Assessing The Potential Of Reduction And Recycling Of Household Waste In Malaysia

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Abstract:

A detailed composition analysis of household waste, with emphasis on waste avoidance and recycling, was carried out in Bandar Baru Bangi, Selangor, Malaysia, which is a typical suburb adjacent to Kuala Lumpur. Four survey neighbourhoods were selected, based on housing types. In total, 1005kg of waste from 282 households were sorted into 120 categories. At the same time, a questionnaire survey was conducted to gather information on household size, recycling activities, cooking habits etc.

The results indicated a clear difference in waste generation between the housing types. The average composition showed that the percentage of packaging waste in waste is less than that of Japan or Europe, both in terms of weight and volume. It was also shown that the percentage of plastic packaging added at the retail stage was much greater than that in Japan or Europe. "Unused food" and "disposable diapers" were found to be the largest items that consumers could reduce. The average recycling rate of household waste was 6.5%, while 23% of waste was potentially recyclable. Old newspaper is thoroughly collected for recycling, but some kind of intervention is desired to promote the recycling of other items.

Keywords: *Malaysia, composition, reduce, recycle, packaging, food*

1 Introduction

1.1 Background

In most parts of the world, the problem of municipal waste arises in the process of economic development, as more people start to live in cities, and at the same time there will be an increase in per capita material consumption. As a consequence, the amount of waste handled by the municipality increases drastically. Quality-wise the waste starts to contain new materials and items that are difficult to treat. Often the provision of waste facilities fails to keep up with this change, leading to inappropriate treatment of waste that causes local pollution. Once and even now, it is believed that arranging for the provision of adequate facilities vis-a-vis the predicted quantity and quality of waste would solve the problem. For this purpose, in highly industrialised countries such as Japan, waste treatment technology and practice have been improved to such an extent that one can hardly smell of waste even just outside the facilities. Critical emissions from incinerators have decreased drastically. Hence theoretically, there is no room for NIMBY complaints. On the other hand, economists and politicians have been trying hard to invent various ways to channel enough money for waste facilities.

However, this paradigm of "predict and provide" is shifting in the light of new public management and global sustainability. In many industrialised countries, there is now doubt whether the huge expenditures for waste facilities are bringing due benefits to the society. The one-way stream of mass-consumption and mass disposal has been viewed as incompatible with the earth's limited resources and carrying capacity. It may be economically and environmentally more efficient to reduce the amount of waste, and to recycle, instead of disposing.

The waste hierarchy has become an established concept in industrialised countries. This prioritises source reduction before reuse and recycling, while safe disposal is ranked as the last option. In the primary stage of waste management in a developing country, it is important to first provide for proper disposal of waste (e.g., engineered sanitary landfill). As the economy develops, there will be a need to tackle with the increase in the amount of waste, and this is where the waste hierarchy becomes relevant. Malaysia has experienced a rapid increase in material consumption, and at the same time, waste reduction and recycling activities have become less economically attractive because of the relative decrease in the price of commodities in comparison to labour wages.

The research described in this paper was conducted in Malaysia. In which location would the findings of this research be applicable? From observation, it appeared that any item with value as resource was collected and recycled, and not disposed of as waste in countries such as Indonesia, Philippines, Thailand and Vietnam. Bluntly speaking, secondary resources are traded at world market price, while the local wages differ. Probably it could be said that the economics of recycling is determined by the latter, for which per capita GDP could be a surrogate indicator. Malaysia has a per capita GDP of $6950 (IMF 2010), which is one of the highest in Southeast Asia. Hence the results here may not apply to other major SE Asian countries, but many countries in South America such as Brazil and Argentina have a per capita GDP larger than that of Malaysia, and so do many "transition economy" countries such as Russia, Romania, and Lithuania. 1.8 billion people live in countries with GDP larger than Malaysia. Less than half of this is in "advanced industrialised economies" of North America, Western

Europe and Japan. The case of Malaysia may be regarded as representing the middle-income countries, which hold a significant proportion of the world population.

In situations like in these middle and high income countries, the commitment of the government sector is important, not only for the provision of waste collection and disposal services, but also for encouraging activities higher up the waste hierarchy. For this, we need to assess the potential for 3R (Reduce, Reuse and Recycle). Only with rigid numerical data, we can achieve sound policies and plan accordingly.

Detailed compositional data is required as we pursue measures higher up in the waste hierarchy (Table 1). For landfilling or incineration, "gross" figures, such as the total weight, total calorific value, or the percentage of biodegradable materials are desired. In order to plan for recycling, the material composition (metal, paper, plastics etc) is required. To determine the "reuseability" of an item, we need to know whether the item was thrown away because it was broken beyond repair, or it had been thrown away despite it was maintaining its functions. For source reduction, we need to identify the actors and activities that added the item into the societal material flow. In other words, the context of the waste becomes important (e.g. is it goods or is it packaging? At what stage was the packaging added?).

Table 1: Waste Hierarchy and Data Requirements

Waste Hierarchy	Typical Data Requirements
Waste Minimisation / Source Reduction	Original purpose of items (goods /packaging etc) Target waste creating actors /activities
Material Recycling	Material composition
Incineration	Calorific value / Elemental composition
Landfill	Basic quantity data (weight)

Policy insights can be obtained from comparisons of the situations in different cities under various conditions and waste management systems. An accurate comparison of the detailed waste composition is very useful in order to assess the feasibility of various schemes in these different locations. Currently, the data to make this kind of comparison possible are lacking, especially in the international context. Even when survey results are available, it is difficult to compare one with another, because of the differences in survey methods and categorisations of waste.

