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Influence of Income Level and Age on Per Capita Household Solid Waste Generation in Putrajaya, Malaysia

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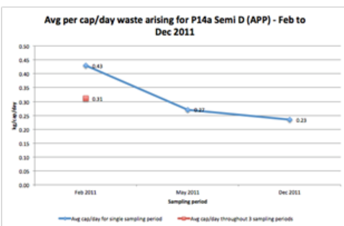
Graphical abstract



Abstract

Municipal solid waste (MSW) has always been an unavoidable byproduct of human habitation and activities. It has continued to be a problem as we are forced to find ways to properly manage it. As the world now sees an exponential growth in population, so does it sees an alarming increase in the quantity of generated MSW. If managed and disposed of improperly, MSW is a major cause of adverse environmental conditions. Rapid development, urbanization, changes in consumption patterns and elevated levels of affluence in recent decades have only exacerbated the issue, especially in transitionary countries such as Malaysia. Hence, the impetus to handle these problems and to manage MSW in an efficient yet environmentally sound manner is reaching an apogee currently. Determining per capita MSW generation rate and understanding its influencing factors is one step towards efficient MSW management. The objectives of this study is to determine current per capita residential MSW arising rate and subsequently to discern if a relationship exists between MSW generation rate, affluence and age of the residents of nominated households. Three discrete housing neighborhoods in Putrajaya were selected as the areas under study. To capture varying socioeconomic levels, the selected study areas consists of bungalow, semidetached and terraced houses. Primary data was obtained by door-to-door weighing of MSW for 12 consequent days which makes up a sampling phase. This was conducted concurrently in all study areas, with a total of 3 sampling phases done over a 1 year period. A face-to-face survey was then performed on all households under study to obtain relevant socioeconomic data. From this study, it is determined that on average, the bungalow houses under study generated 0.47 kg/cap/day of MSW, semidetached housing area produces 0.31 kg/cap of MSW daily and terraced houses had an MSW output of 0.26 kg/cap/day. This shows that affluence has a positive affect on MSW discharge rate as households that earn a higher income tend to produce more waste. However, the link between age and MSW discharge rate is found to be inconclusive. From this study, concerted efforts to reduce MSW arising can be better focused on selected target groups and demographics, bringing us a step closer to formulating and implementing sustainable waste management practices.

Keywords: MSW; municipal solid waste; generation; affluence; age; income

1.0 INTRODUCTION

Every human activity produces waste in one form or another. In its solid and most abundant form, it is called municipal solid waste (MSW) or trash. After cement production, MSW is the single largest mass generated by humanity (Matsunaga 2002). Generally, MSW constitutes what one consumes or make use of and then dispose of everyday.

Strasser (1999) states that nothing is inherently trash and that waste is actually produced by the act of sorting. It is difficult to be more specific in the definition of MSW, as what is considered to be waste in one society, culture or country may not be considered as such in another. In short, waste is dynamic and relative to the one producing it. This varying definition of waste is one of the hurdles in the proper management of waste.

Ultimately, it cannot be denied that MSW generation has been on the rise year on year, most notably in the past several decades. It has been estimated that humankind's generation of waste has exceeded the earth's carrying capacity by more than 30% and that daily $2x10^9$ tons of waste is generated (Agamuthu 2011). The increase in MSW generation can be attributed to several factors, namely the exponential global population boom, rapid development, increased consumer buying power and a plethora of other causes. Agamuthu *et al.* (2010) stated that waste generation in Malaysia has increased because of rural-urban migration, rising per capita income and changes in consumption patterns. This situation is particularly acute in developing countries such as Malaysia, where the fast pace of development has brought along rapid urbanization and increased migration patterns from rural to urban areas. It has been estimated by Mansor (1999) that MSW generation in Kuala Lumpur will increase from 2620 tons per day in 1995 to 3070 tons in 2000. Murad *et al*. (2007) reports that in the year 2000, Kuala Lumpur's actual MSW generation stood much higher at 4000 tons per day. It has also been approximated that in 2007, 65% of the nation's waste was generated by urbanites (Agamuthu 2010).

