

## Socio-economic influence on municipal solid waste generation in Petaling Jaya

Agamuthu, P.<sup>1</sup>, Lingesveeramani, M.<sup>2</sup> and Bregnhøj, H.<sup>3</sup>

<sup>1</sup>Institute of Biological Science and <sup>2</sup>Institute of Postgraduate Studies, University of Malaya, Kuala Lumpur, Malaysia.

<sup>3</sup>Technical University of Denmark, Denmark

**ABSTRACT** Municipal Solid Waste (MSW) generation rate in Malaysia was found to vary according to the type of waste generator, land use and economic level. Waste was collected and sorted from five types of housing area (single-storey terrace, double-storey terrace, single-storey bungalow, double-storey bungalow and condominium) in Section 11 and 12, Petaling Jaya, Selangor Darul Ehsan. Residents in single-storey bungalow generate 17.6kg/week/dwelling of MSW, followed by double-storey terrace houses at 16.3kg/week/dwelling, single-storey terrace houses produced at 10.2kg/week/dwelling, double-storey bungalow 10.2kg/week/dwelling and condominium residents generated 7.3kg/week/dwelling. Per capita generation rate which depends on waste generated and number of people in the house, shows residents in single-storey bungalow generate 0.12-0.88kg/person/day of MSW, double-storey bungalow residents (0.14-0.41kg/person/day), single-storey terrace residents (0.11-0.52kg/person/day), double-storey terrace residents (0.20-0.62kg/person/day), condominium residents (0.12-0.26kg/person/day). Physical characteristics of MSW also differed for the various types of housing area. MSW pH values ranged from 5.08 to 6.20. Conductivity values of MSW ranged from 83 to 969 $\mu$ S and moisture content of MSW was from 36.59% to 76.16%. On the occupational aspect, public sector working residents generate more MSW (0.44kg/person/day) compared to private sector working residents (0.34kg/person/day) and students (0.24kg/person/day). Indian residents were found to generate more MSW, at 0.35kg/person/day compared to Chinese, 0.32kg/person/day while Malays generated, 0.29kg/person/day. Medium-income residents (RM1500-RM4000) generated less MSW at 1.26kg/residence/day while high-income residents (>RM4000) generated 1.38kg/residence/day and low-income residents (<RM1500) generated, 1.94kg/residence/day. Average MSW generation rate at Section 11 and 12, Petaling Jaya was range from 0.11-0.88kg/person/day and average waste composition are organic 42.0%, paper products 18.2%, plastics 18.7%, glass 4.3%, non-ferrous metal 3.4%, ferrous metal 0.5%, polystyrene 1.1% and others 11.8%. Socio-economic factors; housing type, occupational type, race and income level play a major role in MSW generation while educational level has a minor influence.

(Municipal solid waste, socio-economic, waste composition, waste generation, physical characteristic)

**ABSTRAK** Kadar penghasilan Sisa Pepejal Perbandaran (SSP) di Malaysia telah didapati dipengaruhi oleh jenis penghasil sampah, status ekonomi dan guna tanah. Sisa pepejal dari lima jenis jenis kediaman (teres satu tingkat, teres dua tingkat, banglo satu tingkat, banglo dua tingkat dan kondominium) di Seksyen 11 dan 12, Petaling Jaya telah dikutip dan dikategorikan. Penghuni banglo satu tingkat menghasilkan 17.6kg/minggu/kediaman SSP, diikuti penghuni teres dua tingkat (16.3kg/minggu/kediaman), penghuni teres satu tingkat dan banglo dua tingkat (10.2kg/minggu/kediaman), dan penghuni kondominium (7.3kg/minggu/kediaman). Kadar penghasilan per kapita SSP yang mana bergantung kepada penghasilan sisa pepejal dan bilangan penghuni per kediaman, menunjukkan penghuni banglo satu tingkat menghasilkan 0.12-0.88kg/penghuni/hari SSP, penghuni banglo dua tingkat (0.14-0.41kg/penghuni/hari), teres satu tingkat (0.11-0.52kg/penghuni/hari), teres dua tingkat (0.20-0.62kg/penghuni/hari) dan penghuni kondominium (0.12-0.26kg/penghuni/hari). Sifat fizik SSP juga berbeza untuk sisa pepejal dari jenis kediaman yang berlainan. Julat nilai pH ialah dari 5.08 ke 6.20, julat nilai konduktiviti dari 83 ke 969 $\mu$ S dan julat kandungan kelembapan SSP dari 36.59% ke 76.16%. Dari segi aspek jenis pekerjaan, kakitangan sektor awam menghasilkan lebih banyak SSP (0.44kg/peghuni/hari) berbanding kakitangan sektor swasta (0.34kg/penghuni/hari) dan pelajar (0.24kg/peghuni/hari). Penghasilan SSP adalah paling tinggi di kalangan penghuni berbangsa India,