1.2 General Methodology

Household waste has a difficult character in that it is rather non-homogeneous. Thorough mixing is one method to make the sample more uniform. On the other hand, mixing will make the sorting more unpleasant and difficult. Another method is to record the items before they get into the dustbin. The shortfall with this method is that the research activity is likely to influence the household in their waste generation activity. Various bodies have conducted waste composition analyses, and each of them has devised methods to suit the local conditions and their aims. The methods can be generalised into three types (Table 2).

Table 2: Methods of Waste Composition Analysis

Methods	
Cone Sampling	2-4t Sample(collection vehicle)->Mechanical mixing->200-300kg handsort (Representative mix / Detailed sorting difficult)
Bag (Bin) Sampling	200-300kg sample in container (Representativeness? Detailed sorting possible)
Panel Survey	Panel Households provided with a scale and recording sheet (Representativeness? influences behaviour)

One method for waste composition analysis is that involving cone (or grid) sampling (cf. Warren Spring Laboratory and Aspinwall & Co. 1993). Sample waste for analysis is collected by stratified sampling of households. Typically, 5~7 tonnes of waste is obtained as sample from waste compactor vehicles. Analysis is often carried out after the sample is trommelled (i.e. sorted by particle size). Each size-sorted sample is fractioned by cone sampling. About 300 kilograms of this fractioned sample is hand-sorted. The emphasis is put on mixing well to achieve a representative sample.

This method is good in obtaining a representative sample for analysing the elemental makeup (i.e. the proportion of carbon, nitrogen, chlorine, etc in waste), but the analysis is 'dirty', as everything is stirred and soiled. Mixing involves a physical change, which destroys the actual features of household waste. Some items will break, and this makes it difficult to sort. Mixing also makes it difficult to judge whether the item had been abandoned because it was broken or despite the fact that it was still usable. Moisture migration takes place and originally dry items will become heavier than at the point of waste generation.

On the other end of the spectrum of methods, there is the "panel survey" (cf. Yamaguchi et al 1989). Selected 'panel' households will be provided with a survey sheet and a kitchen scale, and during the survey period, they are asked to weigh and record everything that is disposed from the household. This method relies on the cooperation of panel households, and does not involve 'dirty' work for investigators. The negative side is that it is difficult to find a large number of cooperative households. There are also chances that the subject households would be a biased sample. In many cases, subject households are approached via certain groups, such as employees of the city council, or members of a co-operative. Volunteers who express their willingness to participate are likely to have a higher awareness of the problems with waste management. Other risk factors are that householders may not record properly, and that the survey itself influences their behaviour. It is suspected that during the survey period, householders tend to recycle more than usual, and would avoid producing very wet kitchen waste, as it is difficult and unpleasant to weigh.

Takatsuki (Kyoto University, Environmental Preservation Centre), Kyoto City, and ARPA-K have been developing the "bin (bag) sampling method" that suits the objective of detailed household waste composition analysis (cf. ARPA-K 1998a, 1998b). For the past 30 years, Kyoto City has been conducting analyses with more than 250 sorting categories every year. Sampling is from 3 to 6 housing type areas. Collection of sample waste is done by flat loading trucks. Receptacles or sacks containing waste will be loaded as they are set out for collection. Mixing of waste is avoided as much as possible to enable the detailed analysis. About 300kg of waste is hand-sorted for each housing type.

This method has less chance of influencing the subjects' behaviour as compared to the one above, and the sorting can be done relatively cleanly. There is moisture migration while the waste is kept in the bin or sack (Watanabe 1991), but this is to a much lesser extent than with physical mixing. The disadvantage compared to the first method is that as waste from only relatively small number of households would be sampled, the representativeness can be a question. A larger sample will overcome this doubt, but this means more labour is needed to carry out the work.

1.3 Methods of the Project in Bandar Baru Bangi

The aim of this project is to identify the per capita arisings of each detailed waste item from urban Malaysian households, including those that are recycled. Through the waste sampling, sorting, and weighing procedure, the waste composition in terms of percentage, and the amount of waste per household were obtained. The items and the amounts recycled (per household), and the number of persons per household were obtained by a questionnaire survey.

1.3.1 Characteristics of the Sampling Area Due to ease of logistics, we have designated Bandar Baru Bangi (Bangi New Township) area as the sampling area. This is where the main campus of Universiti Kebangsaan Malaysia is located. B.B.Bangi is a part of Kajang Municipality, in the state of Selangor. This is about 30km south of central Kuala Lumpur, where a palm oil plantation was converted into residential and industrial land use in the 1980s. Bandar Baru Bangi was designed as a township to support the needs of industries and institutions such as universities and, government training centres, and is one of the urban areas in Malaysia that is experiencing a rapid population growth (Fariz and Jamaludin, 2000; Fariz and Nordin, 2003). Other than universities and related institutions, assembly factories such as Sony, Hitachi, and Denso are the main employers in this area. There are also many people that commute to the Kuala Lumpur area. It could be said that this is a typical suburban area in the greater Kuala Lumpur region.

Sampling areas within B.B.Bangi were identified by housing types. After a few site visits and investigation into census block data, four neighbourhoods were selected (Fig. 1). Two are terraced housing which is the major housing type in this area. The others are bungalow area and flats. Flat dwellers tend to be less educated and have a lower income. Many of them work in the nearby factories.

Door-to-door waste collection service is usually provided three times a week (e.g., Mon, Wed, Fri, or Tue, Thu, Sat). Any items other than bulky items and garden waste are accepted in this waste collection. Kajang Municipality delegates waste collection to Alam Flora Sdn. Bhd., the regional concessionary (and its subcontractors). Collected waste is delivered to the "Recycle Energy" MRF /RDF /Incineration facility in Semenyih (within Kajang municipality). In this facility, metals, plastics, and hazardous items are removed and the rest is incinerated, whereby the generated heat is utilised for electricity generation (the items and the amount recycled in this facility is not included as "recycled" in the discussion below).