On a smaller scale and by looking at per capita levels, the national average for per capita waste generation in Malaysia was 0.68 kg/capita/day in 2001 (UNEP 2010). That figure has increased in 2006 to roughly 0.85 kg/capita/day resulting in a total of 7.34 million tons of MSW generated in the nation as a whole for that year (Siraj 2006). According to Agamuthu (2010), waste generation in Malaysia is increasing at a rate of 3% annually. Still other studies have reported a much higher figure, such as Sakurai *et al*. (1996) which reported a 1.3 kilogram per capita per day waste generation rate for Malaysia. Nonetheless, it is unclear if that figure is the generation rate per capita in urban or rural areas. However, so far other studies have been unable to come up with a definitive and consistent figure for waste generation in any given area that is under study. This is primarily due to several factors such as the varying definition of waste from area to area, the method of analysis and problems during measurement (Watanabe 2010). This varying rate of generation serves to only highlight the need for a detailed study to determine exactly the per capita per day waste generation rate of Malaysia.

One of the most influential factors thought to play a major role in determining waste generation rates is the affluence or income level of a particular household or person. A positive correlation between affluence and waste generation rate means that the more affluent a person is, the more waste he will produce due to his possession of expendable income that is used to buy and consume more products. On the other hand, a negative correlation could denote that the more money a person earns, then they are more apt to eat out and be more aware of environmental concerns, thus producing less waste per capita. Hitherto, prior researchers have found conflicting indications showing the correlation between waste generation rates and affluence. EAWAG, The Swiss Federal Institute of Aquatic Science and Technology (2008), stated that a higher economic status results in an increase in MSW volume. Wertz (1976) and Jenkins (1993) also found that there is a direct positive correlation, while Cargo (1978) have found otherwise. Still others such as Hockett (1995) find the relation to be inconclusive.

The relationship between affluence and municipal waste generation is very close. AAAS (2000) found that a 40 percent increase in the GDP of countries belonging to The Organisation of Economic Cooperation and Development (OECD) since 1980 has been accompanied by the same percentage increase in municipal waste generated. Even more troubling is the fact that the OECD predicts there will be a further 70 to 100 percent increase in GDP in its region by 2020. Agamuthu (2011) reports that there is a strong link between the gross national income of a nation and the per capita waste generation of it's populace. Developed countries with high gross national income, such as the United States of America, Germany and Switzerland all produce waste at very elevated levels, approximately 700 kilograms per capita annually (Agamuthu 2011). This is not validated for all countries, however. Japan, which also has a high gross national income, only generates 400 kilograms per capita of waste per annum. India, a transitory country with low gross national income, only produces waste at a rate of 100 kilograms per capita per year. However, it is clear that unless the link between waste generation and GDP is severed totally, there could be a corresponding and commensurate increase in waste arising in these countries. This may be further exacerbated by certain social trends, such as the increase in single person households due to higher divorce rates, lesser desire to raise a family and the aging population, particularly in the developed world. As the developing world industrializes and grows more affluent, it too can expect an increase in waste generation, unless an absolute decoupling of waste generation from GDP occurs.

Other factors thought to have an influence on the rate of MSW generation are spatial in nature, such as neighborhood area and housing type. Demographic and geographical factors, such as population density, size of land area and average age of the populace, ethnicity and others like it also has a bearing on the generation of waste to a certain extent (Matsunaga 2002). Of particular interest is age of the population. Preceding researchers have found age to be one of the variables that have a significant impact on waste generation. Kim (2009) determined that those in the 18-24 age bracket are the ones that produce most waste when compared to other age brackets. Sircar *et al*. (2003) and Lindh (2003) also states that there is a positive relationship between the medium age group and MSW arising. Other prior researches support this theory, such as the findings of Vining and Ebreo (1990) and Lansana which state that older people are more likely to recycle thus ultimately contributing less to the general waste stream, while Schultz *et al*. (1995) found the relationship between age, recycling and MSW arising to be uncertain and contradictory.

MSW management has been defined as the discipline of controlling generation (Tchobanoglous *et al*. 1993). Hence, apart from establishing average per capita waste generation in the study areas, this study also aims to investigate what socioeconomic factors influence our decision-making process the most in producing trash.

2.0 METHODOLOGY

Three housing neighborhoods in Putrajaya were selected as the areas under study. Table 1 shows the neighborhoods selected, the housing type present and the number of houses on which this study was performed. To best capture varying socioeconomic levels, the selected study areas were deliberately selected so that they consist of bungalow, semidetached and terraced housing elements which are discrete and discontinuous from each other. The households selected for this study is presumed to be representative of the entire neighborhood and other similar housing projects in other localities in the country.