(0.35kg/penghuni/hari), diikuti oleh penghuni Cina (0.32kg/penghuni/hari) dan penghuni Melayu (0.29kg/penghuni/hari). Penghuni berpendapatan sederhana (RM1500-RM4000) menghasilkan kurang SSP (1.26kg/kediaman/hari), manakala penghuni berpendapatan tinggi (>RM4000), 0.38kg/kediaman/hari dan penghuni berpendapatan rendah (<RM1500), 1.94kg/kediaman/hari. Purata penghasilan SSP di kawasan kediaman Seksyen 11 dan 12, Petaling Jaya ialah 0.11-0.88kg/penghuni/hari dan purata komposisi SSP adalah organik 42.0%, kertas 18.2%, plastik 18.7%, glass 4.3%, logam bukan besi 3.4%, logam besi 0.5%, polistirena 1.1% dan lain-lain 11.8%. Faktor-faktor sosio-ekonomi; jenis kediaman, jenis pekerjaan, bangsa dan aras pendapatan memainkan peranan yang penting berbanding aras pendidikan yang kurang mempengaruhi penghasilan SSP.

(Sisa pepejal perbandaran, sosio ekonomi, komposisi sisa, penghasilan sisa, sifat fizik)

### INTRODUCTION

Municipal Solid Waste (MSW) is mainly household waste and also includes organic waste from commercial and institutional outlets. Urbanization and industrialization in Malaysia has brought in many changes in quality and quantity of solid waste generated. MSW is highly heterogeneous and its composition reflects the affluence of the society, their way of life, their economic status and their social behaviour. The characteristics of MSW changes with time as the society evolves to the needs of development. For example, in Petaling Jaya, Malaysia, the amount of paper disposed increased by 3.5% in a period of less than 5 years, whereas the putrescible waste decreased from 55% to 48% within the same period [1].

In 1997, the total solid waste generated throughout Malaysia was 5.6 million tonnes or 15,000 tonnes/day and of this 80% was domestic waste and the rest was commercial waste. In 1998, the MSW generated increased to 6.0 million tonnes, with an average of 0.5 to 0.8 kg per capita per day. One quarter of the total solid waste was generated in the Klang Valley, where Selangor generated the highest amount (2,375 tonnes) of waste. Per capita waste generation increased in Malaysia from 0.70 kg/person in 1990s to 1.20 kg/person in 2000 [2].

Table 1 below shows the waste generation characteristics in the municipality of Petaling Jaya. By the year 2005 it is projected that the rate of generation will increase by as much as 50% compared to the current rate.

Table 1. Projected waste generation for Petaling Jaya.

Year	Projected population	Total waste generation (tonnes/day)
		777.2
2000	607,200	959.1
2005	695,000	1158.8
2010	777,700	

Source: Master Plan on Solid Waste Management for Petaling Jaya Municipality (1990-2010).

Urban migration is one of the immediate causes of high-density populations in some cities including Kuala Lumpur and Petaling Jaya. The rapid increase in population is one of the increases in MSW generation.

### EXPERIMENTAL

The study area is housing estates in Section 11 and 12, Petaling Jaya Municipality, Selangor Darul Ehsan. Five houses from each type of housing area (single-storey terrace, double-storey terrace, single-storey bungalow, double-storey

bungalow and condominium) randomly identified. Waste collected from each house for one week, started on Monday till Sunday. Physical properties such as pH and conductivity determined using pH meter and Conductivity meter respectively. Then, the waste collected was separated into six categories; organic, paper, plastic, metal, glass and others. Separated waste materials were placed in individual containers to be weighed. Waste heated in oven at 105°C to determine moisture content of waste.