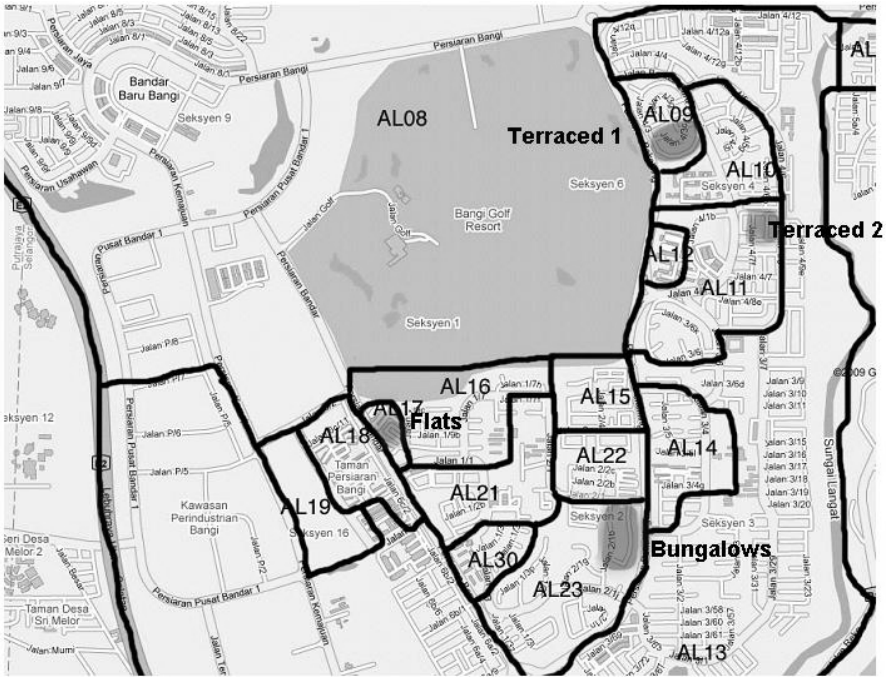

Figure 1: Sampling Area

Collection of recyclable materials is available in this area, through collectors who circulate frequently (paper and metals), as well as through collection points (recycling centres - paper, plastics, and metals) and donation to charity organisations (mostly clothes and electric appliances). The scope of this project is the items dealt by the abovementioned regular waste collection as well as these recycle/reused items.

1.3.1 Waste Composition Analysis The sampling of waste was conducted with the cooperation of Alam Flora. In the morning of a waste collection day, waste set out for collection from each household was put into a plastic bag(s) labelled with the house number. Waste was collected on a flat loader truck, instead of the regular compactor vehicle, and carried to the site for waste sorting in the Engineering Department (UKM).

The amount (kg) and volume (ml) from each household is measured before sorting. The volume was estimated by putting the sample into a bucket marked with graduation of 5 litres. Waste was sorted into ca.120 categories, following the category table (see Table 3), which was based on those used in the earlier studies in Neyagawa (jp), Cambridge (uk), Freiburg (de), and Aarhus (dk), where Fukuoka and Watanabe were involved (Watanabe, 2003).

This table was devised so that its results could be used as base data for discussing various waste management measures. Material types such as paper and plastics (and their sub-types, e.g. "corrugated card") are an important categorisation criterion for assessing the potential recyclablity and compostablity. Further classification was made according to the pre-disposal purposes of the items - durable goods, disposable items, advertisement materials, packaging, etc., as such distinction is useful in identifying actors and activities for source reduction. As packaging is a major

item in waste, this was classified even further, so that the stage in which the packaging item had been added could be identified, and also what kind of product it had been used for (i.e., food /non-food goods). With this information, it is possible to indicate the current contribution and the reduction potential of each actor in the packaging chain (producer, retailer etc). The summary tables (tables 4~6) are a result of various ways of aggregating the detailed categories. They were generated through cross-tabulation using various characteristics criteria.

The table was modified to suit the local condition. For example, the item "big fruit peels" was added, reflecting the significant appearance of tropical fruits such as Durian and Rambutan, which does not happen in higher latitudes. On the other hand, some items were deleted due to the non-occurrence in B.B.Bangi waste.

After the sorting was complete, each item was weighed and its volume measured. For some items such as disposable nappies, bottles and carrier bags, the number of the items was also counted. Each day, the analysis of waste from one neighbourhood was conducted. This was carried out for five days (done in March 2010, except for Terraced A, two analyses was conducted Jan and Mar 2010). The number of houses and the amount sampled were as follows:

29 Jan: Sek4/3 (Terraced A) 44 houses 215kg
15 Mar: Sek2/1 (Bungalow) 36 houses 282kg
16 Mar: Sek4/7 (Terraced B) 34 houses 164kg
17 Mar: Sek4/3 (Terraced A) 46 houses 177kg
18 Mar: Sek1/9 (Flats) 10 chutes (3 blocks, 122 housing units) 167kg
Total: 282 houses (units), 1005 kg

1.3.2 Questionnaire Survey The questionnaire sheet was created in both English and Bahasa Malaysia. Students of the waste management course were assigned with the street and house numbers, and they conducted a structured interview to each household based on the questionnaire sheet. 329 households were selected as survey subjects; those are the households that had their waste sampled, and their neighbouring houses. Valid responses were obtained from 248 houses (for details see below). The major reason for not being able to obtain a response was "nobody at home", although students were instructed to make a repeated visit to such houses. There were less than 10 cases where the householders refused to cooperate in the survey.

