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Solid Waste Composition among the Residence in Iskandar Malaysia-IM (WPI@SJER), Johor, Malaysia

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Abstract: This research study provides an estimation of solid waste composition produced by the residents of Iskandar Malaysia (IM), Johor, Malaysia. 100 houses were selected from the region and the solid wastes generated by the selected household were collected, segregated and classified into 8 compositions namely organic, plastic, paper, glass, metal, wood, textiles and others. Each type of waste was weighted and calculated in order to get the percentages of weight. This practice was undertaken from May 2015 to August 2015 for alternate 3 days in a week namely on Monday, Wednesday and Friday. The findings indicate that from the total 1516.27 kg solid waste collected, the organics waste was found as the biggest contributor to the solid waste composition which comprises approximately 52.29% followed by others (17.53%), plastic (13.75%), paper (7.66%), metal (3.81%), glass (3.14%), wood (1.19%) and the lowest percentage was textile 0.63%. From the total waste generated in IM, 28.36% were recyclable. The studies on waste composition, particularly on household waste are important in establishing proper solid waste management. This can be highlighted through the information provided on the estimation of recyclable potential, sources identification and distribution of waste types which in turn facilitates the process of solid waste treatments and disposition including the design process of waste processing equipment and implementing suitable advanced technologies.

Key words: Solid waste composition, IM, Malaysia, estimation, household waste, technologies

INTRODUCTION

Malaysia is a country with a middle-income economy and by the year of 2020, Malaysia is expected to be one of the developed countries. Over the last decade, the process of economic growth and urban transformation in Malaysia is growing exponentially in line with vision 2020. According to the Department of Statistics Malaysia, Malaysia's population has reached up to 30 million people in 2016. Overall, this situation directly contributes to the increase of solid waste production in Malaysia. The issue occurs due to the changes of living standard, increasing of population and a variety of daily activities among Malaysians. As one of the rapid developed states in Malaysia besides Kuala Lumpur, Iskandar Malaysia has shown a drastic waste generation increment from year to year.

Iskandar Malaysia: Iskandar Malaysia (IM) or previously called Iskandar Developed Region (IDR) and South Johor Economic Region (SJER) is the primary development centre in Johor, Malaysia. On 8 November 2006, Iskandar Malaysia was officially established and named after the 24th and 4th Sultan of Johor, Almarhum Sultan Iskandar Ibni Almarhum Sultan Ismail. Iskandar Regional Development Authority (IRDA) was chosen to be the administrator of the project. Figure 1 and 2 show the location of Iskandar Malaysia and geographical coverage of Iskandar Malaysia.

The region of IM covered an area of 2.217 km^2 including the city of Johor Bahru and the connecting towns of Pontian, Senai and Pasir Gudang. The new administrative capital is constructed in Iskandar Puteri. There are 5 local government authorities which have control over the development area, including Johor Bahru City Council Johor Bahru Tengah Municipal Council, Pasir Gudang Municipal Council, Kulai Municipal Coucil and Pontian District Council. There are 5 key economic flagships (A-E) within IM.

Flagship A: JB city centre, the development activities will be focused on new financial district, danga bay integrated waterfront city, upgrading the central business district, Tebrau Plentong mixed development and the enhancement of causeway infrastructure connecting Johor Bahru and Singapore.

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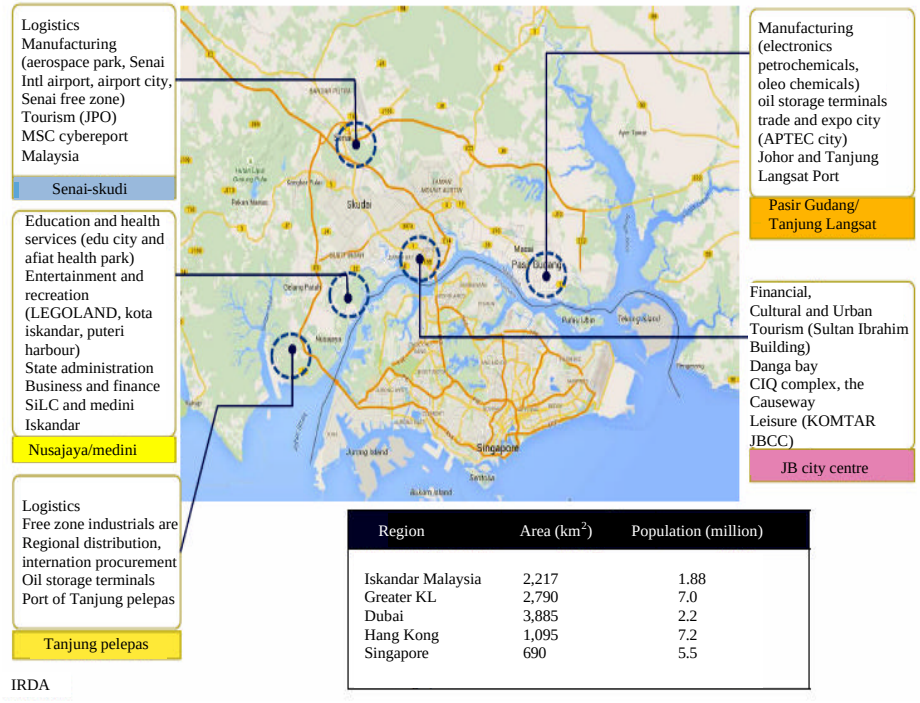
Fig. 1: Location of Iskandar Malaysia



