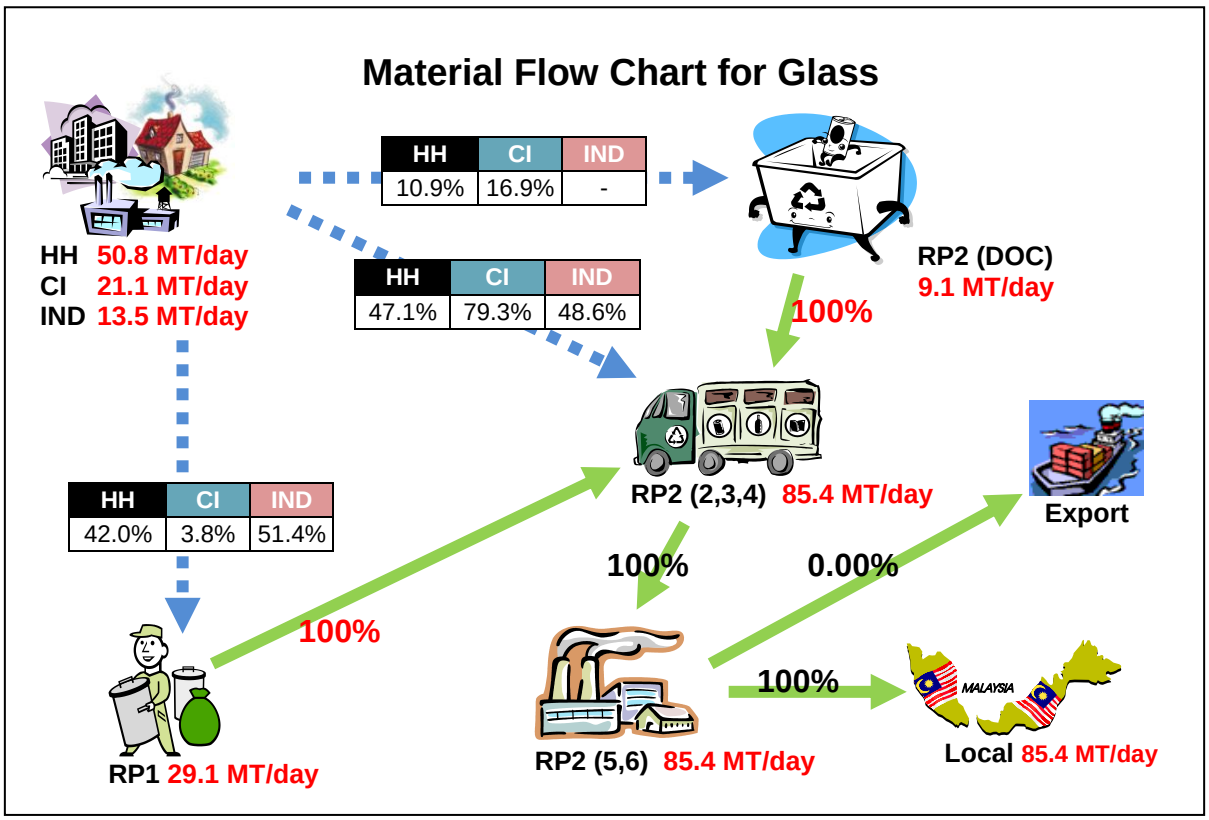
a) selling plastic to traders, middle men and buy-back centres (79.3%),
b) leaving it to street-pickers or waste collection workers (3.8%) and
c) sent their plastics to drop-off centres (16.9%)

For Industries, plastic recyclables were:

a) disposed off glass in municipal waste bins for street-pickers or waste collection workers (51.4%) and
b) sold to traders, middle men and buy-back centre (48.6%)

All glass collected by traders, middle men and buy-back centres are sold to local recyclers. Recyclers only buy glass from middle men, junk shops dealing with recyclables, and buy-back centres. The recyclers sell processed glass locally (***Figure 31***).

Figure 31: Material flow chart for glass in Malaysia



Note:

HH denotes 'Household', CI denotes 'Commercial and Institution', IND denotes 'Industry',

RP1 denotes 'Recycling Player 1: Door-to-door Collector, Street Collector, Waste collection worker & Scavenger',

RP2 DOC denotes 'Recycling Player 2: Drop off Centre', RP2 (2,3,4) denotes 'Recycling Player 2:Trader, Middle Man, Junk shop and etc' and RP2 (5,6) denotes 'Recycling Player 2: Recycler

12.5.4 Ferrous Metals

As with other recyclables, households handled ferrous items by:

a) more than half of households sold their ferrous items to traders, middle men and buy-back centres (59.5%),
b) disposing off the rest in waste bins for door-to-door collectors or waste collection workers (30%),
c) sent these to drop-off centres (10.5%) and
d) a very small percentage sold them directly to recyclers (0.01%).

CI handled ferrous recyclables by:

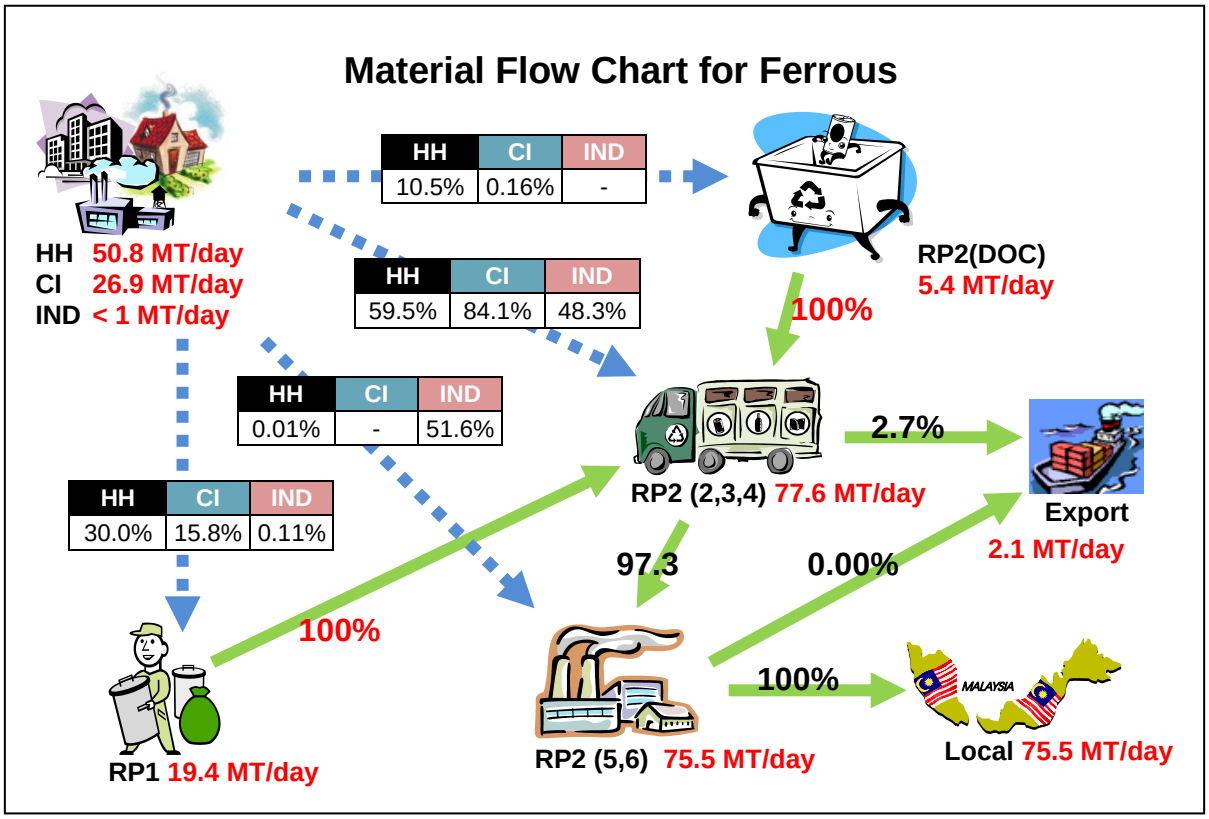
a) selling their ferrous recyclables to traders, middle men and buy-back centres (84.1%),
b) disposal in waste bins (15.8%) and
c) delivery to drop-off centres (0.16%).

For Industries, ferrous recyclables were:

a) sold directly to recyclers (51.6%),
b) sold to traders, middle men and buy-back centres (48.3%) and
c) disposed in waste bins (0.11%).

About 97.3 per cent of ferrous recyclables collected by traders, middle men and buy-back centres were sold to the recyclers while the remaining 2.71 per cent were exported. The ferrous materials collected by recyclers are processed and sold locally (***Figure 32***).