The questionnaire sheet included items such as how many person live in the house, items and the amount that were collected for recycling in the past two weeks, practise of any waste disposal methods other than the regular waste collection, the frequency of eating out, etc. Some bungalow households indicated that they burn garden waste on site. As garden waste is not in the scope of this project, it can be assumed that all wastes and recyclables were captured by the sampling and questionnaire survey.

Questionnaire survey (8-31 Mar)
Seksyen 2/1 (Bungalows) 55 houses (valid response: 44)
Seksyen 4/3 (Terraced A) 82 houses (66)
Seksyen 4/7 (Terraced B) 83 houses (63)
Seksyen 1/9 (Flats) 109 units (75)
Total 329 (248)

2 Results

Table 3 is the results table of the composition analysis. The purpose of the detailed categories is for creating summary tables according to various criteria. Various summary tables are discussed below.

2.1 Household Characteristics and the Amount of Waste

A tendency was observed that houses with larger number of people generate less waste per person. This tendency can also be observed in the results from many existing research in other places (e.g. Jenkins 1993, Yamakawa and Ueta 2002). There was no rigid correlation between per capita arisings and the percentage of meals taken at home, nor the percentage of the use of takeaways. Results indicate that households with higher educated persons, households which make efforts to reduce waste, and households that recycle, all produce more waste per person. This appears paradoxical, but probably this is due to the fact that each of the above has a positive correlation with income.

2.2 Difference between Household Types

A large difference in the amount of waste between housing types was observed (fig 2). This confirms the results of the investigation conducted by JICA in Kuala Lumpur in 2004 (JICA 2006). It is interesting to see that in all housing types, "general kitchen waste" is constant at about 100g/person/day. At flats, there are less of other items, while in bungalows, there are more of recyclable materials such as paper, textile, and metals.

