Appendix 2B

APPENDIX 2B

REVIEW OF CURRENT CONDITIONS – WASTE CHARACTERISTICS AND QUANTITIES

1. Introduction

Solid wastes analysis and data for major towns in Malaysia have not been well documented. In Malaysia, the study on characterisation of solid waste has been randomly carried out, whenever the need arises. For example, studies on solid waste characteristics were carried out during the preparation of Solid Waste Master Plans for Local Authorities such as the Petaling Jaya Municipal Council (1993), Ipoh Municipal City (1990), and Pulau Pinang and Seberang Perai Municipal Council (1994). Reference is also made to waste characteristics in the Action Plan for Beautiful and Clean Malaysia (ABC Plan) (1987) (Nazeri, 2002).

2. Past Studies On Solid Waste Characteristics

Several studies have been undertaken in the past on waste composition but they were not undertaken using proper sampling techniques. These waste composition studies used spot sampling or random sampling, where a limited quantity of waste was collected and sorted before being analysed for its composition. Recent studies use a truckload method, which is a more accurate and representative of the waste that is collected and disposed.

An earlier study on waste composition was carried out in May 1978, involving two days of sampling, with the objective of getting an indication of refuse composition in the Municipality of Ipoh (Cowie, 1978). The results of this study are reported in **Table 1**.

Appendix 2B

Table 1: Characteristics of Solid Waste in Ipoh (1978)

1.	Composition	% by Weight
	Vegetable and putrescible	40
	Paper, cardboard	18
	Dust, ash	1
	Textiles (rags, string)	6
	Metals, tins	10
	Glass, ceramics	3
	Meat, fish waste	2
	Rubber	5
	Plastics	10
	Miscellaneous	5
	TOTAL	**100**
2.	**Density of wastes**	
	Mechanically compacted refuse	220 kg/m^3
	Self compacted refuse (dual-tipper)	154 kg/m^3
	Open lorry (non-compacted)	66 kg/m^3
3.	**Generation rate of refuse**	0.34 kg/cap/day

Source: Cowie (1978)

According to Hassan *et al.* (1998), past studies on the characteristics of solid waste in Kuala Lumpur were undertaken in 1975, 1980, 1990 and 1995. However, these studies were limited to the physical characteristics or the physical composition of waste only and none reported on the chemical characteristics. The sampling methods used were not described in detail. The results of these studies are presented in **Table 2**.

One of the most comprehensive study on solid waste characteristics in Kuala Lumpur was reported in 1982. The study was undertaken by Marubeni Corporation, as part of the report on Recommendation for Disposal of Solid Waste for the City of Kuala Lumpur at that time. The results of the study are shown in **Table 3**.

Appendix 2B

Table 2: Characteristics of Solid Waste in Kuala Lumpur (1998)

Composition (%)	1975[1]	1980[1]	1990	1995	1997[2]
Combustible					
Food waste & organic	63.7	54.4	48.4	45.7	36.5
Mix paper	11.7	30.7	35.0	29.9	27.0
Mix plastics	7.0	8.0	8.9	9.0	16.4[a]
Textiles	1.3	2.2	0.0	2.1	3.1
Rubber & leather	0.0	0.0	0.0	0.0	2.0
Wood	6.5	1.8	0.0	0.0	7.0
Other combustible	0.0	0.0	0.0	0.0	0.0
Yard waste	0.0	0.0	0.0	0.0	0.0
Fine	0.0	0.0	0.0	0.0	0
Sub-total	**90.2**	**97.1**	**92.3**	**86.7**	**92.0**
Incombustible					
Glass	2.5	0.4	3.0	3.9	3.2
Ferrous	6.4	2.2	4.6	5.1	3.0
Aluminium	0.0	0.0	0.0	0.0	0.0
Nonferrous	0.0	0.0	0.0	0.0	0.9
Other inorganic	0.9	0.3	0.0	4.3	0.9
OBW	0.0	0.0	0.0	0.0	0.0
Sub-total	9.8	2.9	7.6	13.3	8.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Moisture Content (%)	62.0	65.0	n.a	61.5	43.3
Bulk density (kg/m^3)	n.a.	n.a.	n.a.	230	n.a.
Lower Heating Value (kcal/kg)	n.a.	n.a.	n.a.	1500	n.a.

Source: Hassan et al. (1998)
Notes: [1] *Reference was taken from Fogelholm et al. (1997)*
[2] *Reference was taken from MITSUI & NIPPON KOKAN (1985)*
[a] *figure shows composition of plastic and rubber component*
n.a. = not available.

Appendix 2B

Table 3: Characteristics of Solid Waste as received in Kuala Lumpur (1982)

Components (% wt, Dry Basis)	Sources of Solid Waste					
	MA	HD	CD	LC	FL	Ave
Combustible						
Putrescible	38.0	16.0	0.0	34.0	0.0	17.6
Plastics PVC, Rubber	5.0	2.7	0.0	4.0	15.0	5.3
Paper, Cardboard, Rag, Textile, Leather	41.0	58.7	100.0	31.0	57.5	57.6
Wood, Saw dust	16.0	11.3	0.0	0.0	0.0	5.5
Sub-total	**100.0**	**88.7**	**100.0**	**69.0**	**72.5**	**86.0**
Non-combustible						
Metal, Cans, Glasses	0.0	11.3	0.0	17.0	14.5	8.6
Others	0.0	0.0	0.0	14.0	13.0	5.4
Sub-total	**0.0**	**11.3**	**0.0**	**31.0**	**27.5**	**14.0**
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**
Density (kg/m^3)	310	270	190	290	370	270
Moisture (percent of weight)	64.0	45.0	2.2	64.0	44.0	50.2
Lower heating value (kcal/kg)	1119	1773	3982	939	1604	1560

Notes: 1. MA= market, HD= housing district, CD= central district, LC= low cost district, FL=flat
2. Lower heating value was calculated by Japanese estimated formula
Source: Marubeni Corporation (1982)

In 1997, another study on solid waste characteristics in WP Kuala Lumpur was carried out by Fogelholm *et al.* (1997). The results were reported in "The Treatment of Municipal Solid Waste in Malaysia - Comparing the Biothermal Process and Mass Burning". The physical characteristics of wastes from this study were tabulated earlier in **Table 2**. The ultimate analysis results of the waste are shown in **Table 4**. This report did not provide detailed methodology on how the analysis of waste was carried out.