**RESULTS AND DISCUSSION**

**Housing type**

Table 2 shows the range of MSW generated and physical properties from five types of housing

estates and Table 3 shows min of MSW generated and physical properties from five types of housing estates.

**Table 2.** Range of MSW generated and physical properties from various type of housing estates in Section 11 and 12, Petaling Jaya.

Housing type	1	2	3	4	5
	<b>Range</b>				
Waste generated (kg/week/dwelling)	4.6-21.7	4.12-43.7	9.3-21.9	7.7-11.7	5.0-10.8
Per capita (kg/person/day)	0.11-0.52	0.20-0.62	0.12-0.88	0.14-0.41	0.12-0.26
Density (kg/m <sup>3</sup> )	0.16-0.62	0.14-0.35	0.27-0.43	1.62-1.94	0.08-0.14
pH	5.1-6.0	4.6-6.0	5.8-6.1	5.7-6.4	4.7-5.5
Conductivity (μS)	211-257	296-969	441-538	405-526	83-109

<sup>1</sup>Single-storey terrace, <sup>2</sup>Double-storey terrace, <sup>3</sup>Single-storey bungalow, <sup>4</sup>Double-storey bungalow, <sup>5</sup>Condominium

**Table 3.** Min of MSW generated and physical properties from various type of housing estates in Section 11 and 12, Petaling Jaya.

Housing type	1	2	3	4	5
	<b>Min</b>				
Waste generated (kg/week/dwelling)	10.2	16.3	17.6	10.2	7.3
Density (kg/m <sup>3</sup> )	0.30	0.22	0.33	1.73	0.13
pH	5.4	5.4	5.9	6.0	5.1
Conductivity (μS)	227	638	516	446	96

<sup>1</sup>Single-storey terrace, <sup>2</sup>Double-storey terrace, <sup>3</sup>Single-storey bungalow, <sup>4</sup>Double-storey bungalow, <sup>5</sup>Condominium

From Table 3, single-storey bungalow residents generate the highest amount of MSW per week (17.6kg/week/dwelling) but condominium residents generate lowest quantity of MSW per week (7.3kg/week/dwelling). Except condominium, residents from all housing type produced more than 10.0kg per week. From Table 2, single-storey bungalow residents generate high range of per capita generation (0.12-0.88kg/person/day) and condominium residents generate lowest range (0.12-0.26kg/person/day). Condominium residents are mainly undergraduate students and young professionals, where they will spend more time outside residence and therefore condominium residents generate less MSW. MSW from all type of housing area are acidic (pH<7) due to the food

waste, which has deteriorated. Waste from condominium residents also has lowest density (0.19kg/m<sup>3</sup>) due to polystyrene food packaging materials. Conductivity of double-storey terrace residents waste gives highest value (638μS) and condominium residents waste gives lowest value (96μS).

**Occupational**

Table 4 shows the range of MSW generated and physical properties from public sector employees, private sector employees and students and Table 5 shows min of MSW generated and physical properties from public sector employees, private sector employees and students.

**Table 4.** Range of MSW generated and physical properties from various occupational type residents in Section 11 and 12, Petaling Jaya.

Occupational type	Public sector	Private sector	Student
	Range		
Waste generated (kg/week/dwelling)	4.1-19.4	7.7-11.5	5.0-43.7
Per capita (kg/person/day)	0.20-0.88	0.30-0.41	0.11-0.62
Density (kg/m <sup>3</sup> )	0.14-0.28	0.20-1.94	0.08-1.81
pH	4.6-6.0	5.1-6.4	4.7-6.1
Conductivity (µS)	296-969	231-534	83-542

**Table 5.** Min of MSW generated and physical properties from various occupational type residents in Section 11 and 12, Petaling Jaya.