Table 3A: Results Table 1 of 2

code	Bangi Household Waste Survey 2010 Side 1				29-Jan 4/3	15-Mar 2/1	16-Mar 4/7	17-Mar 4/3	18-Mar 1/9	average			
	1	2	3	4	wt%+rec	wt%+rec	wt%+rec	wt%+rec	wt%+rec	wt%	vol%	weight(g	volume(ml)
1101	Pape	Produ	Newspapers - recyclable		0.17	0.11	0.20	0.58	0.29	0.27	0.63	1.22	14.99
1100			Newspaper - recyced		6.16	5.76	6.33	6.16	4.22	5.73	13.46	26.10	321.11
1102			Newspapers - heavily soiled used for wrappin		3.60	4.75	2.47	3.36	3.41	3.52	3.07	16.03	73.19
1103			Magazines		0.00	0.00	0.00	0.13	0.00	0.03	0.02	0.12	0.49
1104			Books		0.00	0.15	0.00	0.49	0.00	0.13	0.05	0.58	1.24
1106			Personal correspondence etc		0.00	0.01	0.61	0.00	0.00	0.12	0.10	0.57	2.50
1109			Other products		0.00	0.21	0.23	0.03	0.00	0.09	0.04	0.43	0.85
		subtotal			9.93	10.99	9.84	10.73	7.92	9.88	17.37	45.04	414.37
1201		Dispo	Tissue Paper /serviettes		1.05	2.38	2.79	1.86	0.51	1.72	1.03	7.83	24.62
1203			paper plates and cups		0.00	0.17	0.07	0.00	0.04	0.05	0.18	0.25	4.19
1209			Other Consumables		0.11	0.33	1.01	0.47	0.38	0.46	0.40	2.10	9.65
		subtotal			1.16	2.88	3.87	2.34	0.92	2.23	1.61	10.17	38.46
1301		Papers used for Advertising			0.52	1.82	1.41	1.47	0.31	1.11	0.86	5.05	20.52
1401		Conta	Drinks tetrapak#		0.53	0.58	0.80	0.58	0.09	0.52	1.68	2.35	40.15
1411			takeaway box		0.51	0.46	0.07	0.60	0.06	0.34	0.88	1.55	20.92
1413			product Box for food		0.35	0.69	0.36	0.80	0.11	0.46	1.07	2.10	25.63
1414			Corrug card boxes for food		0.83	0.14	0.00	0.00	0.57	0.31	0.75	1.40	17.88
1421			Paper mold for eggs		0.19	0.08	0.00	0.45	0.46	0.24	0.54	1.07	12.97
1423			Wrapping for food (wax/plastic)		0.57	0.73	0.83	0.48	0.91	0.70	0.87	3.21	20.65
1424			bags - food retailer		0.13	0.14	0.00	0.04	0.00	0.06	0.21	0.29	5.00
1425			bags - food producer		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1461			Boxes for non-food		0.73	0.85	0.81	0.83	1.18	0.88	1.82	4.01	43.43
1462			Corrug card boxes for non-food		1.93	1.09	0.00	2.27	0.00	1.06	2.48	4.83	59.18
1479			Other non-food packaging		0.01	0.00	0.37	0.00	0.00	0.08	0.11	0.35	2.51
1481			Wrapping (no wax)		0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.36
1482			Shopping Bags - with handle#		0.00	0.11	0.44	0.26	0.06	0.18	0.43	0.80	10.23
1483			Cushions / buffer materials		0.00	0.16	0.00	0.20	0.00	0.07	0.15	0.33	3.59
1499			Other container and packaging		0.00	0.00	0.12	0.14	0.00	0.05	0.17	0.24	4.05
		subtotal			5.80	5.04	3.80	6.64	3.45	4.94	11.17	22.54	266.54
1501		Invoice / bills etc			0.40	2.55	0.11	0.60	0.00	0.73	0.86	3.34	20.48
1502		Paper from workplace / school			0.74	0.32	0.04	0.48	0.86	0.49	0.60	2.24	14.30
1601		Miscellaneous			0.87	2.53	1.42	0.42	0.66	1.18	0.67	5.38	16.08
	Total				19.42	26.12	20.49	22.69	14.13	20.57	33.15	93.75	790.73
2101	Plas	House	food related		0.06	0.00	0.00	0.03	0.25	0.07	0.06	0.31	1.40
2109			non-food		1.26	0.43	0.78	1.46	0.36	0.86	0.99	3.92	23.60
		subtotal			1.32	0.43	0.78	1.49	0.62	0.93	1.05	4.23	25.00
2201		Dispo	food		0.02	0.05	0.00	0.05	0.06	0.03	0.18	0.16	4.36
2209			others (non-food)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
		subtotal			0.02	0.05	0.00	0.06	0.06	0.04	0.18	0.16	4.41
2401		Conta	Drinks bottles pet#		1.73	1.35	1.13	1.33	0.80	1.27	6.44	5.77	153.60
2400			recycled pla bottles (food)		0.20	0.13	0.11	0.19	0.28	0.18	0.92	0.83	21.99
2402			Drink bottles non-pet#		0.47	0.17	0.20	0.36	0.03	0.24	1.01	1.11	24.09
2403			Bottles for sauce etc#		0.00	0.00	0.00	0.49	0.15	0.13	0.71	0.59	17.02
2411			Tubs/Jars/boxes - food prod#(w/lid)		0.12	0.31	0.15	0.25	0.19	0.21	0.75	0.94	17.81
2412			Other hard plastic for food (w/o lid etc)		0.15	0.21	0.19	0.06	0.03	0.13	0.63	0.59	15.03
2413			Takeaway boxes (nonPS)#		0.15	0.00	0.09	0.27	0.11	0.12	0.44	0.57	10.41
2414			exp PS takeaway container#		0.39	0.36	0.42	0.28	0.51	0.39	4.84	1.80	115.51
2415			Cups for takeaway drink		0.17	0.25	0.21	0.25	0.31	0.24	1.49	1.08	35.64
2421			Exp PS trays (for uncooked foods)		0.01	0.04	0.05	0.03	0.00	0.03	0.13	0.12	3.14
2422			Other trays for food (egg?)		0.08	0.07	0.05	0.08	0.04	0.06	0.38	0.29	8.98
2423			bags - food producer (w/ printing)		2.15	1.40	1.31	1.58	2.19	1.73	3.47	7.86	82.87
2424			bags - food retailer (w/o printing)		2.21	2.01	2.11	1.61	1.83	1.96	2.70	8.91	64.35
2425			bags for food refil products		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2426			Wrap/Clingfilm		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2427			tubes (food)		0.00	0.00	0.04	0.00	0.00	0.01	0.00	0.03	0.05
2451			bottles for non-food#		0.74	1.21	1.99	0.77	0.44	1.03	2.34	4.69	55.92
2450			recycled pla bottles (non-food)		0.07	0.10	0.16	0.09	0.14	0.11	0.26	0.52	6.16
2461			Tub/jar/box/tray for nonfood (w/lid)		0.01	0.02	0.00	0.16	0.00	0.04	0.12	0.17	2.76
2472			bags - non-food producer		0.16	0.18	0.03	0.34	0.26	0.20	0.65	0.89	15.51
2473			bags - non-food refills		0.00	0.00	0.03	0.00	0.01	0.01	0.01	0.04	0.25
2474			tubes (non-food)		0.05	0.08	0.17	0.08	0.13	0.10	0.25	0.47	5.95
2481			Shopping	Large - Department stores etc	0.00	0.11	0.18	0.04	0.01	0.07	0.25	0.32	5.99
2482				Mid - supermarket carrier bags	1.08	0.98	1.16	1.14	0.75	1.02	1.96	4.65	46.82
2483				Small - lightweight corner shop typ	3.53	2.38	3.16	2.45	4.73	3.25	4.09	14.81	97.60
			subtotal		4.61	3.47	4.50	3.63	5.49	4.34	6.31	19.77	150.41
2484			Bin liners (sacks)		0.57	1.19	0.56	0.64	0.97	0.79	1.74	3.58	41.40
2487			Buffer m	Exp polystyrene	0.00	0.02	0.02	0.12	0.01	0.03	0.36	0.15	8.69
2488				Others	0.09	0.07	0.18	0.12	0.03	0.10	0.26	0.46	6.16
			subtotal		0.09	0.09	0.20	0.24	0.04	0.13	0.62	0.61	14.86
2499			Miscellaneous packaging		0.35	0.15	0.31	0.19	0.06	0.21	0.39	0.97	9.34
		subtotal			14.46	12.80	14.03	12.92	14.03	13.65	36.60	62.20	873.08
2501		Plastics from workplace /school			0.00	0.00	0.00	0.02	0.55	0.11	0.13	0.51	3.07
2601		Other miscellaneous plastics			0.14	0.71	0.77	0.00	0.12	0.35	0.46	1.58	11.01
	Total				15.94	13.98	15.58	14.48	15.36	15.07	38.42	68.68	916.57