Table 1 Type and number of houses present in the selected study areas

Study Area	Precinct P14A	Precinct P14A	Precinct P16D
Housing type	Bungalows	Semidetached	Terraced
Number of sampled houses	25	51	66
Number of sampled houses post-sporadic exclusion	13	30	26

The first stage of the study is the waste weighing or sampling phase which spanned a period of 1 year. Primary generation data from the households under study was obtained by simple door-to-door weighing of MSW for 12 consecutive days from Mondays to Saturdays. This makes up a data sampling phase and was conducted concurrently in all study areas, with a total of 3 sampling phases done in predetermined months over a 1 year period. Sampling phase 1 was performed in February 2011, phase 2 was done in May 2011 and finally phase 3 took place in December 2011 with each phase consisting of 12 consecutive sampling days. Given that the households under study usually have their waste collected every other day, this means that each house in the study area will have their MSW output sampled 6 times in any given sampling phase.

The door-to-door MSW weighing activities were conducted by 3 teams with each team having 2 to 3 personnels. Each team used standardized digital electronic weighing scales with a maximum capacity of 40 kilograms, a resolution of 10 grams and a readability of 10 grams. Standard operating procedure are for the team members to identify, withdraw and then uncover the waste bin of the house under study, take out all the waste that has been discharged within and then weigh the same using the digital scale. Waste that are 'loose' or those that has been scattered inside the waste bin were repackaged in new litter bags and then weighed whenever possible. Materials that were sorted into distinct categories such as plastics, paper and metals which were obviously sorted with a purpose to facilitate recycling activities, were weighed and recorded separately from commingled waste.

Houses that were vacant or that discharged waste too sporadically such as guesthouses and houses that were only occupied on the weekends were precluded from the final data analysis to preserve data accuracy and avoid outliers in the analysis. A particular house is designated as being sporadic if it has more than 4 zero readings in 1 sampling phase. After all sporadic and questionable premises were eliminated, the number of houses included in the final analysis is shown in Table 1. This set of houses is identified as the APP (All Periods Present) dataset, signifying houses that consistently produced good data and discharged waste regularly throughout the whole 1 year sampling period.

A face-to-face survey was performed on all households under study after the third sampling phase to obtain relevant socioeconomic data of the occupants. The face-to-face method was utilized because it has been shown to be the most reliable questionnaire survey approach, especially in the collection of socioeconomic figures (Afroz 2011). The survey took place in November 2011 and went on for 3 weeks. Trained student enumerators were used during this phase of the study. The questionnaire consisted of 24 questions pertaining to the demographic, socioeconomic status and waste management habits of the household under study. Among the more pertinent questions is one regarding the number of persons living in the house. Another salient question asks the respondent to state the approximate combined monthly income of their entire household. To avoid undue suspicion and to increase the respondent's willingness to answer, the answer to this latter question is given as set ranges as shown in Table 2. Each income group shown in Table 2 has an inferred socioeconomic strata linked to it.

Table 2 Income groups and corresponding inferred socioeconomic strata of survey respondents

Income group	Total monthly household income range (RM)	Socioeconomic strata
1	Below 1,000	Impoverished
2	1,000 to 2,000	Low income
3	2,000 to 5,000	Middle income
4	5,000 to 10,000	Upper middle income
5	Above 10,000	Wealthy

Call cards were left in the mailboxes of houses that were vacant and those that seemed to be devoid of occupant even after repeated visits by the enumerators. Call cards were also given to uncooperative or aggressive respondents. These call cards implored the reader to visit the URL of a website which in turn leads to a link that enables them to download a soft copy of the survey questionnaire form. They can then fill out the questionnaire form at their convenience after which they were instructed to submit the form they filled out to the study team via email. Unfortunately, out of the hundreds of call cards that were left, only 1 respondent reverted back to the study team with his/her filled-in questionnaire form. However, the data obtained from the said respondent couldn't be utilized in the analysis as the respondent neglected to include his/her house address.

Subsequently, the MSW generation data is compiled and then analyzed with the prime aim being to determine average per capita per day waste generation figures. The socioeconomic data acquired from the questionnaire survey exercise is then studied in parallel with the aforementioned waste arising figures.

3.0 RESULTS AND DISCUSSION

Table 3 and Table 4 shows salient socioeconomic data pertaining to affluence level and household size which was obtained from the questionnaire survey for all 3 study areas. The proceeding average per capita daily MSW generation results and subsequent discussion will be split into 4 sections, that is demographics, waste arising data and subsequently the relationship between arising, affluence level and household size of the houses under study.