Occupational type	Public sector	Private sector	Student
	Min		
Waste generated (kg/week/dwelling)	12.1	8.1	13.6
Density (kg/m <sup>3</sup> )	0.22	1.12	0.37
pH	5.5	5.9	5.4
Conductivity (µS)	620	392	263

Table 5 shows, students generate high amount of waste per week per residence (13.6kg/week/dwelling) and private sector employees generate less waste (8.1kg/week/dwelling). Waste generation per dwelling from student was high due to high number of students per dwelling, which ranged from 4 to 19 students per dwelling. Number of residents per dwelling in non-student residences is only ranged from 3 to 6 residents per dwelling. Therefore, from Table 4, student has lowest per capita waste generation (0.11-0.62kg/person/day), followed by private sector workers (0.30-0.41kg/person/day) and the highest was public sector workers (0.20-

0.88kg/person/day). Waste from private sector employees has highest density (1.12kg/m<sup>3</sup>) while conductivity value from public sector employees was highest (620µS). pH value which ranged from 5.4 to 5.9 shows acidic characteristic in waste collected.

**Race**

Table 6 shows the range of MSW generated and physical properties from Malay, Chinese and Indian residents and Table 7 shows min of MSW generated and physical properties from Malay, Chinese and Indian residents.

**Table 6.** Range of MSW generated and physical properties from Malay, Chinese and Indian residents in Section 11 and 12, Petaling Jaya.

Race	Malay	Chinese	Indian
	Range		
Waste generated (kg/week/dwelling)	4.6-43.7	7.7-10.0	4.1-19.4
Per capita (kg/person/day)	0.11-0.62	0.29-0.37	0.12-0.88
Density (kg/m <sup>3</sup> )	0.14-1.81	0.20-1.94	0.08-1.66
pH	4.6-6.1	5.7-6.2	4.7-6.4
Conductivity (µS)	83-542	257-534	96-969

**Table 7.** Min of MSW generated and physical properties from Malay, Chinese and Indian residents in Section 11 and 12, Petaling Jaya.

Race	Malay	Chinese	Indian
		<b>Min</b>	
Waste generated (kg/week/dwelling)	14.9	8.5	9.8
Density (kg/m <sup>3</sup> )	0.51	1.05	0.40
pH	5.4	5.9	5.5
Conductivity (µS)	308	431	384

From Table 7, Malay residents in Section 11 and 12, Petaling Jaya generate high quantity of solid waste per dwelling (14.9kg/week/dwelling) and Chinese generate lowest quantity of solid waste (8.9kg/week/dwelling) while from Table 6, Malay residents generate lowest per capita waste (0.11-0.62kg/person/day) and the highest per capita waste generated by Indian residents (0.12-0.88kg/person/day). Malay residents in this study are mainly undergraduate student from University of Malaya and 4 to 19 students will share the house. Chinese and Indian residents in Section 11 and 12 are mainly family and only 3 to 6 residents per residence. Therefore, waste generation for Malay residents is highest but the

per capita waste generation is lowest. Waste density of Chinese residents is highest (1.05kg/m<sup>3</sup>) and lowest by Indians residents (0.40kg/m<sup>3</sup>). Wastes from all races residence are acidic and conductivity from Chinese residents waste is highest (431µS).

**Income**

Table 8 shows the range of MSW generated and physical properties from low, medium and high income residents and Table 9 shows min of MSW generated and physical properties from low, medium and high income residents.

**Table 8.** Range of MSW generated and physical properties from low, medium and high income residents in Section 11 and 12, Petaling Jaya.

Income	Low Income <sup>a</sup>	Medium Income <sup>b</sup>	High Income <sup>c</sup>
		<b>Range</b>	
Waste generated (kg/week/dwelling)	5.0-43.7	4.1-17.2	9.3-19.4
Per capita (kg/person/day)	0.11-0.62	0.16-0.49	0.29-0.88
Density (kg/m <sup>3</sup> )	0.08-1.81	0.14-0.38	0.27-1.94
pH	4.7-6.1	4-6-6.0	5.7-6.4
Conductivity (µS)	83-542	231-969	344-538

<sup>a</sup>Monthly income below RM1000.

<sup>b</sup>Monthly income between RM1500 to RM4000

<sup>c</sup>Monthly income above RM4000

**Table 9.** Min of MSW generated and physical properties from low, medium and high income residents in Section 11 and 12, Petaling Jaya.