Table 3B: Results Table 2 of 2

code	Side 2			29-Jan 4/3 wt%+rec	15-Mar 2/1 wt%+rec	16-Mar 4/7 wt%+rec	17-Mar 4/3 wt%+rec	18-Mar 1/9 wt%+rec	average wt%	vol%	weight(g	volume(ml)
3101	Text	Produ	Clothings	0.11	0.75	1.08	0.18	0.68	0.56	0.52	2.55	12.33
3100			recycled textiles	0.07	0.49	0.00	0.07	0.00	0.13	0.12	0.58	2.78
3109			Other products	0.60	2.03	0.33	0.40	0.18	0.71	1.10	3.22	26.16
		subtotal		0.78	3.26	1.41	0.65	0.86	1.39	1.73	6.35	41.27
3401		Packaging		0.00	0.00	0.04	0.00	0.00	0.01	0.01	0.03	0.25
3501		Textiles from workplace		0.00	0.00	0.24	0.08	0.00	0.06	0.09	0.30	2.23
3601		Other textiles		0.15	0.00	0.00	0.00	0.14	0.06	0.05	0.26	1.29
	Total			0.93	3.26	1.68	0.73	1.00	1.52	1.89	6.93	45.04
4101	Rubl	Household Products		0.00	0.14	1.10	1.12	0.23	0.52	0.36	2.37	8.63
4109		Others		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total			0.00	0.14	1.10	1.12	0.23	0.52	0.36	2.37	8.63
5101	Leat	Household Products		0.36	0.29	0.50	0.00	0.00	0.23	0.28	1.05	6.72
5109		Others		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total			0.36	0.29	0.50	0.00	0.00	0.23	0.28	1.05	6.72
6101	Glas	Produ	Kitchen utensils	0.05	0.00	0.00	0.00	0.00	0.01	0.00	0.05	0.04
6102			Flourescent tubes#	0.04	0.00	0.17	0.03	0.00	0.05	0.04	0.21	0.87
6109			Other products	0.06	0.00	0.00	0.19	0.01	0.05	0.04	0.23	0.93
		subtotal		0.15	0.00	0.17	0.22	0.01	0.11	0.08	0.50	1.84
6401		Conta	Beverage bottles#	0.52	0.43	0.13	0.00	0.15	0.25	0.12	1.13	2.94
6402			Bottles and Jars for food#	1.10	1.97	1.76	2.47	0.98	1.66	0.82	7.55	19.49
6403			Bottles and Jars for non-food#	0.01	0.36	0.15	0.21	0.40	0.23	0.06	1.03	1.34
6409			Broken bottles and jars (unidentifyable)	0.43	0.54	0.00	0.00	0.41	0.28	0.10	1.26	2.28
		subtotal		2.06	3.31	2.04	2.67	1.95	2.41	1.09	10.97	26.05
6601		others		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total			2.22	3.31	2.21	2.89	1.96	2.52	1.17	11.47	27.88
7101	Meta	Produ	Kitchen utensils	0.02	0.06	0.05	0.04	0.00	0.03	0.03	0.14	0.63
7103			e-waste#	0.00	1.27	0.02	0.05	0.71	0.41	0.16	1.87	3.91
7109			Other products	0.97	0.23	0.07	0.00	0.02	0.26	0.59	1.17	14.01
		subtotal		0.99	1.55	0.14	0.08	0.73	0.70	0.78	3.19	18.55
7201		Dispo	Dry cell batteries#	0.00	0.12	0.05	0.03	0.03	0.05	0.01	0.21	0.18
7209			Other disposables	0.00	0.03	0.00	0.01	0.00	0.01	0.00	0.03	0.10
		subtotal		0.00	0.14	0.05	0.04	0.03	0.05	0.01	0.24	0.28
7401		Conta	Beverage	Aluminum#	0.10	0.11	0.01	0.08	0.10	0.08	0.36	0.35	8.52
7402				Steel#	0.00	0.00	0.00	0.06	0.00	0.01	0.01	0.05	0.34
			subtotal		0.10	0.11	0.01	0.14	0.10	0.09	0.37	0.41	8.86
7403			Food cans#		0.61	0.49	0.55	0.72	1.20	0.71	1.49	3.25	35.42
7400			cans recycled		0.60	0.33	0.41	0.60	0.14	0.42	0.86	1.89	20.62
7404			Pet food cans#		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7411			boxes for food#		0.00	0.22	0.00	0.00	0.00	0.04	0.01	0.20	0.28
7419			other metal food packaging		0.08	0.00	0.00	0.00	0.00	0.02	0.01	0.07	0.36
7451			Boxes for non-food#		0.00	0.06	0.00	0.00	0.00	0.01	0.00	0.06	0.08
7454			Spray canisters (non-food)#		0.19	0.18	0.39	0.00	0.16	0.18	0.16	0.83	3.85
7499			Other container and packaging		0.00	0.04	0.02	0.00	0.00	0.01	0.00	0.05	0.07
		subtotal			1.58	1.42	1.38	1.45	1.61	1.49	2.92	6.78	69.54
7601		others			0.00	0.19	0.00	0.00	0.00	0.04	0.01	0.17	0.28
	total				2.57	3.30	1.57	1.57	2.37	2.28	3.72	10.38	88.65
8901	Plants/Garden waste				1.14	0.42	2.71	2.25	1.42	1.59	1.33	7.24	31.69
8101	Wod	Products			0.02	0.02	0.04	0.01	0.00	0.02	0.03	0.08	0.65
8201		Disposable items			0.03	0.04	0.04	0.09	0.02	0.04	0.06	0.19	1.43
8401		Container and Packaging materials			0.08	0.25	0.22	0.26	0.08	0.18	0.31	0.80	7.44
8501		from workplace			0.00	0.19	0.00	0.00	0.00	0.04	0.00	0.18	0.06
8601		Others			0.01	0.00	0.00	0.00	0.13	0.03	0.03	0.13	0.73
	total				0.14	0.50	0.29	0.35	0.23	0.30	0.43	1.38	10.30
9101	Cera	Products			0.29	0.53	0.95	0.12	0.24	0.43	0.13	1.94	3.17
9401		Containers and packaging materials			0.43	0.00	0.00	0.00	0.00	0.09	0.04	0.39	1.07
	total				0.71	0.53	0.95	0.12	0.24	0.51	0.18	2.33	4.24
9601	Kitc	Unused Food (>1/2 of whole)			10.02	8.35	6.42	9.83	3.93	7.71	3.33	35.14	79.33
9602		General food waste			21.78	18.77	25.30	21.38	36.92	24.83	7.37	113.16	175.76
9603		Big Fruit peels / cores (durian etc)			13.56	7.67	9.33	13.31	7.74	10.32	4.37	47.04	104.27
	total				45.35	34.78	41.06	44.52	48.59	42.86	15.07	195.34	359.37
9901	Misc	Diapers#			3.87	6.72	6.61	3.12	11.31	6.33	2.98	28.83	70.99
9902		Cat Litters / Animal Bedding			1.35	1.33	0.86	0.00	0.00	0.71	0.33	3.23	7.83
9903		Medicine			0.06	0.10	0.26	0.69	0.11	0.24	0.16	1.10	3.85
9904		Combustible			0.32	0.35	0.44	0.70	1.27	0.62	0.40	2.81	9.64
9905		Non-Combustible			0.87	0.27	0.00	0.16	0.13	0.29	0.14	1.30	3.23
	total				6.47	8.77	8.17	4.67	12.81	8.18	4.01	37.27	95.53
	Total of all items				95.25	95.41	96.32	95.40	98.35	96.15	100.00	438.19	2385.36
	escaped moisture				4.75	4.59	3.68	4.60	1.65	3.85		17.56	
	Grand Total (original weight/ volume)				100.00	100.00	100.00	100.00	100.00	100.00		455.75	