Figure 32: Material flow chart for ferrous in Malaysia



Note:

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12.5.5 Non-Ferrous Metals

Households handled non-ferrous recyclables by:

a) selling more than three quarters to traders, middle men and buy-back centres (80.5%),
b) disposing off in waste bins for door-to-door collectors or waste collection workers (13.8%) and
c) sending the recyclables to drop-off centres (5.7%).

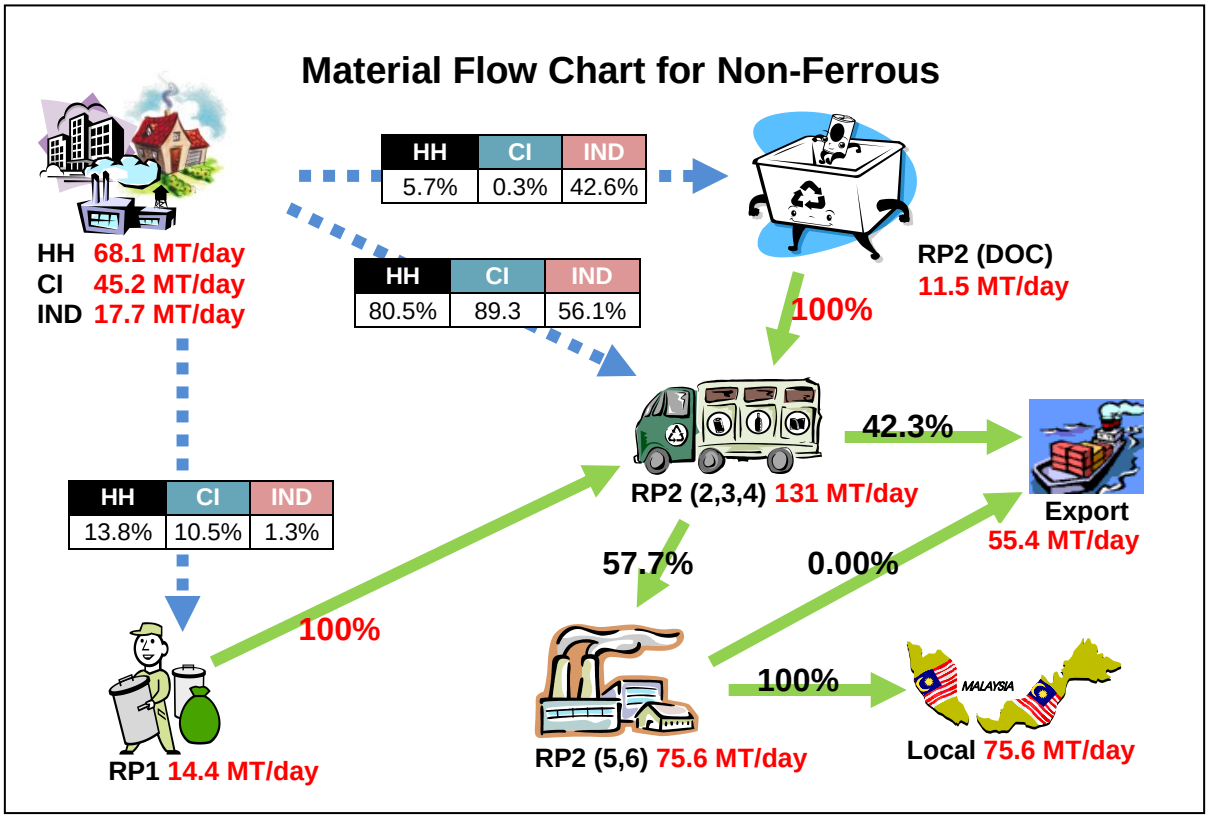
For both CI and Industries, non-ferrous recyclables were:

a) sold to traders and middle men (more than half of their non-ferrous recyclables) (89.3%),
b) sold to buy-back centres (56.1%),
c) sent to drop-off centres - 0.25% (CI) & 42.6% (Industries) and

d) collected by the street collectors and waste collection workers - 10.5% (CI) &1.3% (Industries).

The received non-ferrous (100%) at drop-off centres was assumed to be sold to the middle men and buy-back centres. 57.7 per cent were sold to the local recyclers and 42.3 per cent were exported. The processed non-ferrous was all for local use (***Figure 33***).

Figure 33: Material flow chart for non-ferrous in Malaysia



Note:

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RP1 denotes 'Recycling Player 1: Door-to-door Collector, Street Collector, Waste collection worker & Scavenger',

RP2 DOC denotes 'Recycling Player 2: Drop off Centre', RP2 (2,3,4) denotes 'Recycling Player 2:Trader, Middle Man, Junk shop and etc' and RP2 (5,6) denotes 'Recycling Player 2: Recycler'

12.6 Recyclable material being Imported and Exported

Table 89 shows the Malaysia import and export of waste and scrap in year 2011. Recyclable ferrous materials formed the largest volume, of the four types of imported scrap materials assessed. Plastic waste was the highest in volume for export, whilst ferrous scrap was the largest export in terms of monetary value (USD). Overall, the imported volume of recyclable materials was less than the exported volume; however, in terms of value, the value of imported recyclables was more than the value of the exported recyclables. Consequently, there was a deficit in the balance of trade for all types of recyclables, except for plastic waste.

Table 89: Malaysia External Trade of Recyclable Materials for year 2011

Type of Waste and Scrap	Import			Export			Trade Balance (USD)
	Quantity in MT	USD/ MT	Total (USD)	Quantity in MT	USD/ MT	Total (USD)	
Paper	218,929	326	71,370,854	214	1,159	248,026	(71,122,828)
Plastic	142,860	456	65,144,160	153,865	695	106,936,175	41,792,015
Ferrous	2,050,146	527	1,080,426,942	70,107	306	21,452,742	(1,058,974,200)
Non-ferrous	104,829	2,566	268,987,672	57,058	2,786	158,978,345	(110,009,327)
Total	**2,522,800**	**-**	**1,507,912,740**	**301,015**	**-**	**292,538,267**	(1,215,374,473)

Source: International Trade Centre (UN Commodity Trade Database) Year 2011

Table 90 shows the top 10 countries exporting recycling material to Malaysia by type of waste and scrap. Australia supplied the highest volume of paper waste and scrap to Malaysia. Most plastics came from the United Kingdom which is a major country for plastic waste and scrap exports to this country. United States of America exported the largest volume of ferrous and non-ferrous metals to Malaysia.

Table 90: Top 10 Countries Export to Malaysia by Type of Waste and Scrap

Type of Waste and Scrap	Rank									
	1	2	3	4	5	6	7	8	9	10
Paper	Australia	Singa-pore	United Kingdom	Japan	USA	Nether-lands	Belgium	New Zealand	Italy	Sweden
Plastic	United Kingdom	USA	Germany	Singa-pore	Spain	Phil-ippines	Belgium	Japan	Republic of Korea	Hong Kong
Ferrous	USA	South Africa	Singa-pore	United Kingdom	Australia	Phili-ppines	Germany	United Arab Emirates	New Zealand	Chinese Taipei
Non-ferrous	USA	South Africa	Singa-pore	United Kingdom	Australia	Phili-ppines	Germany	United Arab Emirates	New Zealand	Chinese Taipei

Source: International Trade Centre, (UN Commodity Trade Database) Year 2011

Table 91 shows that Malaysia largely sells paper waste to Singapore and Thailand. China is the main importer of Malaysia's plastic waste. India is the main importer for Malaysia's recyclable ferrous materials. Japan imports most non-ferrous recyclables from Malaysia.

Table 91: Top 10 Countries Received Import from Malaysia by Type of Waste and Scrap

Type of Waste and Scrap	Rank									
	1	2	3	4	5	6	7	8	9	10
Paper	Singa-pore	Thailand	-	-	-	-	-	-	-	-
Plastic	China	Hong Kong	Indo-nesia	India	Chinese Taipei	Estonia	Thailand	Viet Nam	Sing-apore	Pakistan
Ferrous	India	Republic of Korea	Thailand	China	Brunei	Chinese Taipei	Viet Nam	Oman	Japan	Spain
Non-ferrous	Japan	China	India	Republic of Korea	Thailand	Hong Kong,	Singa-pore	Chinese Taipei	Viet Nam	USA