Region	Area (km^2)	Population (million)
Iskandar Malaysia	2,217	1.88
Greater KL	2,790	7.0
Dubai	3,885	2.2
Hang Kong	1,095	7.2
Singapore	690	5.5

Fig.2: Geographical coverage of Iskandar Malaysia

Flagship B: Green field of Nusajaya, the development is centered on the Johor New Administration Centre (JSNAC) at Kota Iskandar, University Park in Edu-city, International destination resort comprise of outdoor and indoor theme parks and clean and green factories as well as the warehouse at the southern industrial logistic cluster area.

Flagship C: Western gate development, the development is focused on the development of free trade zone at Port of Tanjong Pelepas, petrochemical and maritime Industrial hub at Tanjung Bin and Tanjung Bin power plants. Flagship C also has the three RAMSAR sites (Pulau Kukup, Tanjung Piai dan Sungai Pulai). A part of this flagship is Tanjung Piai, one of RAMSAR conservation

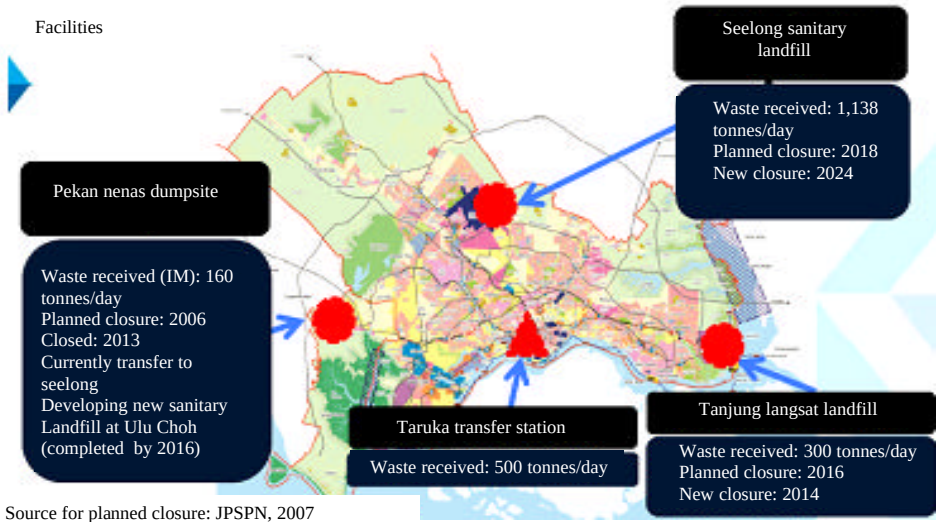


Fig. 3: Planned closure and recommendation for new closure of landfill facilities in IM

site and called as the Southern-most tip of mainland of Asia as well as the good land linkages through second link access to Singapore.

Flagship D: Eastern gate development, there is a mixed development with city of knowledge in Seri Alam, a regional distribution centre in Kim-Kim, Pasir Gudang Industrial Park, Tanjung Langsat Industrial Park, Pasir Gudang Port and Tanjung Langsat Port.

Flagship E: It is the most northern part which includes Universiti Teknologi Malaysia (UTM) at Skudai, Senai International Airport, Senai Cargo Hub, Senai High Technology Park and Senai Industrial Parks. Upon completion, the region will boast state-of-art facilities and infrastructure that are comprehensive and toward becoming a one-stop business centre where all local and international activities are converged within a sustainable metropolis.