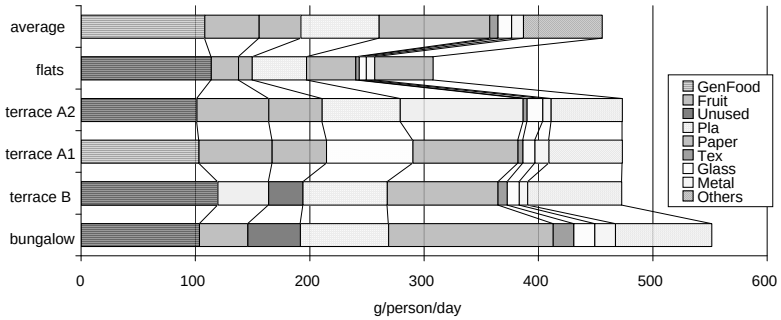

Figure 2: Arisings according to housing types

2.3 Average composition

The average of five analysis runs is used here as the average composition. Table 4 is a summary table based on the original use of the items, in comparison with past results of the authors' investigations in England and Japan (Watanabe 2003). There is less packaging waste in B.B.Bangi, both in terms of percentage and actual weight. Looking at the stages in which packaging is added, it is apparent that the B.B.Bangi sample has the highest proportion of plastic packaging added at the retail stage. As these are mostly carrier bags, it occupies less volume compared to rigid plastic packaging which is used more frequently in England and Japan. Households often put kitchen waste in these plastic bags, hence the moisture content of the sorted plastic bags was high (ca.80%). It could be said that packaging waste in B.B.Bangi is even less than what is indicated on the tables (2233 plastic carrier bags were found in the total sample of 1005kg. Their total weight was 33.9kg. On the other hand, 2233 dry bags would weigh only about 6.7kg).

Table 4: International Comparison of per Capita Arisings

		B.B.Bangi		Neyagawa		Cambridge	
		Weight(g)	Vol(ml)	Weight(g)	Vol(ml)	Weight(g)	Vol(ml)
Packaging	Total	103.70	1244	176.62	4252	218.75	3432
	Paper	22.54	267	57.45	1483	52.13	1153
	Plastic	62.20	873	72.17	2335	53.87	1713
	Glass	10.97	26	28.75	64	81.98	196
	Metal	6.78	70	18.11	370	30.36	370
	Others	1.21	8	0.13	0	0.41	2
Food	Total	195.34	359	241.28	369	215.83	500
	General	113.16	175	199.13	274	161.19	342
	Fruit	47.04	104	-	-	-	-
	Unused	35.14	79	31.70	95	50.46	158
Goods		65.84	524	169.16	1105	185.26	817
Disposables		39.59	116	39.62	305	56.19	238
Others		51.28	142	135.30	856	201.97	923
Total		455.75	2385	761.99	6887	878.00	5910

Table 5 and 6 are summary tables in relation to 3R potentials. The main items that reduction efforts by consumers could be applied are "unused food" and "disposable diapers". These percentages at B.B.Bangi are similar to those in highly industrialised countries.

The overall recycling collection rate for B.B.Bangi was calculated as 6.5%. This is less than half the value derived from the JICA (2006) investigation. It is not clear whether this is due to chronological, locational, or methodological differences. In order to evaluate the value of 6.5%, we would need to note that the overall percentage of recyclable item is lower (23%) than in Japan or Europe (30-40%). The recycling rates for individual items are as follows: Newspaper not used for wrapping etc 96%, Total recyclable paper 47%, Metal containers 28%, Clothing 19%, Plastic bottles 10%, Glass 0%.