Source: International Trade Centre (UN Commodity Trade Database), Year 2011

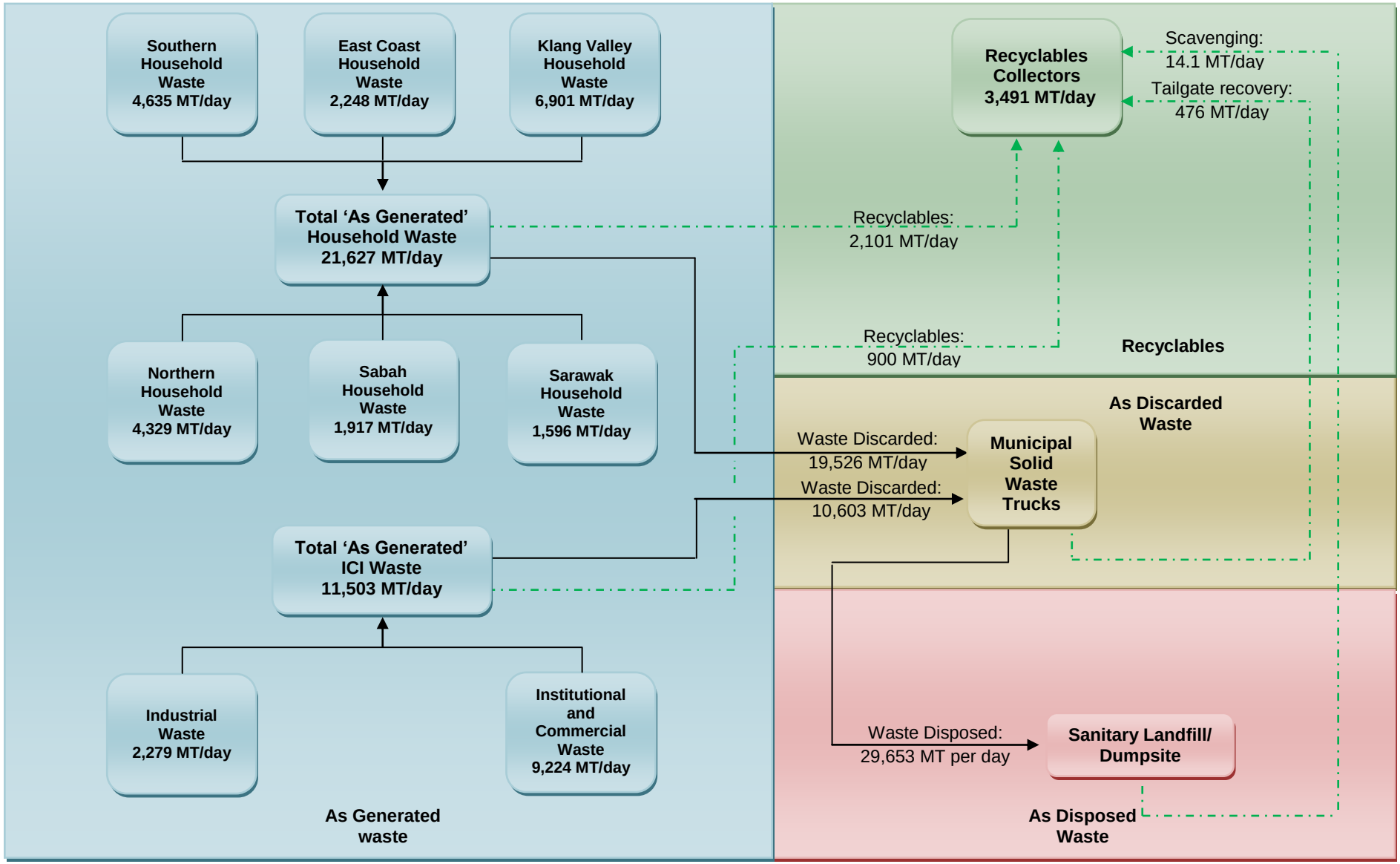
13 WASTE FLOW

Figure 34 presents the overall waste flow for Malaysia. The amount of household waste generated from the 6 regions and the waste generated from the ICI sectors is the total waste generated in Malaysia and is estimated to be 33,130 Mt/day.

Approximately 3,500 Mt/day is extracted from this waste as recyclable material, while the balance primarily gets disposed off in Sanitary landfills or dumpsites around the country.

It must be noted that the values for the overall waste generation was taken from the housing types. As previously explained some variations between the housing types and regions were noted but these were adjusted so that the quantity of waste distribution is consistent in this waste flow diagram.

Figure 34: Overall Waste Flow for Malaysia



14 COMPARISON OF RESULTS TO THE STUDY CONDUCTED BY JICA

The following section compares the results obtained from ***Waste Composition Survey*** with the survey conducted by JICA in September to November 2004 under the "*The Study on National Waste Minimisation in Malaysia".* The report was published in 2006.

The JICA's Survey was carried out continuously for 8 days, during which period 100 samples were collected for analysis. Following were the objectives of the survey:

- To estimate the amount and composition of waste generated from households with identification of recyclable and currently recycled materials
- To identify and understand the existing storage and collection manner of waste and recyclables from households.

The ***Table 92*** presents the waste components that have changed over the last 8 years in Malaysia.

Table 92: Comparison of the Waste Composition between the years 2004 and 2012

Categories		JICA (Waste composition for the year 2004)		Present Study (Waste composition for the year 2012)	
Combustible		%	MT/day	%	MT/day
1	Food waste	48.04	7,718	44.50	9,624
2	Bones	1.26	202	-	-
3	Mix paper	17.09	2,746	8.50	1,838
4	Plastics (Film)	5.35	860	3.85	833
5	Plastics (Rigid)	3.73	599	7.98	1,726
6	Polystyrene	0.58	93	1.35	292
7	Textile	1.85	297	3.06	662
8	Rubber & Leather	1.82	292	2.15	465
9	Wood	0.22	35	1.35	292
10	Yard waste	6.58	1,057	5.79	1,252
11	Diapers	5.06	813	12.14	2,626
12	TetraPak	-	-	1.58	342
Sub-total for combustible		91.57	14,712	92.25	19,951
Incombustible		%	MT/day	%	MT/day
13	Glass	3.71	596	3.32	718
14	Ferrous	1.61	259	1.77	383
15	Non-ferrous	0.02	3	0.05	11
16	Aluminium	0.37	59	0.91	197
17	Batteries	0.03	5	0.11	24
18	Electrical & Electronics	0.18	29	0.40	87
19	Others	2.55	410	1.19	257
Sub-total for Incombustible		8.47	1,361	7.75	1,676
Total		100.00	16,066	100.00	21,627
Recyclable fraction*		31.88	5,122	27.96	6,048

* - Paper, Plastics (film and rigid), TetraPak, Glass and metals

The waste components were firstly grouped into the categories used in the JICA for direct comparison. The Food waste, Paper and yard waste were the largest components of the waste generated by weight in 2004. However, in 2012, after Food waste, which still remained the highest, the next 3 highest components were diapers, paper and rigid plastics (HDPE, PP, PVC and other plastics). In the last 8 years, there is more than a 400% jump in the amount of Diapers and almost 300% jump in the rigid plastics generated daily.

The overall average combustible waste generated over the 8 years seems to be consistent and is approximately 92% and the balance 8% being non-combustible waste.

In terms of recyclable materials, it was found that about 31.88% or 5,122 MT/day of major recyclable materials were generated at the households in 2004, this included mixed papers, mixed plastics, glass, ferrous metals and non-ferrous metals. By 2012 these recyclable material have increased to 6,048 MT/day representing almost 28% of the total household waste generated.

15 LIMITATIONS AND ISSUES

Every possible effort was taken to ensure that the quality of samples collected for this study was reliable, representative and accurate. Nevertheless, there were some uncertainties identified during the course of the study as summarised below:

- The results and conclusions made in this report are based on the samples obtained during the survey. These samples included interviews conducted in Households, Industries, Commercial and Institutional sectors and the recycling players. It must be noted however, the interviews conducted for the recycling players did not cover all of them in this study. The primary reason being the lack of available information on this sector. The assumption is that the samples or interviews taken were an adequate representation of the recycling activities in Malaysia.

- Not all recycling players interviewed were obliging and forthcoming with information for this study. Therefore, some information used in the study was based on estimates. Many of them were offended when the surveyors tried to approach them and did not want to disclose any information, particularly related to business performance. This may be due to the following reasons:

  - The respondents were afraid of releasing information, especially matters related to prices and income due to tax issues.

  - Some recycling players were frustrated and reluctant in taking part in the recycling survey as they feel have not gained any support from both, the Local Authorities and Kementerian Kesejahteraan Bandar, Perumahan Dan Kerajaan Tempatan, for their efforts in the recycling programme/businesses.

  - Some respondents were operating without proper licenses or permits and were afraid of being issued with summonses or incurring other legal issues.

- Collectors or companies such as traders or middle men do not have a proper record-keeping system and therefore the data provided by them were based on estimates rather than actual figures.

- Results obtained from interviews and from on-site observations and discussions with recycling players have limitations in that the reported data may have slight variations to the actual amount handled by the recycling players.

- A total of 421 recycling players samples were collected in this study, which covered a large part of the entire recycling system. However the exact size or market of the recyclable materials cannot be determined. Therefore, some assumptions and estimations were used to generate the amounts of recyclable material.