The economics growth of IM has brought prosperity, population increase, accelerated urbanization and industrialization. In 2010, the population of IM was recorded to be 1.8 million, increases by 0.5 million from 2000. By the year of 2025, IM is planned to be populated by 3 million inhabitant. Furthermore, 1.46 million population of IM are expected to contribute in workforce which increases by more than 50% compared to the value recorded in 2005. This eventually will raise the GDP per capita (PPP) up to $31,100 in 2025 with an annual change of 6%. However, as the population escalated drastically over the years, the amount of solid waste generated in the region of IM substantially increases.

With the increasing amount of solid generated in IM, efficiency and effectiveness of current solid waste management need to be enhanced. Thus, to create an effective solid waste management system, refined and comprehensive data on current situation is required. The information and data acquired from the studies of composition of household waste is one of the vital components in enhancing performance of current solid waste management.

In Malaysia, there are two solid waste disposal systems which are commonly used, namely landfill and incineration. There are 171 landfill sites in Malaysia. From the 171 disposal sites, 83 of the sites are consisting of open dumping while 51 are controlled tipping. Then, 21 of the sites are having bund which the solid waste is backfilled everyday, 8 sites have leachate and ventilation pipe and another 8 have leachate treatment system (MHLG, 2001).

Existing situation in IM: Presently, Southern Waste Management Sdn. Bhd. (SWM) is responsible in handling collection and disposal of solid waste in all regions of IM except Pasir Gudang area which is managed by the Department of Environment. The amount of solid waste generated in IM is 419,922 tons annually in average and it is disposed in sanitary landfill areas with an area of 212.5 acres in Seelong Selatan, km 23, Jalan Tiram-Kulai. Within IM, the collected waste is temporarily stored at a transfer station situated in Jalan Taruka, Larkin, Johor Bahru before reaching centralized waste disposal area at Seelong Selatan. Approximately, this transfer station capable of handling 856 tones of waste per day 0.12 tons-capacity containers is used to transport the waste from transfer station to Seelong Selatan with a distance of 12 km. Figure 3 shows planned closure and recommendation for new closure of landfill facilities in IM. With the escalation amount of waste generated, the capacity of landfill is decreasing by time. It is estimated

that 108.2 acres of area remains at the landfill. Therefore, pertaining to this problem, improvement on efficiency of existed waste management is necessary to lengthen the lifespan of current landfill.

Literature review: Solid waste is defined as any garbage, sludge, refuse and unwanted solid materials generated from industrial and commercial processes and activities within groups of community. However, dissolved materials in domestic sewage or major water pollutants which usually found in industrial wastewater effluent and irrigation return flows such as silt, dissolved or suspended solids is not considered as solid waste. (Bernik *et al*., 2015; Pichtel, 2005; Kurniawati and MeilianaIntani, 2016). While according to Agumuthu (2001), the definition of solid waste can be taken as a waste that are no longer needed produced from human and animal activities. Generally, it is in the form of solid with physical criteria such as consist of mass and volume.

According to Solid Waste Management and Public Cleansing Acts LOM, 2007 (Act 672), solid waste is interpreted as any extra scrap or other material that is no longer in used or rejected from the use of any activity or process. In addition, solid waste also includes a substance which Department of Environment. The amount of solid waste is broken, worn out, polluted or damaged and to be disposed. It also includes any other material under this act or any other written law may be required by the authorities for disposal.

There are a few categories or types of solid waste that can be classified. The solid waste classification is based on their sources. For example, the solid waste generated by residential, commercial and institutional can be classified as municipal solid waste. Then, the waste that results from industrial activities is classified as industrial waste. The industrial waste sometimes may contain toxic substances. Then, the construction waste is the waste produced during construction, renovation and demolition of structures.

Municipal solid waste is the waste which originates from residential, commercial, institutional and municipal sources. It is also known as domestic waste or sometimes household waste (Pichtel, 2005). Thus, the solid waste on this study can be classified as municipal solid waste because the research is conducted in a residential area. The example of municipal solid waste that is generated from household is food waste, kitchen waste and garbage.

In general, industrial waste is not categorized directly by the authorities as either municipal waste or hazardouswaste. Most of the industrial waste is hazardous to the surrounding and some of industrial wastes are not (McCoole *et al*., 2008). The solid waste is designated as hazardous waste if an industrial waste stream, supported by the knowledge developed from laboratory processes (Pichtel, 2005).