Appendix 2B

Table 4: Ultimate Analysis Results of MSW in Kuala Lumpur (1997)

Component	% by Weight
Carbon	25.3
Hydrogen	3.4
Oxygen	14.5
Nitrogen	0.5
Sulphur	0.1
Chlorine	0.4
Ash	12.5
Water	43.3
TOTAL	**100.0**

Source: Fogelholm et al. (1997)

A recent study on solid waste characteristics in Kuala Lumpur was carried out in 1997 by FICHTNER & KTAT (1997). The results were reported in "Thermal Waste Treatment Plant – Feasibility Study and System Planning (1997)". The analysis provides a breakdown of waste sources into seven (7) groups, namely residential (houses and high-rise buildings), commercial, market, hotel, office and hawkers centres. The results of the various waste composition and characteristics investigations are shown in **Tables 5, 6, 7** and **8**.

Appendix 2B

Table 5: Composition (%) of Solid Waste in Kuala Lumpur (1997)

Components of solid waste	Sources of Solid Waste							
	Residential (Houses)	Residential (High Rise)	Commercial	Market	Hotel	Hawker centre	Office	Average
Food and organics	44.6	49.2	42.5	61.3	30.0	55.6	22.3	43.6
Plastics	20.0	13.2	21.3	8.7	15.9	6.5	18.4	14.9
Textiles	3.1	2.1	1.8	0.5	0.6	0.1	0.7	1.3
Dry paper	3.3	7.5	0.9	2.1	11.9	0.8	16.8	6.2
Dry cardboard	0.6	1.4	1.8	1.6	2.3	4.8	2.7	2.2
Wet paper and cardboard	17.0	14.9	20.2	21.5	27.3	17.1	30.6	21.2
Leather and rubber	0.2	0.7	0.7	0.3	0.4	0.0	0.4	0.4
Wood	1.8	1.2	1.5	1.7	0.6	10.3	0.5	2.5
Other combustible	2.7	2.1	0.6	0.1	0.9	0.1	1.2	1.1
Subtotal	**93.3**	**92.3**	**91.3**	**97.8**	**89.9**	**95.3**	**93.6**	**93.4**
Metals	1.3	2.3	5.8	1.5	1.6	2.4	4.4	2.8
Glass	3.0	2.6	1.4	0.3	3.7	1.3	0.7	1.8
Other non-combustible	0.6	0.5	0.6	0.0	0.5	0.0	0.2	0.3
Hazardous waste	0.2	0.0	0.0	0.0	1.2	0.0	0.2	0.2
Fine < 12mm	1.6	2.3	0.9	0.4	3.1	1.0	0.9	1.5
Subtotal	**6.7**	**7.7**	**8.7**	**2.2**	**10.1**	**4.7**	**6.4**	**6.6**
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: Adapted from FICHTNER & KTAT (1997)

Table 6: Moisture Content for Components of Solid Waste in Kuala Lumpur (1997)

Component	Moisture (% by Weight)
Food and organics	71.4
Plastics	20.4
Textiles	41.2
Paper	50.8
Leather and rubber	7.7
Wood	29.3
Yard wastes	59.6
Glass	0.7
Metal	9.3

Sources: Adapted from FICHTNER & KTAT (1997)

Appendix 2B

Table 7: Proximate Analysis Data for Components of Solid Waste in Kuala Lumpur (1997)

Component	Proximate Analysis - % by Weight (Wet Basis)			
	Moisture	Combustible	Ash	TOTAL
Food and Organics	50.3	44.3	5.4	100
Paper	16.0	76.7	7.3	100
Plastics	5.9	90.3	3.8	100
Textiles	17.8	72.9	9.3	100
Wood	17.2	79.0	3.8	100
Other combustibles	41.2	38.4	20.4	100
Non-combustible	2.5	2.5	95.0	100

Source: Adapted from FICHTNER & KTAT (1997)

Table 8: Heating Value for Components of Solid Waste in Kuala Lumpur (1997)

Component	kJ/kg
Food and organics	13,886
Plastics	33,400
Textiles	20,527
Paper	17,572
Leather and rubber	25,582
Wood	19,301
Yard wastes	15,093
Glass	-
Metal	-

Sources: Adapted from FICHTNER & KTAT (1997)

In Johor, Southern Waste Management Sdn. Bhd. carried out studies on waste characteristics of Johor and reported them in the Technical Study Report (1996). They have reported results on bulk density and composition, which are shown in **Tables 9** and **10**.

Appendix 2B

Table 9: Bulk Density of Waste in Johor Bahru (1996)

Date	Sampling Location	Bulk Density (kg/m^3)
20/12/96	Larkin Disposal Site (MBJB)	175.0
20/12/96	Larkin Disposal Site (MBJB)	171.8
21/2/96	Larkin Disposal Site (MBJB)	173.5
21/2/96	Larkin Disposal Site (MBJB)	151.5
	Average	**168.0**

Source: Southern Waste Management (1996)

Table 10: Composition of Waste (Wet Basis) in Johor Bahru (1996)

Component	% by Weight
Household garbage	54.5
Paper	12.1
Plastics	17.2
Glass, ceramics, soil/rubble	0.7
Metal	6.0
Textile	3.4
Wood, bamboo, hide,	2.9
Straw, rubber, leather	-
Coconut shell	3.2
Other	0
TOTAL	100.0

Source: Southern Waste Management (1996)

In September 2000, waste experts from the Japan External Trade Organisation (JETRO) carried out a waste characteristic study. The study resulted in the Feasibility Study on the Southern Region Waste Treatment Facility. The results are shown in **Tables 11** and **12**.

Appendix 2B

Table 11: Composition of Waste (Wet Basis) in Johor Bahru (2000)

Component	% by Weight
Household garbage	19.0
Paper	23.3
Plastics	34.8
Glass, ceramics, soil/rubble	2.8
Metal	1.5
Textile	10.2
Wood, bamboo, hide, straw, rubber, leather	4.1
Coconut shell	0.0
Other	4.3
TOTAL	100.0

Source: JETRO (2000)

Table 12: Proximate Analysis of Waste in Johor Bahru (2000)

Proximate analysis	% by Weight
Moisture	46.5
Combustibles	44.3
Ash	9.2
TOTAL	100.0

Source: JETRO (2000)

Appendix 2B

For the Northern Region of Peninsular Malaysia, Northern Waste Industries Sdn. Bhd. carried out a waste characteristic study to prepare a master plan for this region. The data was reported in the Technical Master Plan Vol. 1 in 1997. **Table 13** shows the results of samples collected and analysed at 14 disposal sites in the Northern Region.

Table 13: Composition of Waste for Northern Region of Malaysia (1997)

Component	All sources* % by wt.	Municipal wastes % by wt.
Food	39.51	53.24
Paper	12.64	13.49
Green	5.59	1.75
Wood	1.96	1.31
Plastics	10.73	10.54
Textile	2.16	2.87
Rubber	0.04	0.04
Glass	1.77	2.35
Metal	5.79	4.79
Bulk	1.25	1.75
Aggregates	12.7	0.87
Moisture	5.86	6.99
TOTAL	100.0	100.0

** All sources: Household, commercial, institutional, public cleansing, industry, building and demolition wastes.*

Source: Northern Wastes Industries Sdn. Bhd. (1997)

For the Eastern Region of Peninsular Malaysia, some data on the composition of solid waste were included in the Strategic Master Plan for Kelantan, 2001. The data results were based on surveys carried out by Universiti Putra Malaysia. The composition of solid waste for the 11 districts in Kelantan is shown in **Table 14**. The data collected was not comprehensive, and included only some components of the waste stream.