3.1 Demographic

Table 3 shows the distribution of households that falls into each income group in the study areas. The above data is in accordance with the general assumption that the more expensive or the bigger a house is, then the more likely it is that the occupants will have a higher total monthly income level. P14A bungalows has the highest number of houses in income group 5, while P14A semidetached and P16D terraced housing areas have more income group 3 and income group 4 houses.

Table 3 Number and percentages of houses in each income group

	Income group 1	Income group 2	Income group 3	Income group 4	Income group 5
P14A Bungalows (%)	0 (0)	0 (0)	0 (0)	3 (23)	10 (77)
P14A Semidetached (%)	0 (0)	1 (3.33)	1 (3.33)	16 (53.33)	12 (40)
P16D Terraces (%)	1 (3.8)	0 (0)	4 (15.2)	7 (27)	14 (54)

There are more residents in P14A semidetached houses that earns between RM5,000 - RM10,000 per month (income group 4) when compared to the P16D terraced housing area. The same is true for income group 3. It is important to note that there are more houses in P16D terraces which belong to income group 5 than in P14A semidetached. The reverse should be expected, as semidetached housing are more expensive than terraced houses. However, it should be mentioned here that several houses in P14A semidetached area are actually being used as staff quarters for the public sector. Hence, the residents of these staff quarters may not earn an income commensurate with their housing type as essentially their housing cost is paid for or subsidized by the government, in whole or in part.

In the questionnaire survey, the question regarding the ages of the residents of a particular household is given as set ranges, that is below 3, 3-18, 19-29, 30-44, 45-58 and above 58 years old. Hence, as a means to quantify the exact age of a particular household in the analysis, we compute its weighted average age. This weighted average age is acquired by calculating the median of each age bracket (e.g. the median of age bracket 3-18 years old is 10.5 years old) then multiplying this median age by the number of residents in the said age bracket, summing everything and finally dividing by the total number of residents of the household. Note that the upper range of the 'above 58 years old' age bracket was set at 73 years, which is the Malaysian life expectancy at birth.

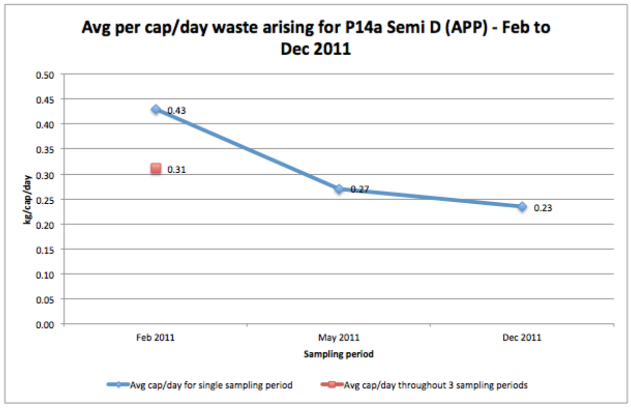
The weighted average age distribution of the households under study in each neighbourhood is shown in Table 4, with P14A bungalows recording the highest weighted average age while P14A semidetached reporting the lowest.

Table 4 Weighted average age of each study area

Study area	Weighted average age of all households (years)
P14A Bungalows	34.4
P14A Semidetached	26.8
P16D Terraces	27.8

3.2 Waste Arising Data

Figure 1 shows the average daily per capita waste arising figure of the households being studied throughout the 3 sampling phases. Average per capita waste generation figures for each sampling phase is also shown. It can be seen that P14A bungalows has the highest average waste discharge rate throughout the study period which stands at 0.47 kilograms/capita/day.