Based on the uncertainties summarised above, the key assumptions were:

- In the estimation of the amounts of material flows in the study, all the recyclable materials from the recycling centres were assumed to be sold to the middlemen.

- The selling prices and amounts of recyclable materials sold by the middlemen / traders / junkshops were used and assumed to be the purchasing prices and amounts of recyclable materials bought by the industries.

16 DISCUSSION

The information provided in this Study is a nation-wide picture of municipal solid waste generation, recycling practices and characteristics of the waste. The current study is a snap shot of the actual waste characteristics of the country and establishes a comprehensive baseline. Future studies may employ the same methodology used in this study lending a historical perspective to establish trends and changes that have occurred over the years, both in types of wastes generated and in the ways they are managed. In addition, the information in this study can also be used to develop approximate and quick estimates of MSW composition and characteristics in a defined area for the local or regional level. That is, the data on generation of MSW per capita nationally may be used to estimate generation in a local area based on the population in that area.

In summary, the data in this study can help in local planning by:

- Developing approximate estimates of total MSW generation in the various zones, level of urbanisation and housing types.
- Being used as a benchmark for the data from future MSW studies that are more localised for accuracy and consistency.
- Accounting for trends in total MSW generation and the generation of individual components.
- Assisting in forecasting, setting goals and measuring progress in source reduction and recycling (including composting).

There are many regional variations which require each area to independently monitor and determine its waste profile so that the waste management requirements are fulfilled based on its unique waste. Such factors are local availability of suitable landfill space, alternate technologies for waste recovery and recycling, proximity of markets for recovered materials, population density, commercial and industrial activity, and climatic and groundwater variations. While the national and zonal average data are useful as a checkpoint against local MSW characterisation data, any differences between local and national data should be examined carefully.

In relation to household recycling practices, a recycling rate of ***9.7 per cent*** was estimated for Malaysia (refer ***Table 31*** and ***Table 38*** for details).

The main reasons for households not recycling were attributed to lack of time (or interest) and that they don't see a need for it. Poor recycling practices were also attributed to the availability of recycling services and facilities. The main reasons why households recycled, was attributed to monetary benefit, while others, also a significant number of people, gave it away as charity and some cited that they were asked to do so.

About 67.8 per cent of the respondents reported they practiced recycling at home, whereas about 32.2 per cent of the total households did not practice any recycling.

The respondents in urban areas of Peninsular Malaysia stated their primary reason for recycling was to protect the environment (29.8%), followed by charity (29.7%) and monetary incentive (26.1%). However, the percentage gaps between these three most important reasons were relatively small.

The respondents in rural areas of Peninsular Malaysia similarly stated that the main reason was to protect the environment (36.5%). The second most important recycling motivator for the rural respondents was monetary incentive (36.5%), followed by the reason of charity (9.6%).

The result shows that both urban and rural respondents were concerned for the environment and the impact caused by solid waste. Charity seems to take precedence over monetary benefits in the urban areas.

Primary reason cited by the respondents in households for not practicing recycling, which was than one-third of the respondents, was that they had “no time” to do recycling. This was clearly evident in the Klang Valley (43%) for Peninsular Malaysia and Sabah in East Malaysia (54%). It was also concluded from the Survey that Households are not interested in paying an additional amount for recycling services. They are however, more willing to support the recycling efforts, by separating their waste, more so if there was a monetary incentive. Only 15 per cent of households would be willing to pay extra for the service. This is an encouraging sign but it would not be enough to sustain a material recovery facility business (if privatised) without a larger section of community following suit.

In terms of more effective ways to promote recycling, many pointed to “awareness raising” and increasing facilities or even to have door-to-door collection, thus suggesting a willingness to change their habits rather than having authorities force them to do so. However, 20 per cent of households agreed that there should be strict regulations or penalties in-place to enforce recycling.

There appears to be a vast recycling network of private collectors and recyclers that are efficient in terms of collecting this recyclable material. However, this network does not stretch into the rural regions including Sabah, Sarawak and the East Coast states.

It would appear that households are conservative. Therefore, to increase the recycling rate for households, it is evident that they prefer the change to come from increased awareness rather than having to pay for the change or be imposed on by any particular party.

17 RECOMMENDATIONS

Waste Composition and Characterisation:

- A more detailed sampling and analysis (time series) plan needs to be carried out. In order to get an accurate and updated statistics on the Waste Composition and Characterisation, survey should be conducted every 3 years. This may be accomplished by employing the following collaborations:

  - Coordination with all public and private universities who carry out Waste Composition and Characterisation studies at Degree, masters and PhD levels. All universities have to use a standard protocol and the report should be in a format that could then go into a national data base which is updated continuously.
  - All service providers & facility operators must provide the same data on operation and the kind of waste being handled before their licences is renewed.
  - Funding from MOHE and MOSTI to all public and private Universities and Research Institutes, specifically for waste management must have a representative from JPSPN / PPSPPA in order to coordinate the research and the data flows back to the agencies.
  - Establishment of a Waste Centre of Excellence.
  - The data coordinating section must also be able to indicate to the various universities in which areas that need to be studied and the scope of work to be done in collaboration with the universities.

- To co-ordinate this task and to establish a national database maintained under JPSPN / PPSPPA.

- Frequent review of the completeness of the national database is required. There are many data banks on MSW around the world. Malaysia has taken the first step in moving towards the national data bank. However, the current information system has not been established and needs to be looked at in a holistic manner to provide input for decision makers.

- MSW database is also linked with health and environmental (climate change) effects. The national data base should also address these issues.

Recycling Survey

- Given the sentiment of the households, the existing collection network of the private recyclers needs to be improved so that they can have a greater coverage of the recycling market. It could come from providing facilities in the less urban areas, so that the private recyclers can operate. However, it is important to note that current limitation of the private recycling network is that they collect items with commercial value and not all items gets picked.

- Provide training of licensed recyclers on available technologies, international experiences in the field of recycling and environmental issues.

- The proposed licensing and permit system by JPSPN may only “upgrade” recycling players in the urban and metropolitan areas. The licensing system is needed in order to ensure that solid waste is properly managed. Due consideration must be given in the implementing of the licensing system to avoid lack of interest from players in the rural sector. It is recommended that the roll-out be done in phases and in zones rather than a national roll-out. A separate exercise is suggested on the precise phasing, coverage and the effectiveness of the recycling activities.

- It would be necessary to ensure that planning regulations be changed to require developers to provide space and facilities for recycling, just as they are required to set aside space for waste collection. Such a requirement would add little cost to the entire (high-rise) development but would facilitate recycling practices for those who want to start it within their own housing area.

- As there seems to be varied levels of awareness already among households, it is important that the local authorities set aside resources to guide resident associations to start recycling practices and initiatives. It is therefore recommended that resources are provided to Local Authorities and NGOs to initiate recycling practices within their areas and on a voluntary basis. Local Authorities apply for funds and resources for this activity while the government provide the allocation and other support.

- A major revamp of the current recycling practices, especially among the private recyclers and collectors, would not be possible in the immediate future. It would require a phased approach and implemented first in the urban areas while providing resources based on the gained experience to the remaining Local Authorities to develop the practices.

- Aggressive 3R awareness programs using social media (facebook, twitter etc.); to initially guide interested household members and business entities on how and what to recycle, closest recycling collection points and the benefits of recycling. Forums for people to share ideas and success stories must also be provided. The administrator of the social media must be well versed with Solid Waste Management and must be in the position to reply promptly.

- The Survey results indicate that making recycling a habit should come from “inside”, rather than be imposed from outside with stricter enforcement of health and safety regulations and imposition of penalties. (Respondents may have related this to littering rather than enforced recycling. e.g. RM500 fine for throwing rubbish on the road etc.). Incentives and awards may be given to regularly complying recycling companies and developers.

- Overall, both urban and rural respondents ranked the method of “raising awareness on recycling” as the most effective way to further promote waste minimization and recycling.