Appendix 2B

Table 14: Composition (%) of Solid Waste in Kelantan (2001)

	Paper	Plastic	Rubber	Organics	Glass	Metals	Wood	Textile
Kota Bahru (MDKB)	0	20	0	80	0	0	0	0
Bachok	25	30	0	35	0	5	5	0
Tumpat	3	2	0	90	0.5	2	2	0.5
Pasir Mas	23	10	0	60	1	3	3	0
Pasir Puteh	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Mac hang	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Tanah Merah	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Jeli	20	20	0	40	5	5	5	5
Kuala Krai North	0	0	0	75	6.25	6.25	6.25	6.25
Kuala Krai South	10	10	0	55	5	5	10	5
Gua Musang	30	25	0	20	6.25	6.25	6.25	6.25

n.a. - not available
Source: Strategic Master Plan for Kelantan, UPEN (2001)

3 Recent Solid Waste Composition Data

The most recent study on waste characteristics was undertaken in 2000 (Nazeri, 2002). The study was carried out at Taman Beringin Solid Waste Landfill, Kuala Lumpur, which is operated by Alam Flora Sdn. Bhd. The report represents the most comprehensive study ever carried out for Kuala Lumpur wastes. Some of the results have been reported in the EIA Report for Kg. Bohol Waste Incineration Plant prepared by MAB Consultant Sdn. Bhd. The complete results of composition and characteristics of waste are presented in **Tables 15** and **16**.

Nazeri's data also details the Proximate Analysis and Ultimate Analysis, which are used to calculate the calorific value of solid wastes, and these are shown as **Tables 17** and **18** respectively.

Appendix 2B

Table 15: Composition of Solid Waste (% wt, Wet Basis) in Kuala Lumpur (2002)

Composition (%)	Residential	Commercial	Institutional	Cleansing	Light Industry	Mixed SW – LI And Com	SW From River	Overall (mixed wastes)
Combustible								
Food waste & organic	63.1	76.6	40.6	6.0	0.0	59.5	37.9	56.3
Mix paper	6.7	7.6	16.0	2.6	12.9	8.9	11.9	8.2
Mix plastics	14.3	9	17.2	2.4	18.5	8.8	35.6	13.1
Textiles	1.7	0.5	0.7	0.4	1.7	6.7	0.6	1.3
Rubber & leather	0.6	0.3	0.1	0.0	0.0	0.7	0.6	0.4
Wood	0.8	2.1	0.7	2.4	16.3	1.2	0.0	1.8
Yard waste	6.3	0.9	18.4	17.6	2.1	3.1	8.6	6.9
Fine	0.6	0.2	0.5	0.0	0.0	0.0	0.4	0.4
Sub-total	**94.1**	**97.4**	**94.2**	**31.4**	**51.5**	**88.9**	**95.6**	**88.4**
Non combustible								
Glass	2.1	0.9	1.5	0.6	2.6	0.9	1.8	1.5
Ferrous	2.3	1.4	2.8	0.5	6.9	0.3	1.8	2.1
Aluminium	0.1	0.1	1.3	0.1	0.9	0.0	0.8	0.3
Nonferrous	0.0	0	0.0	0.0	0.0	0.0	0.0	0
Other inorganics	0.0	0	0.0	65.7	35.4	0.0	0.0	6.4
OBW	1.4	0.2	0.2	1.7	2.7	9.9	0.0	1.3
Sub-total	**5.9**	**2.6**	**5.8**	**68.6**	**48.5**	**11.1**	**4.4**	**11.6**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Nazeri (2002)
Notes:
1. Mixed SW LI & Com. = Mixed Solid Wastes From Light Industry and Commercial
2. SW = Solid Wastes
3. For Light Industry, mixed solid wastes from light industry and commercial and solid waste from river - only one sample taken from each source

Appendix 2B

Table 16: Composition of Solid Waste (% wt, Dry Basis) in Kuala Lumpur (2002)

Composition (%)	Residential	Commercial	Institutional	Cleansing	Light Industry	Mixed SW LI & Com.	SW from River	Overall (mixed wastes)
Combustible								
Food waste & organics	42.4	58.1	26.7	3.1	0.0	35.5	18.5	39.0
Mix paper	8.6	11.2	14.0	2.4	5.7	8. 9	10.4	9.4
Mix plastics	25.9	17.1	27.4	3.4	20.4	14.3	52.9	22.4
Textiles	2.1	0.7	0.7	0.4	0.8	12.2	0.7	1.7
Rubber & leather	1.2	0.7	0.1	0.0	0.0	1.5	1.1	0.8
Wood	1.2	4.3	1.0	2.9	14.3	1.4	0.0	2.6
Yard waste	4.7	0.5	16.5	11.4	1.4	2.6	7.3	5.3
Fine	0.7	0.2	0.7	0.0	0.0	0.0	0.6	0.5
Sub-total	**86.8**	**92.8**	**87.1**	**23.6**	**42.6**	**76.4**	**91.7**	**81.7**
Non-combustible								
Glass	4.6	2.3	3.2	1.0	3.1	1.9	3.4	3.3
Ferrous	5.2	4.1	6.4	1.0	8.1	0.6	3.4	4.6
Aluminium	0.3	0.3	3.0	0.1	1.1	0.0	1.5	0.7
Non-ferrous	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other inorganics	0.0	0.0	0.0	71.6	41.9	0.0	0.0	7.1
OBW	3.1	0.5	0.3	2.7	3.2	21.1	0.0	2.6
Sub-total	**13.2**	**7.2**	**12.9**	**76.4**	**57.4**	**23.6**	**8.3**	**18.3**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Nazeri (2002)
Notes:
1. Mixed SW LI & Com. = Mixed Solid Wastes From Light Industry and Commercial
2. SW = Solid Wastes
3. For Light Industry, mixed solid wastes from light industry and commercial and solid waste from river - only one sample taken from each source

Appendix 2B

Table 17: Proximate Analysis of Solid Waste (% wt, Dry Basis) in Kuala Lumpur (2002)

	Constituent	VM	FC	Ash	TOTAL
1	Food waste & organic	70.7	16.3	13.0	100
2	Mix paper	75.4	14.8	9.8	100
3	Mix plastics	91.8	4.2	4.0	100
4	Textiles	80.8	15.5	3.7	100
5	Rubber & leather	67.9	14.2	17.9	100
6	Wood	74.3	22.2	3.5	100
7	Yard waste	69.2	18.8	12.0	100
8	Fine	39.4	11.8	48.8	100