Income	Low Income <sup>a</sup>	Medium Income <sup>b</sup>	High Income <sup>c</sup>
		<b>Min</b>	
Waste generated (kg/week/dwelling)	13.6	8.8	12.3
Density (kg/m <sup>3</sup> )	0.37	0.22	1.12
pH	5.4	5.4	6.0
Conductivity (µS)	263	523	475

<sup>a</sup>Monthly income below RM1500.

<sup>b</sup>Monthly income between RM1500 to RM4000

<sup>c</sup>Monthly income above RM4000

From table 9, low income residents generated highest amount of solid waste (13.6kg/week/dwelling) and medium income residents generates lowest amount of solid waste per week (8.8kg/week/dwelling). Low income residents prefer to have their meal at home compared to medium and high income residents who like to have their meal outside. Table 8 shows per capita waste generation increase with income level. Low income residents generate lowest quantity (0.11-0.62kg/person/day), followed by medium income residents (0.16-0.49kg/ person/day) and highest by high income residents (0.29-0.88kg/ person/day). Per capita

generation for high income group is high due to frequent disposed of bulk waste and high density waste such as wood products and glass, and also caused total density of MSW high (1.12kg/m<sup>3</sup>), which is highest compared to other income group residents.

**Education level**

Table 10 shows the range of MSW generated and physical properties from secondary and tertiary education level residents and Table 11 shows min of MSW generated and physical properties from secondary and tertiary education level residents.

**Table 10.** Range of MSW generated and physical properties from secondary and tertiary education level residents in Section 11 and 12, Petaling Jaya.

Education level	Secondary	Tertiary
	Range	
Waste generated (kg/week/dwelling)	7.2-19.4	4.1-43.7
Per capita (kg/person/day)	0.14-0.88	0.11-0.62
Density (kg/m <sup>3</sup> )	0.17-1.94	0.08-0.62
pH	5.7-6.0	4.6-6.1
Conductivity (µS)	257-969	83-932

**Table 11.** Min of MSW generated and physical properties from secondary and tertiary education level residents in Section 11 and 12, Petaling Jaya.

Education	Secondary	Tertiary
	Min	
Waste generated (kg/week/dwelling)	11.3	10.4
Density (kg/m <sup>3</sup> )	0.91	0.19
pH	6.0	5.7
Conductivity (µS)	506	271

Table 10 and 11 shows that people with secondary education level generate higher amount of solid waste per week per dwelling (11.3kg/week/dwelling), per capita waste generation (0.14-0.88kg/person/day), waste density (0.91kg/m<sup>3</sup>), pH value (6.0) and conductivity (506µS) compared to people with tertiary education level. Even though the waste generated per dwelling by residents with secondary education level is higher than people with tertiary education level but the difference is less.

**WASTE COMPOSITION AND MOISTURE CONTENT**

Average MSW composition in Section 11 & 12, Petaling Jaya are organic 42.0%, paper products 18.2%, plastics 18.7%, glass 4.3%, non-ferrous metal 3.4%, ferrous metal 0.5%, polystyrene 1.1% and others 11.8% as shown in Table 12.

Average combustible matter is 80% and recyclable matter 45%, whereas the organic component is 42.0%. Moisture content of MSW ranged from 36.59% to 76.16%.

Table 12. Composition of MSW in Section 11 & 12, Petaling Jaya.

Waste type	Percentage by weight (%)
Organic	42.0
Paper products	18.2
Plastics	18.7
Glass	4.3
Non-ferrous metal	3.4
Ferrous metal	0.5
Polystyrene	1.1
Others	11.8

### CONCLUSION

On the waste generation per dwelling aspect, socio-economic factors; housing type, occupational type, race and income level play a major role in MSW generation while educational level has a minor influence. Per capita generation, density, pH value and conductivity of MSW clearly influenced by all socio-economic factors discussed in this paper.

MSW from all type of housing area are acidic (pH<7) due to the food waste, which has deteriorated

Average MSW generation rate at Section 11 and 12, Petaling Jaya was 0.11-0.88kg/person/day and average MSW composition are organics 42.0%, paper 18.2%, plastics 18.7%, glass 4.3%, non-ferrous metal 3.4%, ferrous metal 0.5%, polystyrene 1.1% and others 11.8%.

Studies on socio-economic influence on MSW generation are important in every municipality for a better solid waste management and environmental management.

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