Table 1: Type and examples of waste

Types of waste	Examples of waste
Municipal solid waste	Food scraps, food packaging, cans, bottles, newspapers, clothing, old appliances
Industrial waste	Scrap material, paints, sand paper, paper products and metals
Construction and demolition waste	Wood, concrete, asphalt, metals and wallboard

Table 2: Per-capita waste generation rate per day for state in Peninsular Malaysia

States	kg/capita/day
Kuala Lumpur	1.57
Selangor	1.26
Pahang	0.92
Terengganu	0.86
Kelantan	0.50
Johor	1.35
Melaka	1.20
Negeri Sembilan	1.20
Pulau Pinang	0.96

Waste produced from construction and demolition works is the solid component of the waste stream but does not contain municipal solid waste, commercial and industrial waste, hazardous waste or radioactive waste. (USEPA, 2009). The structure includes residential and non-residential buildings as well as bridges and roads. The examples of the component of construction and demolition waste are wood, concrete, asphalt, metals and wallboard. Table 1 shows the types and examples of waste.

Solid waste generation: From the previous research by Sobian (2012), the generation of solid waste depends on the size of an area, the population and activity. Additionally, the types of solid waste are more complex in urban than rural areas. Apart from than that, it was found that 16.247 tons of garbage is produced every day in Malaysia. Selangor is ahead of other states with the production of 2,955 tons of garbage per day. This is followed by Kuala Lumpur with 2,634 tons per day, Johor with 2,002 tons per day, Perak with 1,596 tons per day and Kedah with 1,383 tons per day. Therefore, in average, the citizens of Malaysia produce about 0.8 kg of solid waste per day (MHLG, 2001).

According to the research conducted by Nasir (2002), Kuala Lumpur achieved the highest level in generation of Municipal Solid Waste (MSW), followed by Johor and Selangor which recorded 1.57, 1.35 and 1.26 kg/capita/day, respectively. While Melaka, Negeri Sembilan and Pulau Pinang are listed in the next three ranks which recorded between 0.96-1.2 kg/capita/day of MSW generation. Table 2 shows the details of per-capita waste generation rate per day for each state in Peninsular Malaysia except Kedah.

Table 3: Solid waste composition in some of the states in Malaysia

Types of solid waste	Majlis Bandaraya Johor Bahru (%)	Majlis Perbandaran K. Terengganu (%)	Majlis Perbandaran Petaling Jaya (%)	Majlis Perbandaran Seremban (%)
Paper	19	15.0	23.56	44
Plastic and rubber	12	3.5	9.37	5
Organic material	45	66.0	48.32	35
Glass and ceramics	3	1.0	4.03	2
Metal	9	5.0	5.93	4
Wood	7	3.0	4.82	4
Textile	5	1.0	3.97	3
Other	0	5.5	0.00	3
Total	100	100	100	100

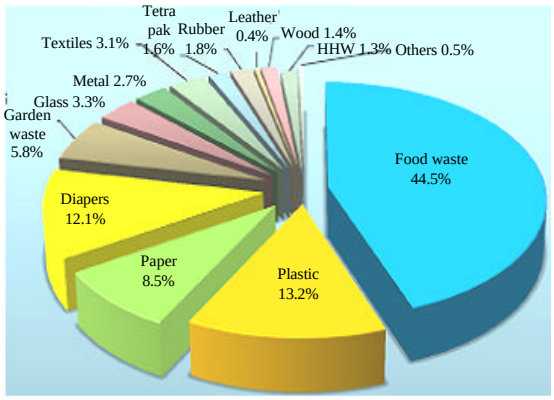


Fig. 4: Malaysian household waste composition (as generated)

Solid waste composition: The amount of solid waste generated is increasing every day. This complicates the process of interpreting the generation of waste. In addition, the generation rate among urban and rural areas is also different. The total amount of solid waste generated in urban area is more than rural areas due to more activities. Then, the different activities will affect the composition of solid waste. Table 3 shows the solid waste composition in some of the states in Malaysia based on a study in 1998 by Pejabat Perkhidmatan Bandar (PPB).

Figure 4 shows Malaysian household waste composition (as generated). In 2012, according to the study conducted by JPBSN reveals that the highest percentage of component in the solid waste is food waste, contributes 44.5% of total solid waste, followed by plastics and paper which contribute 13.2 and 8.5%, respectively. The largest deviation recorded in the waste composition is diapers and feminine sanitary products which contributes about 12.1% of total solid waste components. This is due to the fact that these products are easily obtainable with low cost.