VM - Volatile matter; FC - Fixed carbon; Ash – ash content
Source: Nazeri (2002)

Table 18: Ultimate Analysis of Solid Waste (% wt, Dry Basis) in Kuala Lumpur (2002)

	Constituent	C	H	O	N	S	Ash	TOTAL
1	Food waste & organic	43.94	6.72	34.18	2.23	0.40	12.53	100
2	Mix paper	40.25	6.18	43.41	0.11	0.37	9.68	100
3	Mix plastics	73.26	10.60	11.80	0.12	0.28	3.94	100
4	Textiles	49.70	6.54	38.14	1.44	0.48	3.70	100
5	Rubber & leather	50.39	6.34	23.22	1.80	0.39	17.86	100
6	Wood	45.09	6.20	44.20	0.80	0.27	3.44	100
7	Yard waste	41.64	6.12	38.81	0.83	0.75	11.85	100
8	Fine	24.06	3.45	21.87	0.54	0.0	50.08	100

C - carbon; H - hydrogen; O - oxygen; N -Nitrogen; S - sulphur; Ash - ash content.
Source: Nazeri (2002)

The study by Nazeri was also the first comprehensive study on the moisture content of each of the solid waste components. Generally, there is limited data available that is related to moisture content of wastes. This study provides valuable information for use in the consideration of disposal technology options. The data is shown in **Table 19**.

Appendix 2B

Table 19: Moisture Content for Components of Solid Waste In Kuala Lumpur (2002)

Components (%)	Moisture Content (% by Weight)						
	Residential	Commercial	Institutional	Cleansing	Light Industry	Mixed SWI - LI & Com.	SW From River
Combustibles:							
Food waste & organic	70.6	73.7	69.3	69.4	-	74.3	72.0
Mix paper	41.5	48.0	58.8	42.75	62.4	53.1	53.1
Mix plastics	17.2	32.1	27.2	14.6	6.7	21.7	23.8
Textiles	40.6	42.6	52.4	41.05	59.3	35.1	14.7
Rubber & leather	11.6	10.2	14.3	-	-	1.0	1.3
Wood	26.2	28.2	19.5	19.7	25.7	-	46.4
Yard waste	63.1	78.7	59.8	55	45.1	55.2	61.4
Fines	46.4	69.0	42.6	0	-	26.4	0.0
Incombustibles:							
Glass	0.4	0.4	0.6	1.4	1.1	0.9	0.2
Ferrous	2.8	7.8	13.8	4.9	1.0	22.4	13.0
Non-ferrous	7.3	12.6	9.2	4.95	1.5	11.4	5.0
Other inorganics				31.6	-	-	

Source: Nazeri (2002)
Notes:
1. Mixed SW IL & Com. = Mixed Solid Wastes From Light Industry and Commercial
2. SW from river = Solid Wastes from River

4 Database of Waste Characteristics

Based on the review of past and current data on solid waste characteristics, Malaysian solid waste composition is summarised in **Table 20**. Data on waste composition is not uniform and depends very much on sampling method used. The studies in 2002 by Nazeri provide the most comprehensive information with regard to the waste composition, moisture content, density and the energy content in the waste (i.e. calorific values) but are confined to Kuala Lumpur City. Nazeri also provided comprehensive data on waste characteristics based on the source of solid waste, such as residential areas, commercial areas, etc. For planning purposes, such information will be utilised in the selection for best technology options for waste treatment and disposal.

Appendix 2B

Table 20: Documented Report on Waste Characteristics (1975 – 2002)

Year	1975	1978	1980	1982	1997	1997	2000	2001	2002
City	KL	Ipoh	KL	KL	KL	Northern states	Johor Bahru	Kota Bahru	KL
Composition	Yes	Yes	Yes	Yes Break-down into 5 sources of waste	Yes Break-down into 7 sources of waste	Yes	Yes	Yes	Yes Break-down into 7 sources of waste
Density	No	Yes	No	Yes	No	No	Yes	No	Yes
Moisture content	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes
Calorific value	No	No	No	Yes	Yes	No	No	No	Yes
Proximate analysis	No	No	No	No	No	No	Yes	No	Yes
Ultimate analysis	No	No	No	No	No	No	Yes	No	Yes
Reference	Fogelhome	Cowie	Fogelhome	Marubeni	Fichtner	Northern Wastes	Jetro	UPEN	Nazeri

5 Energy Content of Solid Waste

The energy content or calorific value of municipal solid waste, is important for waste planners because it is a primary consideration when thermal treatment is being considered as an option. The use of such technology will depend very much on the moisture content and also the calorific value of combustible items found in wastes, such as organic, paper, plastics and textiles.

Data on energy content of Malaysian solid wastes is not readily available, and most designers for thermal treatment processes would utilise text book values to estimate the energy content in waste. The most recent study to determine calorific values for Kuala Lumpur wastes, was reported by Yachiyo Engineering Co. Ltd. (2001). This was a study undertaken by Universiti Putra Malaysia and MINT in association with Chemsil Lab Sdn. Bhd. The results of the study are shown in **Table 21 and Table 22**. The lower calorific value of waste, from **Table 22,** will be used to determine sensitivity and viability of any thermal technology options.

Results from Nazeri (2002) show that the energy content of waste varies depending on the composition. Estimation of energy content can be made by identifying the specific components found in the waste stream as shown in **Table 23**.

Appendix 2B

Table 21: Calorific Value by Generation Sources in Kuala Lumpur (2001)
(All units in kcal/kg)

	Residential			Industrial	Commercial	Total
	High income	Medium income	Low income			
Method 1	2695	1992	2023	1958	2134	2151
Method 2	1770	1653	1822	1883	1844	1807
Method 3	3101	1867	1850	1772	1979	2077
Method 4	2455	2102	2062	1983	2220	2173

Method 1: by waste composition
Method 2: by bomb calorimeter
Method 3: by chemical element composition
Method 4: volatile and carbon content
Source: Yachiyo Engineering Co Ltd (2001)

Table 22: Lower Calorific Values of Waste in Kuala Lumpur (2001)
(Results by Chemsil lab - All units in kcal/kg)

	Method 1	Method 2	Method 3	Method 4
HQW High quality	2687	2106	2925	2695
SQW Standard quality	2151	1807	2077	2173
LQW Low quality	1615	1508	1299	1651

Method 1: by waste composition
Method 2: by bomb calorimeter
Method 3: by chemical element composition
Method 4: volatile and carbon content
Source: Yachiyo Engineering Co Ltd (2001)

Table 23: Average Calorific Values for Components of Solid Waste in Kuala Lumpur (2002)
(in kcal/kg)

	Constituent	Calorific value	Range	
			Low	High
1.	Food waste & organic	3911	3146	4656
2.	Mix paper	3469	2551	4296
3.	Mix plastics	8367	6281	9963
4.	Textiles	4236	3254	5510
5.	Rubber & leather	5090	3121	7316
6.	Wood	3759	2889	4281
7.	Yard waste	3261	1361	4059
8.	Fine	2561	1080	3447

Source: Nazeri (2002)

Appendix 2B

6. Waste Generation Rate

There is a lack of comprehensive published data on the solid waste generation rate in Malaysia and most available data have been estimated.