18 SUMMARY OF RESULTS

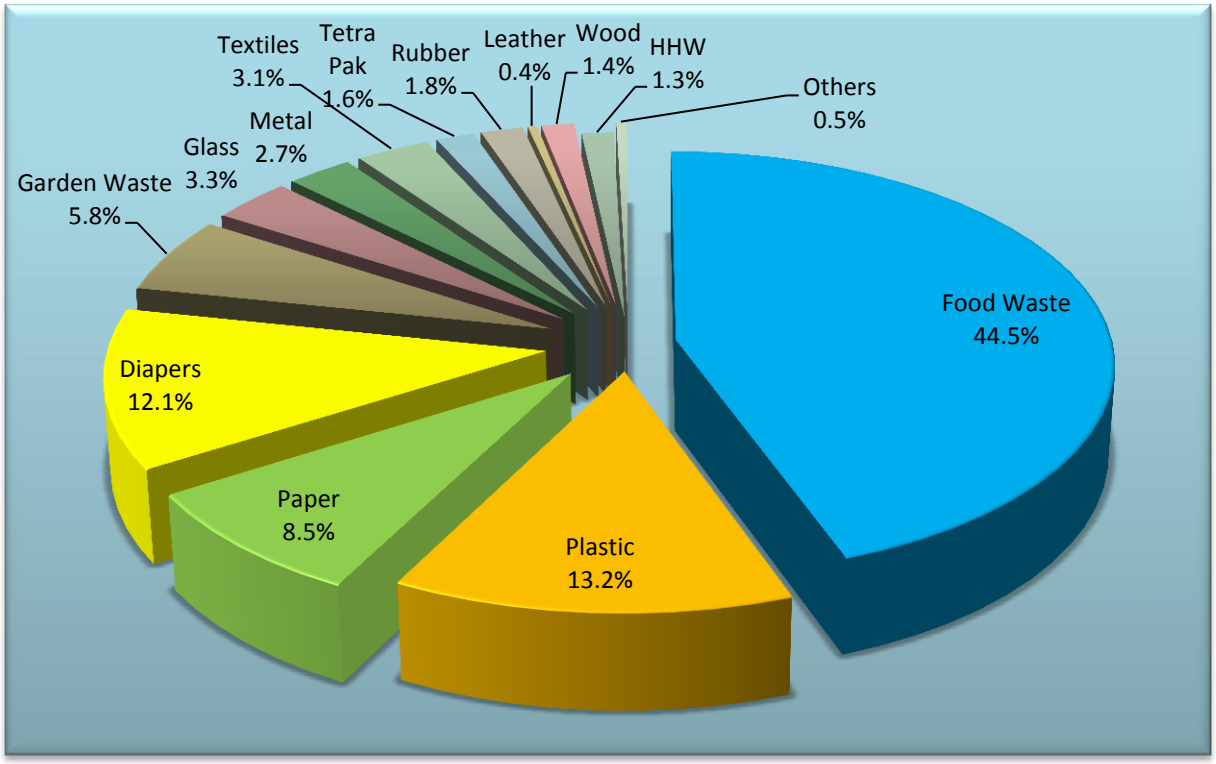
The following section presents the summary of the findings and results of the Survey as required in the Terms of Reference of this Survey.

18.1 Detailed waste composition and characteristics data

18.1.1 Waste composition of the As Generated/As Discarded waste at the various sources

a) Households

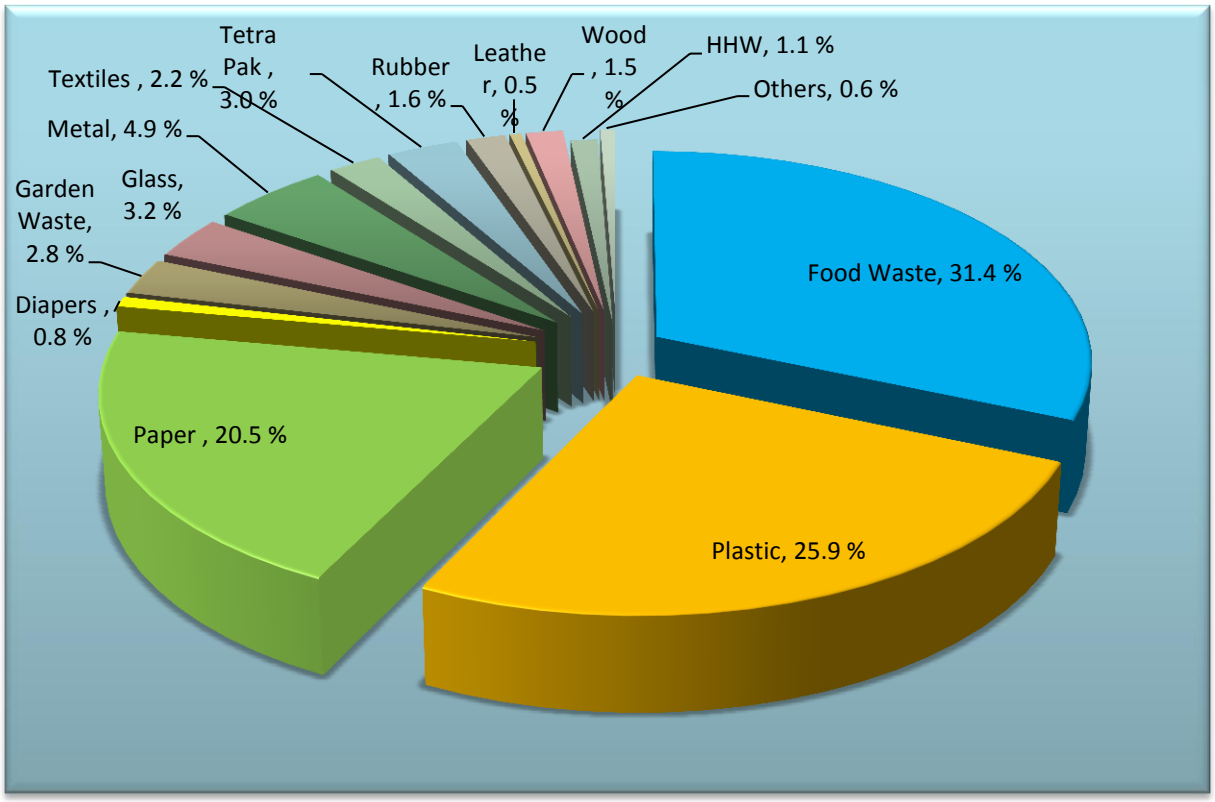
Figure 35: Malaysian Household Waste Composition (As Generated)



- HHW – Household Hazardous waste
- Wood – Wood + Peel / Husk

b) Commercial, institutions and industries

Figure 36: Malaysia ICI Waste Composition



- HHW – Household Hazardous waste
- Wood – Wood + Peel / Husk

18.1.2 *Breakdown of the waste composition for the households – based on the different housing types / income levels*

Table 93: Waste Composition for Low, Middle and High cost houses (As Generated), in gms./capita/day

	Waste Components	Low cost	Medium cost	High cost
Organics	Food Waste	299.21	337.95	358.79
	Garden Waste	30.68	47.50	55.34
	Wood	3.52	3.39	1.98
	Peel /Husk	8.22	5.91	5.94
Paper	Mixed Paper	10.83	9.44	13.63
	Newsprint / Old Newspaper	23.51	33.49	39.95
	Cardboard	23.88	31.02	34.67
Plastics	Polyethylene Terephthalate (PET)	14.77	20.03	13.48
	High-Density Polyethylene (HDPE)	20.86	29.73	31.25
	Polyvinyl Chloride (PVC)	2.51	1.82	7.15
	Low-Density Polyethylene (LDPE)	28.44	28.80	27.76
	Polypropylene (PP)	10.07	10.49	7.98
	Polystyrene (PS)	8.34	10.83	12.04
	Other Plastics	0.50	0.77	0.27
Glass	Glass Bottle	22.59	24.91	26.26
	Sheet Glass	0.20	0.33	1.26
Metals	Ferrous Metal	13.55	12.52	13.83
	Aluminium	6.94	5.55	9.72
	Other Non-Ferrous Metals	0.27	0.07	1.56
Household Hazardous Waste	Batteries	0.57	0.50	2.08
	Fluorescent Tube	2.17	1.14	3.49
	E-Waste	1.08	0.71	1.92
	Aerosol Cans	5.59	4.85	6.04
	Paint Container	0.13	1.12	0.71
Others	Tetra Pak	11.21	9.64	14.59
	Diapers	78.94	93.79	106.53
	Rubber	12.08	13.41	14.51
	Textiles	22.78	22.98	21.36
	Leather	3.58	2.13	3.34
	Other Minor components	3.05	2.11	7.83

18.1.3 Breakdown of the waste composition for the commercial, institutions and industries

Table 94: Waste Composition for Institutional, Commercial and Industrial waste, in MT/day

		Institutional	Commercial	Industry
Organics	Food Waste	1,005.77	2,381.99	132.32
	Garden Waste	194.05	105.76	24.20
	Wood	29.16	46.93	103.23
Paper	Mixed Paper	214.55	353.66	260.61
	Newsprint / Old Newspaper	115.48	238.35	72.76
	Cardboard	254.53	404.93	466.61
Plastics	Polyethylene Terephthalate (PET)	142.37	311.24	82.74
	High-Density Polyethylene (HDPE)	175.91	339.82	202.13
	Polyvinyl Chloride (PVC)	18.16	29.86	200.04
	Low-Density Polyethylene (LDPE)	184.15	363.49	166.70
	Polypropylene (PP)	69.87	139.08	15.73
	Polystyrene (PS)	109.82	201.65	214.97
	Other Plastics	5.38	35.55	9.44
Glass	Glass Bottle	109.88	226.28	21.42
	Sheet Glass	3.51	10.33	1.03
Metals	Ferrous Metal	76.29	61.49	46.95
	Aluminium	72.71	185.64	87.41
	Other Non-Ferrous Metals	0.29	0.90	42.21
Household Hazardous Waste	Batteries	1.31	16.48	2.21
	Fluorescent Tube	8.97	1.78	-
	E-Waste	14.07	21.39	13.94
	Aerosol Cans	12.74	14.08	9.36
	Paint Container	1.09	9.53	2.62
Others	Tetra Pak	93.39	218.69	31.13
	Diapers	50.31	40.55	-
	Rubber	85.17	89.36	14.52
	Textiles	104.28	106.03	42.87
	Leather	18.76	25.02	11.74
	Porcelain / Ceramic	8.13	3.57	-
	Other Minor Components	16.5	44.40	-