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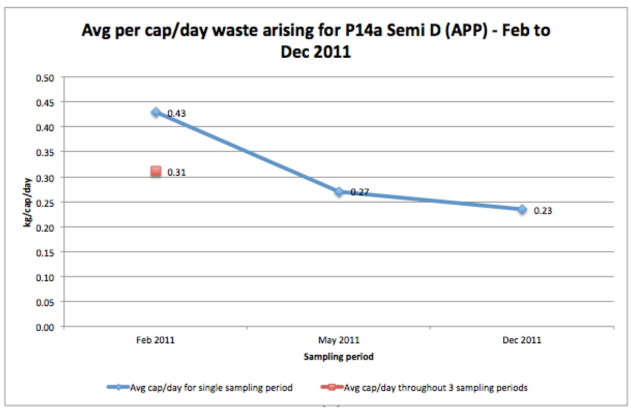

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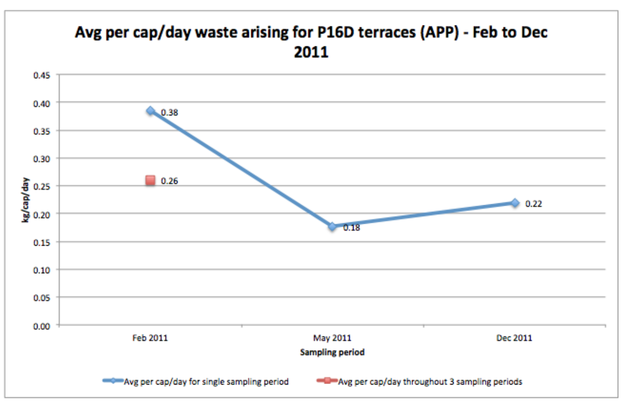


(c)

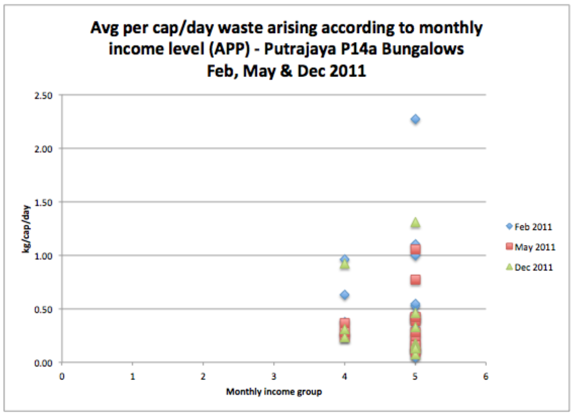
Figure 1 Average per capita per day MSW generation of (a) P14A bungalows, (b) P14A semidetached and (c) P16D terraced houses

This is followed by P14A semidetached houses with an average daily waste discharge rate of 0.31 kilograms/capita/day. P16 terraced housing area has the lowest average daily waste generation of 0.26 kilograms/capita/day throughout all 3 sampling periods. Therefore, the average per capita daily waste generation figures obtained in this study are lower than those cited by Sakurai *et al*. (1996), Siraj (2006) and UNEP (2010). However, it is critical to note that these preceding studies neglected to mention which level of society, what type of housing area and whether urban or rural areas were being studied. It is also unclear whether they devoted themselves to purely studying household solid waste or the wider ranging and inherently more numerous municipal solid waste stream which would include waste from commercial, institutional and industrial areas.

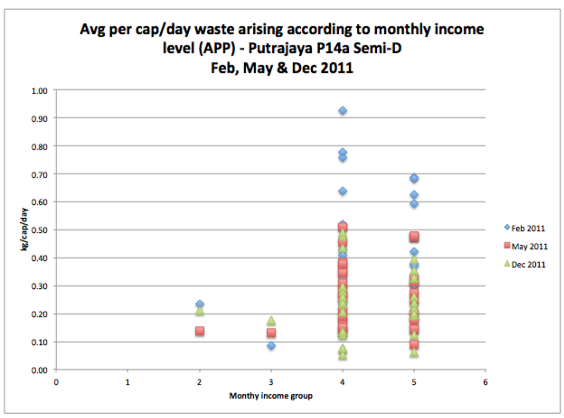
When viewed from a temporal aspect, it is observed that the sampling phase carried out in February 2011 recorded the highest average per capita per day waste generation figures. All subsequent sampling phases recorded lower values except for P16D terraces which recorded a slight spike at the end of 2011. The cause of this temporal fluctuation of waste discharge with time remains unclear.

3.3 Waste Generation and Affluence

Figure 2 shows the average per capita daily waste discharge rates of the household under study according to their total monthly income level. Assuming that the monthly income figures given by the respondents in the questionnaire study is 100% accurate, then it is found that the higher income groups as denoted by income group 4 and income group 5 produces the most waste. In certain cases, average per capita daily waste generation exceeded 1 kilogram per capita per day. This is especially true for households in P14A bungalows which most probably has the highest number of well to do families. Households that reported a lower total monthly income consistently recorded much lower average per capita daily MSW generation rates, as can be seen in Figure 2 (b) and (c). Note that there are several instances in P14A semidetached houses whereby income group 4 houses produced more waste per day when compared to income group 5 houses. Again, this inordinate number of houses with disproportionately high rate of MSW discharge could be linked to the fact that some houses in the said area are used as staff quarters for the public sector.