Some estimates of solid waste generation rate were prepared by Alam Flora (2000) in its Master Plan and this data was gathered from a variety of sources, including the following:

- Site specific landfill survey/questionnaires undertaken in Klang Valley, 1994;
- Due Diligence exercise for the concession area, 1996;
- Experience drawn from other jurisdictions/ Local Authorities;
- Waste Management Master Plans and Environmental Impact Assessments;

The estimates of solid waste generation rate for each of the Local Authorities are tabulated in **Table 24**. The estimated per capita generation rates ranged from 1.1 kg to 1.64 kg for Kuala Lumpur and Selangor areas.

Table 24: Generation Rate of Solid Waste in Kuala Lumpur and Selangor (2000)

Local Authorities	Base Rate (kg/cap/day)
Kuala Lumpur	1.57
Petaling Jaya	1.64
Shah Alam	1.34
Subang Jaya	1.32
Kelang	1.31
Kuala Langat	1.26
Kajang	1.24
Sepang	1.21
Ampang Jaya	1.22
Selayang	1.20
Kuala Selangor	1.20
Hulu Selangor	1.17
Sabak Bernam	1.08

Source: Alam Flora (2000)

Appendix 2B

Tables 25 to **27** show data for other States.

Table 25: Generation Rate of Solid Waste in Pahang (2000)

Local Authority	Base Rate (kg/cap/day)
Kuantan	1.00
Pekan	0.91
Rompin	0.87
Bera	0.87
Maran	0.89
Temerloh	0.89
Bentong	1.14
Jerantut	0.87
Raub	0.87
Lipis	0.86
Bukit Fraser	1.00
Cameron Highlands	0.85

Source: Alam Flora (2000)

Table 26: Generation Rate of Solid Waste in Terengganu (2000)

Local Authority	Base Rate (kg/cap/day)
Kuala Terengganu	0.76
Besut	0.75
Hulu Terengganu	0.75
Marang	0.77
Dungun	0.76
Kemaman	1.37
Setiu	0.74
Ketengah	1.00

Source: Alam Flora (2000)

Appendix 2B

Table 27: Generation Rate of Solid Waste in Kelantan (2000)

Local Authority	Base Rate (kg/cap/day)
MP Kota Bahru	0.52
MD Kota Bahru	0.50
Tumpat	0.51
Pasir Mas	0.50
Tanah Merah	0.50
Jeli	0.49
Machang	0.49
Kuala Krai Utara	0.50
Kuala Krai Selatan	0.50
Gua Musang	0.51
Pasir Putih	0.49
Bachok	0.49

Source: Alam Flora (2000)

Southern Waste Management (2000) reported some values for per capita waste generation. The data is tabulated as follows in **Table 28**.

Table 28: Generation Rate of Solid Waste in Southern Region (2000)

Johor	1996	2019
Rural	0.5 kg/cap/day	1.1 kg/cap/day
Urban (MBJB, MPJBT, MDKU, MPBP, MDK, MPM, IVIDS, PBTPG)	1.0 kg/cap/day to 1.25 kg/cap/day	1.8 kg/cap/day
Melaka And Negeri Sembilan	**1996**	**2019**
Rural	0.5 kg/cap/day	0.88 kg/cap/day
Urban (MPMBB, MPS, MPN, MPPD)	1.0 kg/cap/day to 1.25 kg/cap/day	1.61 kg/cap/day

Source: Southern Waste Management (2000)

Appendix 2B

In the Northern Region, the waste generation rates for MPPP and MPSP in the State of Pulau Pinang were estimated for specific years, as shown in **Table 29**.

Table 29: Generation Rate of Solid Waste in Pulau Pinang (1989)
(kg/cap/day)

	1987	1990	1995	2000	2005
MPPP	0.78	0.83	0.91	1.01	1.11
MPSP	0.70	0.74	0.82	0.90	1.00

Source: Solid Wastes Management Study for Pulau Pinang and Seberang Perai Municipalities Main report Part I Master Plan. August 1989. Japan International Cooperation Agency.

Although, the waste generation rate differs for the two municipalities, it shows a trend of increasing rate over the years. It is anticipated that more accurate data for the rates will be collected following collection and analysis of survey data from the questionnaires sent to all LAs and States.

The summary of waste generation rate for all States, except Kedah and Perlis, is shown as **Table 30**.

Table 30: Summary of Waste Generation Rate based on Year 2000

State/City	kg/cap/day
Kuala Lumpur	1.57
Selangor	1.26
Pahang	0.92
Terengganu	0.86
Kelantan	0.5
Johor	1.35
Melaka	1.20
Negeri Sembilan	1.20
Pulau Pinang	0.96

The waste generation values range from 0.5 to 1.57 kg/cap/day, the lowest being Kelantan (0.5 kg/ca/day) followed by Terengganu, Pahang and Pulau Pinang (0.86 – 0.96 kg/cap/day). Large urban centres in Kuala Lumpur, Selangor and Johor recorded 1.26 to 1.57 kg/cap/day, which is the highest amongst the States. The data in **Table 30** can be used as a planning guide to waste generation but the information requires verification from field data, to justify present values.

The solid waste generation per capita figures were cross-referenced with waste generation figures published for other developing countries for accuracy. The main published data used to verify the estimates of waste generation rate is sourced from the World Bank Study on waste management throughout Asia carried out in 1994. This study developed a set of waste generation statistics for different settings and locations, i.e., large urban centres, small urban centres, villages and rural areas. It also stratified these classification according to economic and income parameters [see from the Alam Flora (2000) report].

Appendix 2B

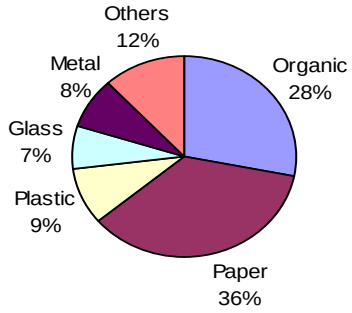
7. Waste Composition of Other Countries

Waste composition information for comparative purposes have been gathered from the World Bank, for the United States, United Kingdom, Tokyo (Japan), and Hong Kong and these are shown in **Figures 1, 2, 3, 4 and 5**, respectively. Changes in waste composition over the years are also reflected in the figures.