18.1.4 Waste composition for As Discarded waste and As Disposed waste at the landfill site

Table 95: Waste Components for As Discarded and As Disposed in Malaysia, in MT/day

	Waste Components	As Discarded	As Disposed
Organics	Food Waste	8,563	8,492
	Garden Waste	1,240	1,445
	Wood	88	92
	Peel / Husk	217	248
Paper	Mixed Paper	286	273
	Newsprint / Old Newspaper	475	360
	Cardboard	697	567
Plastics	Polyethylene Terephthalate (PET)	463	374
	High-Density Polyethylene (HDPE)	610	604
	Polyvinyl Chloride (PVC)	92	90
	Low-Density Polyethylene (LDPE)	782	717
	Polypropylene (PP)	263	188
	Polystyrene (PS)	293	299
	Other Plastics	16	33
Glass	Glass Bottle	528	521
	Sheet Glass	30	59
Metals	Ferrous Metal	336	211
	Aluminium	160	85
	Other Non-Ferrous Metals	15	16
Household Hazardous Waste	Batteries	22	22
	Fluorescent Tube	48	48
	E-Waste	52	52
	Aerosol Cans	140	140
	Paint Container	20	20
Others	Tetra Pak	308	282
	Diapers	2,625	2,625
	Rubber	309	399
	Textiles	660	660
	Leather	85	99
	Porcelain / Ceramic/Stones	95	289
	Other Minor components	8	48

Note: the incoming waste sampled at the landfill were primarily from trucks that collected waste from Households and therefore only the weight of household waste disposed is considered

18.1.5 Analytical report on the waste characteristics - As discarded and As disposed of at the landfill site

Table 96: Average Proximate Analysis Results for Malaysian As Discarded and As Disposed Waste in per cent, Wet basis (n=54)

	As Discarded	As Disposed
Moisture Content	57.34	59.45
Volatile Matter Content	22.79	20.79
Fixed Carbon Content	11.48	11.10
Ash Content	8.39	8.65

Non-combustible fraction removed before analysing the sample

Table 97: Average Ultimate Analysis Results for Malaysian As Discarded and As Disposed Waste in per cent, wet basis (n=54)

	As Discarded	As Disposed
Moisture Content	57.34	59.45
Carbon Content	21.57	17.36
Sulphur Content	0.05	3.35
Hydrogen Content	4.29	5.89
Nitrogen Content	1.37	1.05
Oxygen Content	7.47	5.89
Organic Chlorine Content	0.06	0.04
Ash Content	7.85	6.96

Non-combustible fraction removed before analysing the sample

Table 98: Average Heavy Metal results of the As Discarded and As Disposed Waste in ppm, wet basis (n=54)

	As Discarded	As Disposed
Mercury	0.084	0.092
Vanadium	2.859	3.590
Chromium	37. 46	46.58
Manganese	15.17	21.97
Iron	269.34	318.27
Cobalt	0.30	0.53
Copper	6.46	5.92
Zinc	18.50	19.35
Arsenic	0.18	0.66
Silver	0.41	0.66
Cadmium	0.29	2.38
Lead	1.43	1.98
Aluminium	143.65	148.23
Magnesium	56.98	88.30
Nickel	2.49	1.94

18.1.6 Waste characteristics (ultimate and proximate analysis), for the individual components

Table 99: Proximate, Ultimate analysis and Calorific Value of the Individual Components

	Moisture content, %	Volatile Matter, wet basis %	Fixed Carbon, wet basis %	Ash Content, wet basis %	Carbon Content, wet basis %	Hydrogen Content, wet basis %	Oxygen Content, wet basis %	Nitrogen Content, wet basis %	Sulphur Content, wet basis %	Higher Heating Value dry,kJ/kg	Lower Calorific Value wet,kJ/kg	Lower Calorific Value wet, kcal/kg
		Proximate Analysis			Ultimate Analysis					Calorific Value		
Food	82.00	14.30	1.54	2.16	7.88	1.20	5.60	1.09	0.05	12,427	229	55
Garden	30.85	50.46	11.14	7.55	30.70	3.01	26.88	0.81	0.20	17,522	11,356	2,712
Mixed Paper	54.57	34.51	3.70	7.22	21.63	3.20	12.39	0.79	0.20	20,536	7,988	1,908
Newsprint	22.73	74.33	1.03	1.90	37.78	6.50	29.50	1.35	0.23	16,209	11,953	2,855
Cardboard	12.17	72.53	7.36	7.94	37.39	7.15	33.18	1.61	0.56	16,466	14,148	3,379
Tetra Pak	14.70	71.20	7.33	6.78	38.41	6.39	32.21	1.20	0.32	14,884	12,323	2,943
PET	5.69	92.46	0.93	0.92	79.37	8.06	4.95	0.88	0.12	33,755	31,678	7,566
HDPE	5.65	91.64	1.30	1.41	76.24	9.26	6.40	0.74	0.30	34,706	32,584	7,783
PVC	7.29	79.78	3.77	9.17	69.58	7.30	4.17	1.17	1.33	32,143	29,607	7,072
LDPE	44.69	50.40	0.96	3.95	40.62	6.14	3.72	0.74	0.14	29,924	15,443	3,688
PP	24.52	61.93	6.45	7.10	49.46	7.14	9.99	1.65	0.14	30,620	22,498	5,373
PS	10.32	88.19	0.29	1.20	67.79	8.37	10.33	1.42	0.58	31,725	28,180	6,731
Diapers	76.69	19.91	1.72	1.68	9.93	2.26	9.10	0.26	0.08	25,434	4,049	967
Textile	53.80	37.86	7.31	1.03	25.39	3.19	15.83	0.56	0.21	18,185	7,079	1,691
Rubber	2.96	87.76	0.92	8.36	66.58	5.14	13.51	0.99	2.47	23,092	22,323	5,332
Leather	4.66	81.54	4.86	8.95	58.74	8.64	16.56	1.53	0.93	26,337	24,977	5,966
Wood	15.92	72.07	10.89	1.11	43.65	6.52	31.34	1.21	0.25	20,092	16,488	3,938

18.1.7 Waste characteristics (heavy metals analysis), for the individual components:

Table 100: Heavy Metal Analysis of the Individual Components, in ppm

	Mercury	Vanadium	Chromium	Manganese	Iron	Cobalt	Copper	Zinc	Arsenic	Silver	Cadmium	Lead	Aluminium	Magnesium	Nickel
Food	0.005	0.081	5.46	13.91	31	0.07	0.63	2.95	0.067	0.100	0.010	0.077	-	9.20	2.88
Garden	0.018	0.837	4.68	92.71	226	0.20	3.69	17.15	1.218	0.188	0.030	0.851	-	35.89	0.22
Mixed Paper	-	0.796	59.22	19.20	137	0.62	7.38	109.69	0.760	0.205	0.177	0.245	-	23.59	1.14
Newsprint	0.022	1.412	57.89	35.99	535	0.32	9.68	16.93	0.524	0.349	0.082	2.108	-	39.41	1.18
Cardboard	0.033	1.447	12.55	44.23	174	0.57	15.71	14.78	0.566	0.848	0.051	0.263	-	45.32	0.64
Tetra Pak	0.036	0.616	18.52	29.25	,597	1.07	2.57	75.87	0.679	0.587	0.206	0.092	3,262	45.12	19.20
PET	0.034	0.986	134.06	6.21	2,706	0.34	6.19	200.20	1.173	0.504	0.106	2.490	-	51.17	2.90
HDPE	0.023	1.347	90.00	1.23	148	5.03	2.84	368.04	0.351	0.504	4.057	0.900	-	50.33	2.96
PVC	0.022	1.396	87.49	1.82	141	7.32	1.94	358.41	0.295	0.536	3.197	0.510	-	51.43	3.75
LDPE	0.029	0.698	108.88	4.14	1,019	0.52	2.44	149.89	1.034	0.878	0.046	3.094	-	30.31	1.77
PP	0.027	1.632	75.16	1.59	122	2.82	3.30	271.74	0.257	0.456	1.096	0.507	-	42.89	0.59
PS	-	1.322	6.78	37.56	231	1.05	3.12	33.88	1.343	0.500	0.084	0.737	-	49.12	1.45
Diapers	-	0.358	1.76	0.46	32	0.10	0.43	9.74	0.093	0.135	0.070	0.669	-	12.14	0.13
Textile	0.017	0.235	69.49	2.52	89	0.08	0.96	11.66	0.455	0.222	0.030	0.877	3,225	24.61	0.23
Rubber	0.037	6.121	-	30.89	841	1.43	227.44	1,714.35	1.432	0.398	0.670	1.461	2,069	41.79	2.68
Leather	0.048	8.345	-	35.71	1,139	2.79	278.44	2,188.07	2.059	0.473	0.040	1.770	2,541	51.19	3.04
Wood	0.044	0.281	50.84	3.13	78	0.37	3.95	13.48	0.309	0.264	0.045	1.130	3,455	44.31	0.84

18.2 Waste Generation Rates

18.2.1 Waste generation rate from the households in correlation with the levels of urbanisation and housing type of the study areas. The results are presented in kg/capita/day.