Tables 5 & 4: 3R Potentials

Minimisation and Recycling potential (by weight%) (B.B.Bangi)

Weight %	Total Waste	Currently Recycled	Additionally Recyclable	Reduce Industry	Reduce Consumer
Paper	20.57%	5.72%	6.44%	6.05%	2.23%
Plastic	15.07%	0.29%	4.05%	13.65%	0.04%
Glass	2.52%	0%	2.27%	2.41%	0%
Metal	2.28%	0.42%	1.66%	1.49%	0.05%
Others	59.56%	0.13%	2.12%	0.26%	^14.32%
Total	100.00%	6.56%	16.54%	23.86%	16.64%

^unused food 7.71%, diaper 6.33%

Minimisation and Recycling potential (by volume%) (B.B.Bangi)

Volume %	Total Waste	Currently Recycled	Additionally Recyclable	Reduce Industry	Reduce Consumer
Paper	33.11%	13.41%	11.78%	12.04%	1.61%
Plastic	38.44%	1.17%	13.93%	36.62%	0.19%
Glass	1.17%	0%	1.05%	1.09%	0%
Metal	3.72%	0.86%	2.54%	2.92%	0.01%
Others	23.56%	0.12%	1.79%	0.36%	^6.53%
Total	100.00%	15.56%	31.66%	53.03%	8.34%

^unused food 3.32%, diaper 2.98%

3. Conclusion

3.1 Summary

The findings from this project could be summarised as follows:

Waste arisings - It was indicated that the less person per house, the more waste per person. Should Malaysia follow the paths of highly industrialised countries in terms of proliferation of "nuclear" families and single person households, the results imply that the amount of waste would increase, even with other factors remaining the same.

There was a large difference between housing types in terms of arisings and composition. Further studies would be useful to identify whether it is due to income differences or other factors. This also applies to the relationship between education levels, meal habits etc. The population of Bandar Baru Bangi is growing each year, while the development of new residential areas is now focusing on middle and higher income groups. This scenario in the future will most probably affect waste generation and recycling activities.

3R Potentials - Reduce: Unused food (7.7%) and disposable diapers (6.3%) were the largest items that could be reduced by consumers. Packaging (22.8%wt 52.2%vol) provides a big reduction potential for companies, although the percentages are lower than that in Europe or Japan. Results indicated that it would be most effective to address plastic packaging added at the retail stage.

Reuse: From the questionnaire survey we could identify that some reuse activities do take place (eg, handing clothing items to charity organisation). This type of activities may not have been fully captured in this project. There are other types of reuse such as using refillable bottles. This would eliminate 3.0%wt 11.7%vol of waste, but refillable bottles hardly exist in Malaysia, and are also becoming less popular in the EU or Japan.

Recycle: Collection of old newspaper is operating well, and could be left to market forces at the moment. For other paper and metals, recycling is taking place, but a little more awareness and effort would be useful. For plastics, it appears that the costs (including wages of workers involved in the recycling chain, as well as opportunity costs for storage space at houses) have started to exceed the economic value. Plastics are fetching strong prices at end users, i.e., demand is present (Seah, 2010). Efficiency improvement in the collection and sorting system (e.g. schemes such as deposit-return), and/or some mechanism to internalise the external economy (avoided disposal costs and environmental impacts) is desired. Although glass is an environmentally high performance material (could be reused or recycled easily), the usage of glass containers in Malaysia is low, and there is hardly a market for recovered glass. Promotion of glass recycling would not be an easy task.

3.2 What could be done to improve the results

Improvement in the reliability of numbers is appreciated both from an academic viewpoint (e.g. identifying the relationship between affluence and waste), and also from the policy-making perspective.

The sorting and measuring procedure appears to have produced reliable results. A supporting evidence is that the total weight after sorting was always around 95% of the initial total weight (5% loss in weight is natural, as moisture evaporates during sorting). There is a minor issue with moisture content, as mentioned above, plastic packaging waste in Malaysia appears to have a higher moisture content than in Europe or Japan. This factor may need to be considered when conducting comparative analyses. For some rare occurring items in waste, there is an issue with the sampling size. For example, if we were to assess the amount of hazardous items in household waste, we would suggest collecting a much larger sample and just look through the waste for the items in question. We have found some batteries, fluorescent tubes, pesticide canisters, etc. in this study, but the amount was rather small to be statistically robust.

More doubts can be raised regarding the total amount of waste. For bungalows and terraced housing, the results turned out that the amount of waste for 3 days over the weekend is similar to that for 2 days on weekdays. This suggests that Sat/Sun generation of waste is 1/2 of a weekday, which is slightly dubious. For the flats, sampling was done in units of chutes, each chute was shared by 10 to 20 households. It was rather difficult to estimate the occupancy rate. We cannot apply the response rate from the questionnaire survey, as it does not differentiate units that were unoccupied and those that were occupied but happened to have no one present when the students knocked on the door. In the number crunching process, the "occupied, but no one happened to be at home" rate from bungalows and terraced housing was utilised in the estimation of occupancy of flats, generating a figure of 76%. By observation of the buildings from outside, 70-75% of units had signs of being occupied (have clothes hanging etc) so 76% should not be a far-fetched figure, but if possible, a more accurate

figure is desired. Another issue with flats is that the waste is supposedly collected daily. Under such circumstance, the collection time of the sample waste matters. The usual collection time seemed to be around 11am, while our sampling was around 7am. We could have collected only 21 hours arisings of waste instead of full 24 hours. Repeated door-to-door weighing of waste for consecutive days would produce more accurate figures. There is also possibility to use the weighbridge figures and locational data (this could be gathered by attaching a GPS device to the vehicle) of regular rounds of each collection vehicle.

The amount recycled is only based on questionnaire survey, and a triangulation with data from collectors (monitor collectors activities in the sampling area) would enhance the reliability of the figures. As for socio-economic factors, the items asked in the questionnaire in this project are limited, and probably the census block results from the 2010 census could be used for further analyses.

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