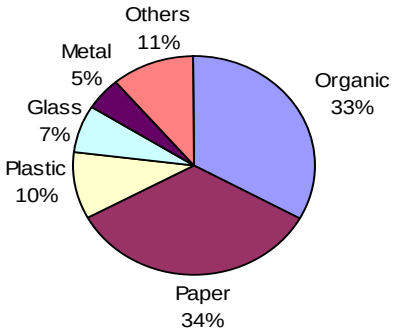
Appendix 2B

FIGURE 1 : WASTE COMPOSITION OF LOW, MIDDLE, AND HIGH INCOME COUNTRIES

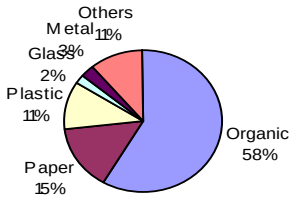
Current Waste Quantities and Compositions
High Income Countries: Current
Total Waste = 85,000,000 tonnes/year



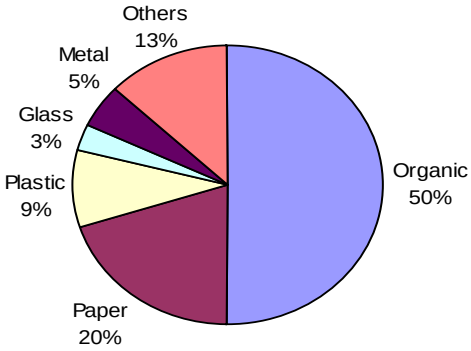
2025 Waste Quantities and Compositions
High Income Countries: Year 2025
Total Waste = 86,000,000 tonnes/year



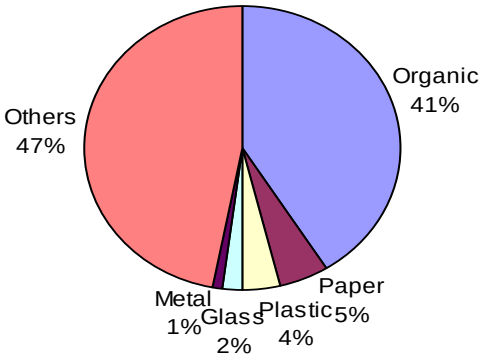
Middle Income Countries: Current
Total Waste = 34,000,000 tonnes/year



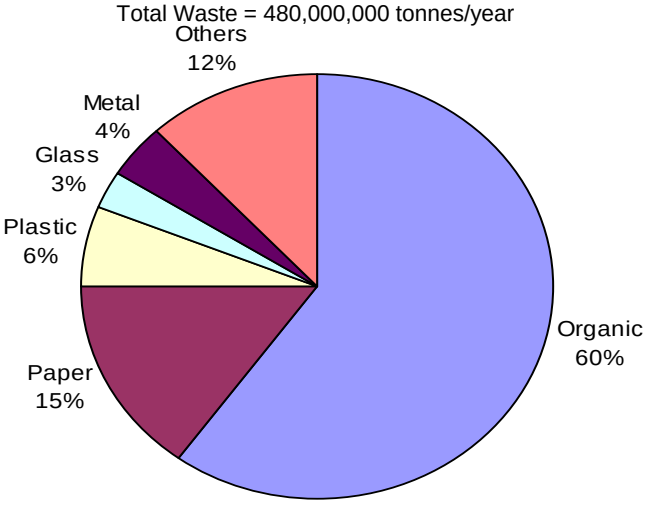
Middle Income Countries: Year 2025
Total Waste = 111,000,000 tonnes/year