MATERIALS AND METHODS

Sampling protocol: Three-way stratification method was used for waste compositions calculation with consideration of season variations, geographical regions and allocation of socio economic. The study on waste composition also includes data on waste produced during maximum and minimum rainfall period. Part of the data was obtained during festive/holiday season. The study also mixed each local authority into housing types and selected the sample based on the housing mix as presented in Table 4.

Table 4: Socio-economic status and housing stratification matrix

Variables	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	

Selection of the study area: The study areas covered five local authoritie's areas within Iskandar Malaysia development. The local authorities are; MBJB Majlis Bandaraya Johor Bahru (Johor Bahru City Council), MPJBT Majlis Perbandaran Johor Bahru Tengah (Johor Bahru Tengah Municipal Council), MPPG Majlis Perbandaran Pasir Gudang (Pasir Gudang Municipal Council), MPK Majlis Perbandaran Kulai (Kulai Municipal Council) and MDP Majlis Daerah Pontian (Pontian District Council). The study area and numbers of house were identified and is as presented in Table 5. The solid waste sample for composition from households was taken from 20 houses for each 5 local authorities and mixed from high, medium and low income areas (based on housing types such as bungalows, apartments, terrace houses, squatters, etc.).

Standards/document used as references: The sampling and analysis methodology was based on the Draft Malaysian Standard (2011): guidelines for sampling of household solid waste composition and characterization analysis. This Malaysian standard specifies the sampling methodology for household solid waste composition and characterization analysis which applies to waste as generated as discarded and as disposed; reporting format after sampling and characterization analysis and the minimum number of components for household solid waste composition.

Table 5: The study area and numbers of house

	Number of houses				
	Low income		Medium income		High income
Variables	Landed units	High rise units	Landed units	High rise units	Landed units
MBJB	4	4	4	4	4
MPJBT	4	4	4	4	4
MPPG	4	4	4	4	4
MPK	4	4	4	4	4
MDP	4	4	4	4	4
Total	20	20	20	20	20
Total	100	-	-	-	-

Gathering information: An interview session was conducted among Majlis Perbandaran officers in order to obtain the information related to the background of the study area such as the entire area of this study, the total number of houses and the communities in this area. On top of that this interview also aims to find out about the solid waste management system provided by this authority. It is necessary to know about the operating system of the solid waste collection, transportation provided and where the solid waste will be transported. Then, the schedule of operation for the solid waste management is needed to obtain more specific data during data collection.

Data collection: The solid wastes obtained from the selected residence were sorted according to the compositions or types of wastes and were weighed using a weight machine. The readings of solid wastes weight measured were recorded to be analyzed. In this study, the data was collected three times a week as the collection schedule of solid waste provided by local authorities of IM is on Monday, Wednesday and Friday. The data collection activities were conducted in the morning before the SWM staff come to collect the solid waste.

RESULTS AND DISCUSSION

Table 6 shows the total waste generated by residences of 100 selected houses on Monday, Wednesday and Friday. A total of 1516.27 kg waste was collected and the segregation shows that the organic waste represented the largest percentage (52.29%) followed by other (17.53%), plastic (13.75%), paper (7.66%), metal (3.81%), glass (3.14%), wood (1.19%) and the lowest percentage was textile (0.63%) as represented in Fig. 5.

From table, it is shown that 430.01 kg or 28.36% from 1516.27 kg of the total waste generated by the residents can be recycled. The recyclable waste generated consists of 48.48% plastic, 27.01% paper, 13.43% metal and 11.07% glass.