Table 101: Average Household Waste Generation in 2012, Malaysia

Housing Type	Urban			Rural			Overall		
	Population	Per Capita (kg/capita/day)	Total (MT/day)	Population	Per Capita (kg/capita/day)	Total (MT/day)	Population	Per Capita (kg/capita/day)	Total (MT/day)
Low cost Landed	2,675,954	0.74	1,988	2,019,579	0.69	1,397	4,695,533	0.72	3,384
Low cost High-rise	3,778,052	0.63	2,394	830,781	0.71	586	4,608,833	0.65	2,981
Medium cost Landed	8,167,292	0.89	7,245	3,377,231	0.67	2,276	11,544,523	0.82	9,521
High-Medium cost High-rise	2,366,232	0.89	2,095	-		-	2,366,232	0.89	2,095
High cost Landed	3,137,440	0.73	2,303	1,981,574	0.68	1,343	5,119,014	0.71	3,646
Total	**20,124,970**	**0.80**	**16,025**	**8,209,165**	**0.68**	**5,601**	**28,334,135**	**0.76**	**21,627**

Note: the population of each housing type by urban and rural was estimated based on the ratio in Property Stock Report 2010 and Census 2010.

18.2.2 Waste generation rate from the industry, commercials and institutions

Table 102: Waste Generation Rate by Commercial and Institution Sub-sectors, in kg/employee/day

CI Sub sectors	Waste Generation Rate
Business offices	1.07
Education	1.32
Health	2.18
Hotel	3.68
Public Administration	1.02
Restaurant	3.92
Transportation	1.56
Wet Market	11.87
Overall	1.94

Table 103: Industrial Non Production Waste Generation Rate, in kg/employee/day

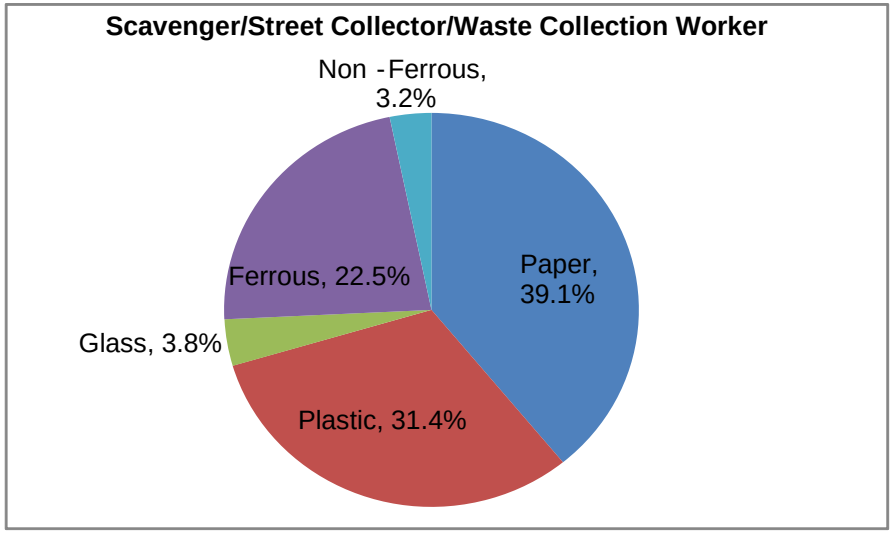
CI Industry by firm size	Waste Generation Rate
Micro	13.72
Small	2.88
Medium	1.26
Large	0.37
Overall	1.26

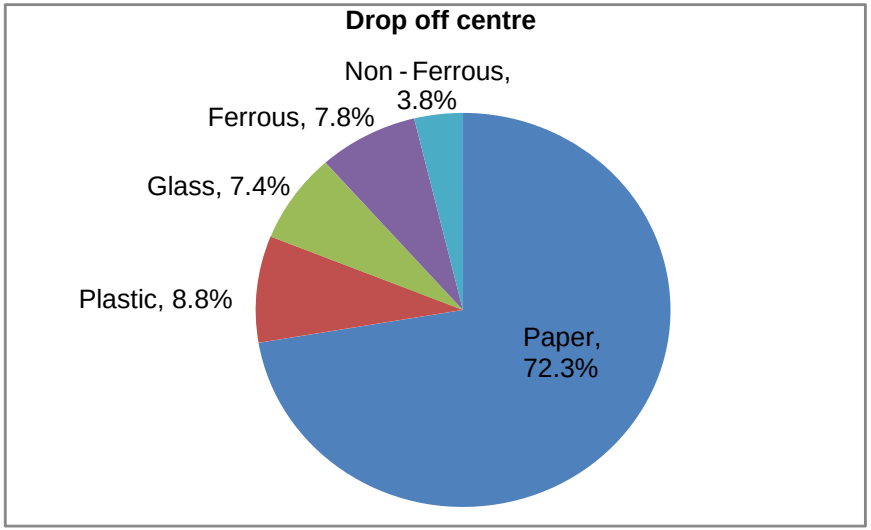
*Source: * Economic Census 2011: Manufacturing, Dept of Statistics.*

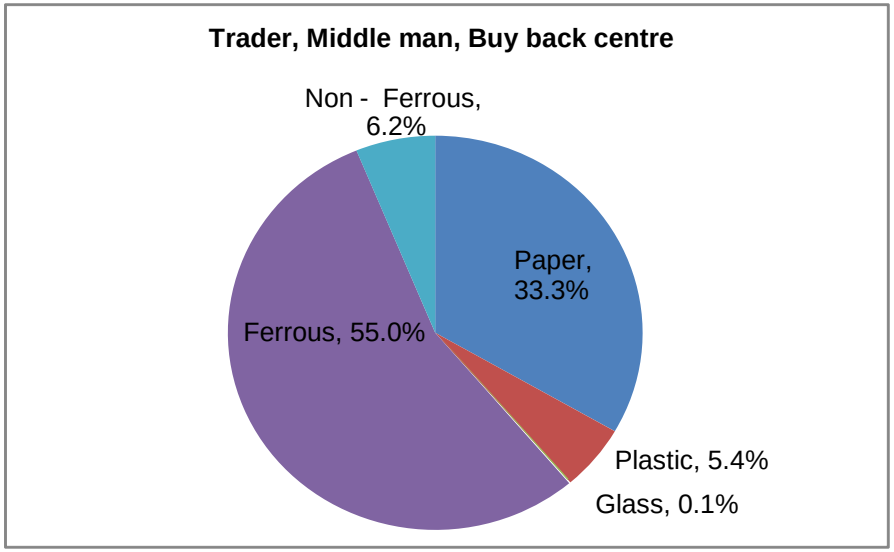
18.3 Existing recycling practices in the markets

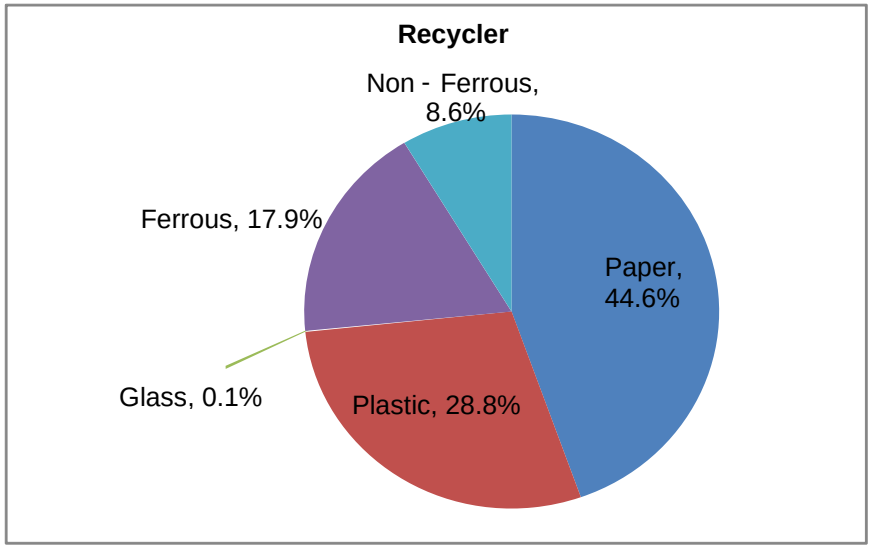
18.3.1 Detailed findings on the existing recycling practices in the markets - Types of recyclable materials being collected / traded