Low Income Countries: Current
Total Waste = 158,000,000 tonnes/year

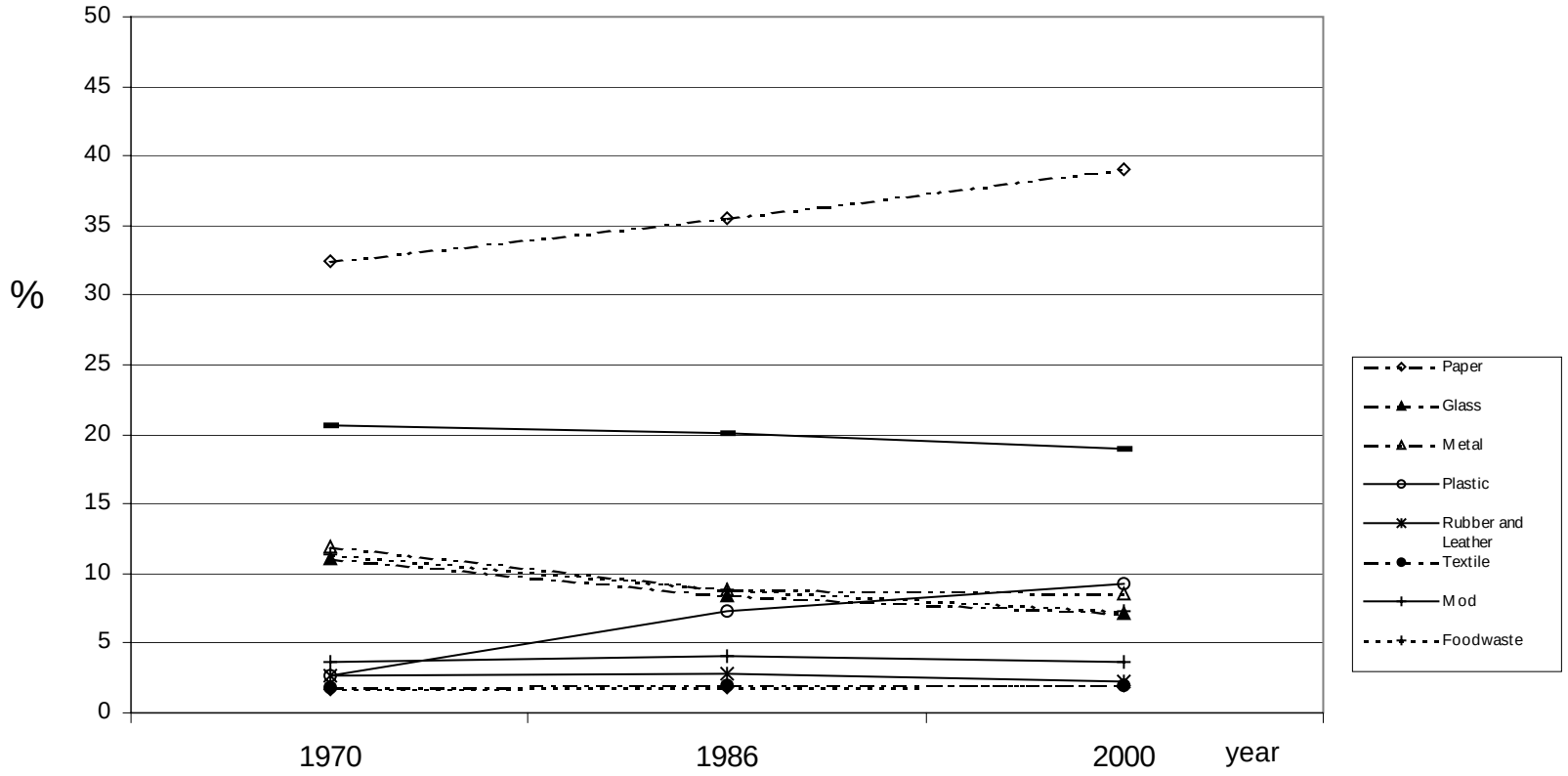


Low Income Countries: Year 2025
Total Waste = 480,000,000 tonnes/year



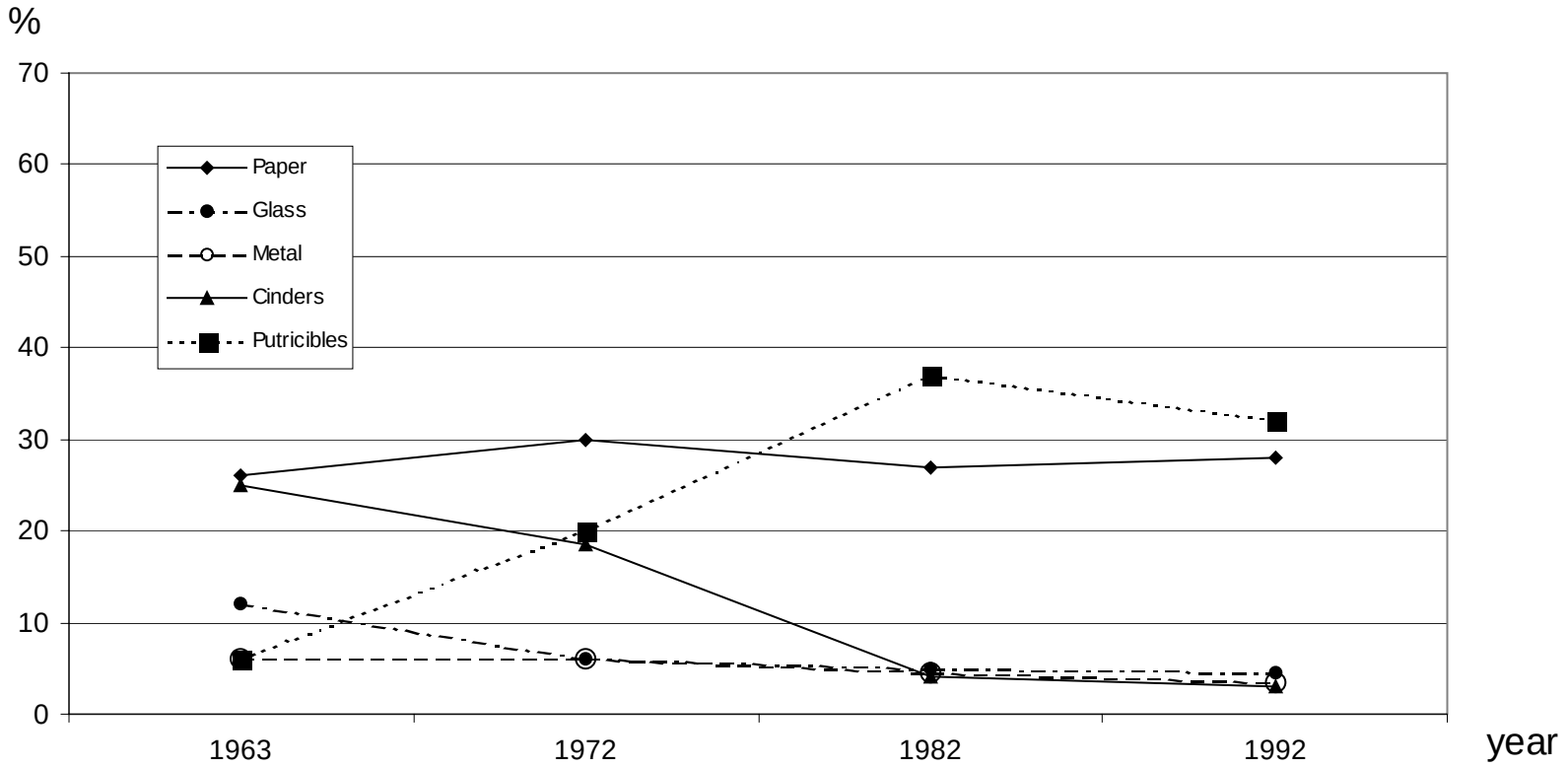
Source: www.worldbank.org/html/fpd/urban/publicat/waste.pdf

Figure 2 : Estimates of Materials and Products in MSW in United States (1970-2000)