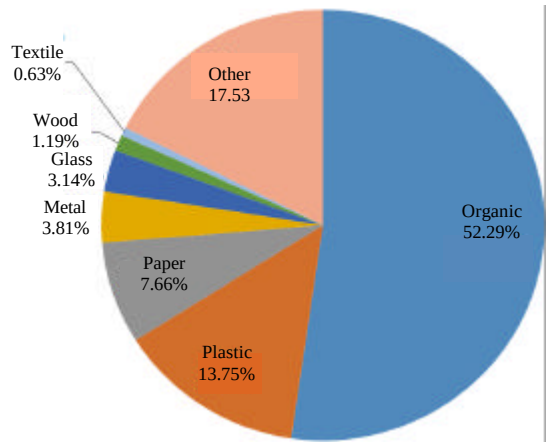


Fig. 5: Composition of waste produced by residence of Iskandar Malaysia

According to the Table 6, it shows that the organic type waste is generated the most which is 792.90 kg or 52.29% from the total waste. This waste is more suitable for compositing instead of recycling. If the 52.29% of the organic waste was composed and the 28.36% of the recyclable waste was sent to the recycling centre, the local authorities of IM could reduce its waste output by up to 80.65%. In another words, only 19.35% of total waste left would need to be disposed in the landfill. Ultimately, this outcome shows a potential on land conservation in landfill together with the cost reduction on transportation and maintenance (Kaseva *et al*., 2002).

Comparison of results to the study conducted by Japan International Cooperation Ageaey JICA (2006) and JPSPN (2013): Table 7 shows the comparison of the composition between the study conducted by JICA (2006) and the survey by JPSPN (2013). The waste components were firstly grouped into the categories used in the JICA for direct comparison. From study conducted by JICA, food waste represents the largest component of the waste generated followed by diapers, paper and rigid plastics. The survey conducted by JPBSN on 2012 found

Table 6: Waste generated by residences of Iskandar Malaysia

Waste Categories	Total waste generated (100 houses) Monday Value (kg)	Wednesday Value (kg)	Friday Value (kg)	Total waste generated (100 houses in 3 days) Perceatage	Value (kg)	Recycable waste Value (kg)	Percentage
Organic	295.57	235.87	261.46	792.90	52.29	-	-
Plastic	77.77	64.01	66.72	208.49	13.75	208.49	48.48
Paper	40.65	37.28	38.21	116.15	7.66	116.15	27.01
Metal	20.97	17.97	18.83	57.77	3.81	57.77	13.43
Glass	17.38	14.66	15.57	47.61	3.14	47.61	11.07
Wood	6.89	5.61	5.54	18.04	1.19		
Textile	3.76	2.70	3.09	9.55	0.63		
Others	96.13	86.87	82.76	265.76	17.53		
Total	559.13	464.98	492.17	1516.27		430.01	28.36

Table 7: Comparison of the composition between the study conducted by JICA and JPSPN

Variables	Waste category	JICA (2006) Value (%)	Value (%)	JPSPN (2013) Value (%)	Value (%)	Present study Value (%)
Food Waste	Organic waste	48.04	49.30	44.50	44.50	52.29
Bones		1.26	-	-	-	-
Textile	Textile	1.85	1.85	3.06	3.06	0.63
Polystyrene	Plastic	0.58	0.58	1.35	1.35	-
Mix paper	Paper*	17.09	17.09	8.50	10.08	7.66
Tetrapak		-	-	1.58	-	-
Plastics (film)	Plastics*	5.35	9.08	3.85	11.83	13.75
Plastics (rigid)		3.73	-	7.98	-	-
Glass	Glass*	3.71	3.71	3.32	3.32	3.14
Ferrous	Metal*	1.61	2.00	1.77	2.73	3.81
Non-ferrous		0.02	-	0.05	-	-
Aluminums		0.37	-	0.91	-	-
Wood	Wood	0.22	0.22	1.35	1.35	1.19
Yards waste	Others	6.58	16.22	5.79	23.36	17.53
Diapers		5.06	-	12.14	-	-
Rubber and Leather		1.82	-	2.15	-	-
Batteries'		0.03	-	0.11	-	-
Electrical electronics		0.18	-	0.40	-	-
Others		2.55	-	1.19	-	-
Sub-total for recyclable material*		-	31.88	-	27.96	28.36

*Recyclable item

that the biggest component in the national waste composition is food waste constituting about 44.5%. Plastics and paper contribute 13.2 and 8.5%, respectively.

Regarding on the recyclable materials, it was discovered that 31.88% of major recyclable materials were generated from household activities in 2004 and the waste component includes mixed papers, mixed plastics, glass, ferrous metals and non-ferrous metals. In 2012, the percentage of these recyclable materials has increased by 27.96%. Moreover, in 2015, it was recorded that the amount of recyclable materials produced increased by 28.36%.

CONCLUSION

The result of this study shows that 52.29% of the 1516.27 kg of the collected waste were organic waste which represent the largest percentage followed by others and plastics. This indicates that the percentage of the organic waste is more than half of the total solid waste generated at IM Region. This study also shows that 28.36% of the produced waste is recyclable.

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