Figure 37: Type of recyclables collected by Recycling Players in Malaysia









18.3.2 Detailed findings on the existing recycling practices in the markets – Pricing of Recyclable Material

Table 104: Price ranges for different recyclables generated from municipal waste of Malaysian industries, in RM/kg

Types of recyclables	Min	Max	Average	Median	IQR (50%of samples)
Aluminium can	0.40	5.00	2.84	3.30	2.35 - 3.80
Black and white paper	0.02	1.00	0.27	0.25	0.20 - 0.30
Cardboard	0.10	0.70	0.29	0.30	0.20 - 0.35
Clear glass	0.1	0.4	0.25	0.25	--
Coloured glass	0.40	0.40	0.40	0.40	--
Colour paper	0.03	0.70	0.24	0.25	0.20 - 0.30
Metal can	0.2	1.5	0.74	0.65	0.55 - 0.83
Newspaper	0.05	0.80	0.23	0.20	0.20 - 0.30
Non PET	0.05	1.15	0.48	0.55	0.25 - 0.70
PET	0.05	1.30	0.40	0.40	0.20 - 0.50

Other recyclables	Min	Max	Average	Median	IQR (50% of samples)
E-waste	0.30	0.30	0.30	0.30	--
Guni (Gunny sack)	0.20	0.20	0.20	0.20	--
HDPE/PVC/PP/ABS/PS	0.10	15.87	2.15	0.50	0.14 - 1.30
Mixed metals	0.60	1.10	0.83	0.83	--
Mixed papers	0.15	1.00	0.35	0.30	0.25 - 0.40
Plastic stretch film, plastic foam films, plastic bags, plastic sheets	0.05	1.60	0.56	0.40	0.28 - 0.80
Scrap metal (Ferrous)	0.05	25.00	4.16	0.90	0.41 - 1.28
Used Oils	0.74	0.80	0.77	0.77	--
Wood	0.01	20.00	2.83	1.10	0.30 - 1.80
Others (cloth gloves, rubber, yarn waste)	3.33	3.33	3.33	3.33	--

18.3.3 Information on the recycling rates by different players

a) Total recyclable materials retained by the households for recycling purpose

***Table 105*:** Quantity of Household Waste and Recyclable Materials Generated in 2012

	Peninsular Malaysia		Malaysia	
	Total (kg/day)	Generation Rate (kg/capita/day)	Total (kg/day)	Generation Rate (kg/capita/day)
Recyclable materials retained by the household	1,821,735	0.08	2,101,129	0.07
Waste discarded	16,306,919	0.72	19,525,600	0.69
Waste generated (waste discarded + recyclables)	18,128,654	0.80	21,626,729	0.76
Recycling rate	10.0%		9.7%	
Number of Population in Peninsular Malaysia (2010 Census)	22,569,345		28,334,135	

b) Total recyclable materials recovered by the truck workers in terms of the percentage of the total waste collected

***Table 106*:** Breakdown of the Recycling Rate of Malaysia, in kg/day

	Households	Industrial, Commercial and Institutions	Waste Collection Truck Workers	Scavengers	Overall
Recyclable materials	2,101,129 (60.2%)	899,585 (25.8%)	476,089 (13.6%)	14,097 (0.4%)	3,490,899

Note:

1. *Projections are made based on the findings of Existing Practise on Solid Waste Recycling Survey of this study and population data published by DOS.*
2. *Estimation for waste collection truck workers was based on secondary data.*
3. *Estimation for scavenger was based on primary data and secondary data.*

c) Total recyclable materials remained in the waste disposed at the landfill site

Table 107: Quantity of Recyclable Material found in the As Disposed Waste

Recyclable Components	Quantity in the As Disposed waste at the landfill	
	MT/day	Percentage of total waste
Mixed Paper	418	1.41%
Newsprint / Old Newspaper	551	1.86%
Cardboard	868	2.93%
Polyethylene Terephthalate (PET)	573	1.93%
High-Density Polyethylene (HDPE)	925	3.12%
Low-Density Polyethylene (LDPE)	1098	3.70%
Polypropylene (PP)	288	0.97%
Glass Bottle	798	2.69%
Ferrous Metal	323	1.09%
Aluminium	130	0.44%
Other Non-Ferrous Metals	24	0.08%
E-Waste	80	0.27%
Paint Container	31	0.10%
Tetra Pak	432	1.46%
Total	6,539	22.05%

d) Total recyclable materials being imported or exported, and their the destinations

Table 108: Malaysia External Trade of Recyclable Materials for year 2011

Type of Waste and Scrap	Import			Export			Trade Balance (USD)
	Quantity in MT	USD/ MT	Total (USD)	Quantity in MT	USD/ MT	Total (USD)	
Paper	218,929	326	71,370,854	214	1,159	248,026	(71,122,828)
Plastic	142,860	456	65,144,160	153,865	695	106,936,175	41,792,015
Glass	6,036	3,642	21,983,112	19,771	249	4,922,979	(17,060,133)
Ferrous	2,050,146	527	1,080,426,942	70,107	306	21,452,742	(1,058,974,200)
Non-ferrous	104,829	2,566	268,987,672	57,058	2,786	158,978,345	(110,009,327)
Total	2,522,800	-	1,507,912,740	301,015	-	292,538,267	(1,215,374,473)

Source: International Trade Centre (UN Commodity Trade Database), 2011

Table 109: Top 10 Countries Export to Malaysia by Type of Waste and Scrap

Type of Waste and Scrap	Rank									
	1	2	3	4	5	6	7	8	9	10
Paper	Australia	Singa-pore	United Kingdom	Japan	USA	Netherlands	Belgium	New Zealand	Italy	Sweden
Plastic	United Kingdom	USA	Germany	Singapore	Spain	Philippines	Belgium	Japan	Republic of Korea	Hong Kong
Glass	Japan	Thailand	Viet Nam	Myanmar	Chinese Taipei	Indonesia	Singapore	Republic of Korea	Lithuania	China
Ferrous	USA	South Africa	Singa-pore	United Kingdom	Australia	Philippines	Germany	United Arab Emirates	New Zealand	Chinese Taipei
Non-ferrous	USA	South Africa	Singa-pore	United Kingdom	Australia	Philippines	Germany	United Arab Emirates	New Zealand	Chinese Taipei

Source: International Trade Centre (UN Commodity Trade Database), 2011

Table 110: Top 10 Countries Received Import from Malaysia by Type of Waste and Scrap

Type of Waste and Scrap	Rank									
	1	2	3	4	5	6	7	8	9	10
Paper	Singa-pore	Thailand	-	-	-	-	-	-	-	-
Plastic	China	Hong Kong	Indon-esia	India	Chinese Taipei	Estonia	Thailand	Viet Nam	Singa-pore	Pakistan
Glass	Indo-nesia	Thailand	Japan	USA	Singa-pore	United Arab Emirates	Romania	India	Banglad esh	China
Ferrous	India	Republic of Korea	Thailand	China	Brunei	Chinese Taipei	Viet Nam	Oman	Japan	Spain
Non-ferrous	Japan	China	India	Republic of Korea	Thailand	Hong Kong,	Singa-pore	Chinese Taipei	Viet Nam	USA

Source: International Trade Centre (UN Commodity Trade Database), 2011

e) The existing recycling rate by households, the business entities and the overall recycling rate estimated for Malaysia.

Table 111: Recycling Rate of Malaysia

	Households	Industrial, Commercial and Institutions	Waste Collection Truck Workers	Scavengers	Overall
Recyclable materials (kg/day)	2,101,129 (60.2%)	899,585 (25.8%)	476,089 (13.6%)	14,097 (0.4%)	3,490,899
Waste discarded (kg/day)	19,525,600	10,603,786			30,129,386
Waste generated (waste discarded + recyclables) (kg/day)	21,626,729	11,503,372	-	-	33,130,101
Recycling rate	9.7%	7.8%			**10.5%**

Note:

1. *Projections are made based on the findings of Existing Practise on Solid Waste Recycling Survey of this study and population data published by DOS.*
2. *Estimation for waste collection truck workers was based on secondary data.*
3. *Estimation for scavenger was based on primary data and secondary data.*

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