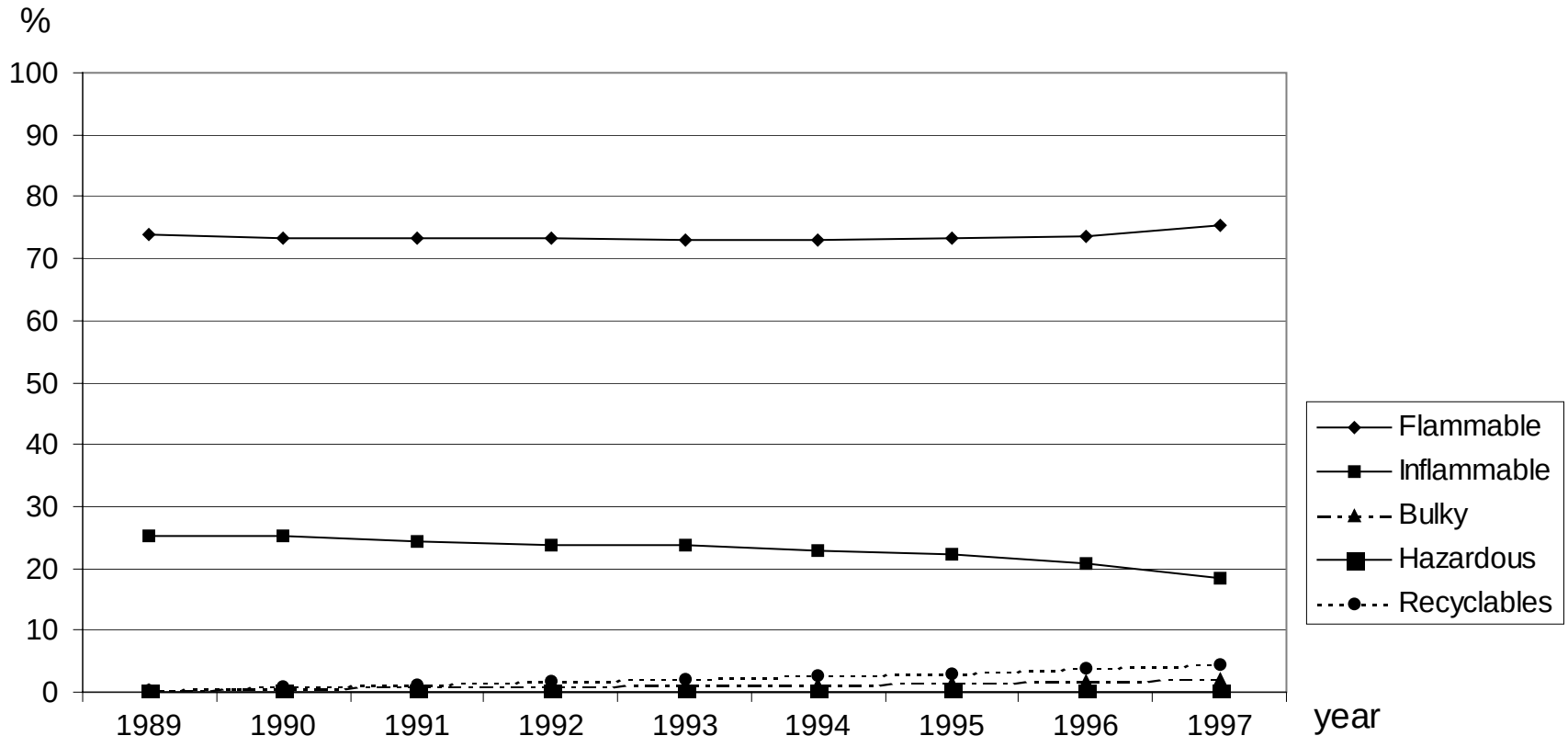
Source : *Franklin Associates, Ltd.'Characterisation of Municipal Solid Waste in the United States, 1960-2000, report prepared for US Environmental Protection Agency*

Figure 3 : Waste Composition in United Kingdom (1963-1992)



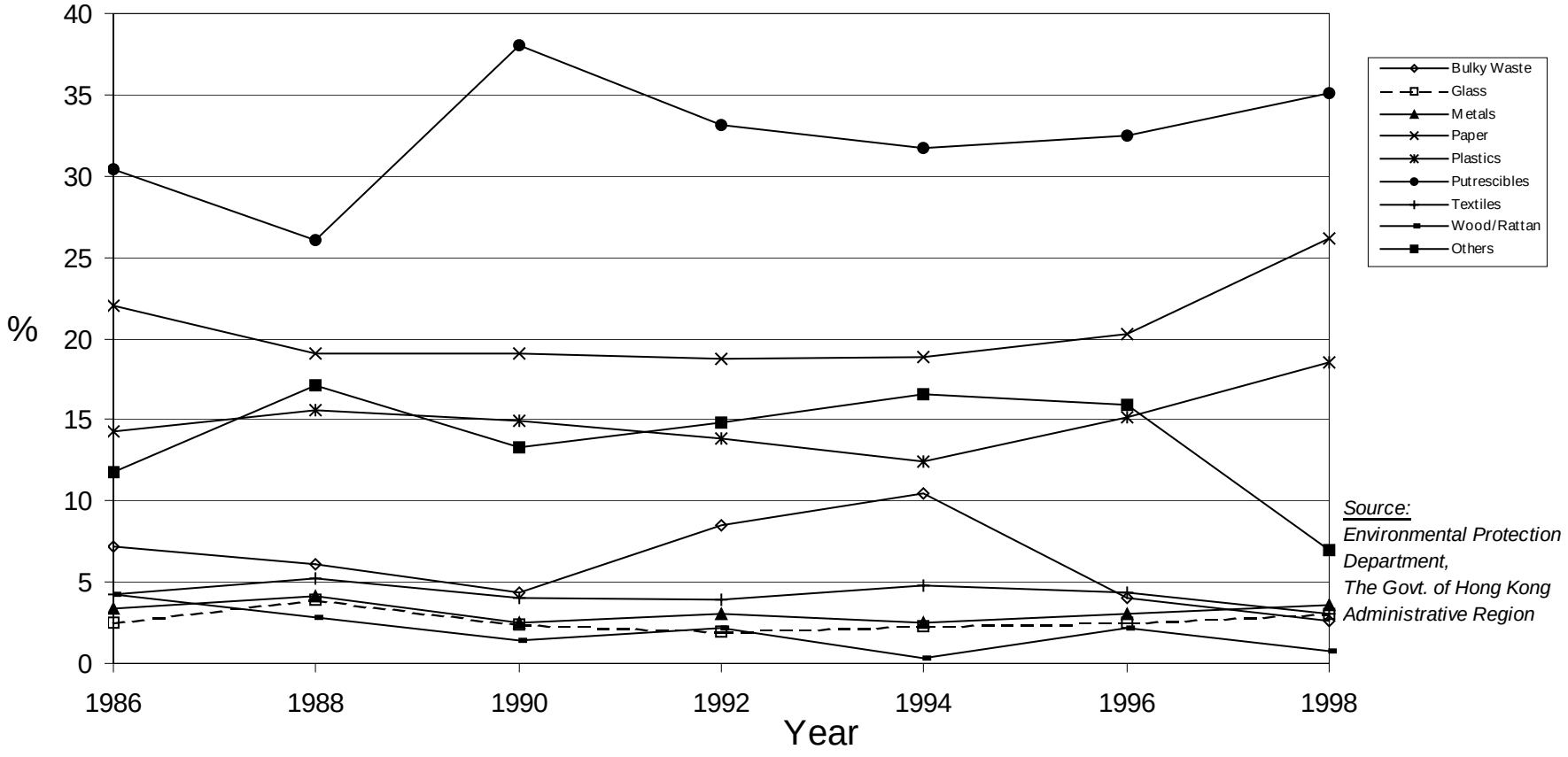
Source : *Waste Technology Lecture Week 2.Extracts from internet*
http://www.scu.edu.au/staff_pages/mcullen/wt_lec2.html

Figure 4 : Waste Composition in Tokyo (1989-1997)



Source: *General Information of Cleansing Services in Tokyo, March 2000, by Tokyo Metropolitan Government*

Figure 5 : Trend of Waste Composition in Hong Kong, (1986-1998)



Source:
Environmental Protection Department,
The Govt. of Hong Kong Administrative Region