(a)



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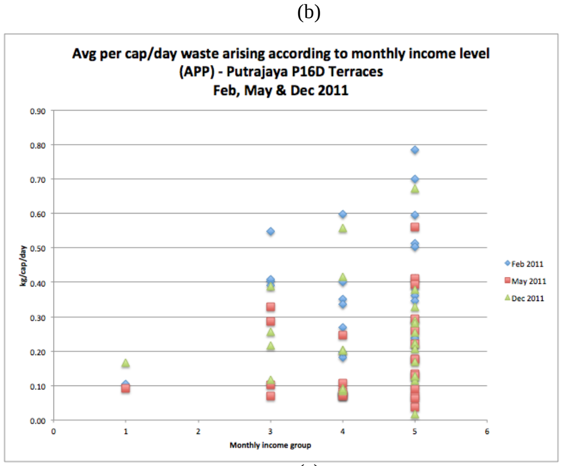

(c)

Figure 2 Average per capita per day waste discharge rates according to monthly income level of (a) P14A bungalows, (b) P14A semidetached and (c) P16D terraced houses

3.4 Age

Having calculated the weighted average age of each household under study as outlined in section 3.1, we can then classify each household as being younger or older by comparing the weighted average age of each household to the overall average age calculated for all houses in the 3 study areas, which in the case of the 3 study areas is Putrajaya is computed to be 28.6 years old. Houses with a weighted average age beyond this figure is designated as older households and vice versa for younger households. Subsequently, we compare the daily per capita waste output over 3 sampling periods of each household against the same figure calculated for the area as a whole to determine if they are producing waste above or below the average level. The results are shown in Table 5.

31.3% of the younger households in the study area have an average per capita daily waste arising that is lesser than their respective area's 3 sampling phases average. A slight majority of the older households (23.9%) have average per capita daily waste discharge that is less than each area's average over the same period of time. Houses that produce above average daily per capita waste discharge over the study period consists equally of younger & older households (22.4%). In essence, this means that on average, for the areas under study, the majority are younger households that have a lower rate of per capita waste generation per day. Older households also appear to be inclined to produce less waste per capita per day but their tendency to do so is very minute.

Table 5 Number of houses with their age classification and relation to average waste discharge over 3 sampling phases

Household age classification	Daily per capita waste arising over 3 sampling periods	P14A Bungalows (%)	P14A Semidetached (%)	P16D Terraces (%)	Total	
Younger households	Below average	2 (15.4)	9 (30)	10 (37)	21 (31.3)	36
	Above average	0 (0)	9 (30)	6 (22.2)	15 (22.4)	
Older households	Below average	6 (46.2)	5 (16.7)	5 (18.5)	16 (23.9)	31
	Above average	5 (38.5)	6 (20)	4 (14.8)	15 (22.4)	
Total		13	29	25	67	

This could indicate that houses with younger residents are more aware of environmental issues and are therefore more likely to practice recycling and other sustainable waste management practices subsequently producing less waste. Unfortunately, this line of reasoning is tenuous and in its current state and is contrary to the findings of Vining and Ebreo (1990) and Lansana (1992). Therefore, the results of this study supports the conclusion drawn by Schultz (1995) which states that the existence and direction of the relationship between age and per capita daily waste output is ambiguous.

4.0 CONCLUSIONS

From the study that was carried out, it can be surmised that generally in Putrajaya, smaller households and households with higher income produces more waste than their counterparts. Thus, it is found that for Putrajaya households, waste generation rate has a positive correlation with affluence. The relationship between age and waste generation rate is however unclear and cannot be established with conviction at this time.

With this information at hand, integrated efforts can be made to try and reduce the amount of waste generated at source which in this case are households in Putrajaya. The local municipality body, Perbadanan Putrajaya, can utilize this information to plan for and provide suitable types and capacities of solid waste management facilities to effectively handle Putrajaya's waste output. In addition, educational and awareness programmes can be targeted and focused on specific groups which are more prevalent in an area. For example, programmes which will appeal more to youths can be held in areas where there are more younger households compared to older ones.

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