

2010

# Measuring bulky waste arisings in Hong Kong

Shan-shan CHUNG

*Hong Kong Baptist University, sschung@hkbu.edu.hk*

Winifred, Ka-Yan LAU

Chan ZHANG

This document is the authors' final version of the published article.

Link to published article: <http://dx.doi.org/10.1016/j.wasman.2010.01.009>

---

## Citation

CHUNG, Shan-shan, Winifred, Ka-Yan LAU, and Chan ZHANG. "Measuring bulky waste arisings in Hong Kong." *Waste Management* (2010).

This Journal Article is brought to you for free and open access by the Department of Biology at HKBU Institutional Repository. It has been accepted for inclusion in Department of Biology Journal Articles by an authorized administrator of HKBU Institutional Repository. For more information, please contact [repository@hkbu.edu.hk](mailto:repository@hkbu.edu.hk).

# Measuring bulky waste arisings in Hong Kong

Shan-shan CHUNG\*, Winifred, Ka-Yan LAU, Chan ZHANG

Croucher Institute for Environmental Sciences, Department of Biology, Hong Kong Baptist University,  
Kowloon Tong, Hong Kong.

\*Tel: (852) 34117741; Fax: (852) 34117743; e-mail: [sschung@hkbu.edu.hk](mailto:sschung@hkbu.edu.hk)

## Abstract

All too often, waste authorities either assume that they know enough about their bulky waste stream or that it is too insignificant to deserve attention. In this paper, we use Hong Kong as an example to illustrate that official bulky waste figures can actually be very different from the reality and therefore important waste management decisions made based on such statistics may be wrong too. This study is also the first attempt in Hong Kong to outline the composition of bulky waste.

It was found that about 342 tonnes/day of wood waste were omitted by official statistics owing to incomplete records on actual bulky waste flow. This is more than enough to provide all the feedstock needed for one regular-sized wood waste recycling facility in Hong Kong. In addition, the proportion of bulky waste in the municipal solid waste (MSW) streams in Hong Kong should be about 6.1% instead of the officially stated 1.43%. Admittedly, there are limitations with this study. Yet, present findings are suggestive of significant MSW data distortion in Hong Kong.

**Key words:** waste composition, bulky waste, municipal solid waste, bulky waste data, Hong Kong

## **1. Introduction**

Bulky waste describes those solid waste materials having a large physical dimension. The US Environmental Protection Agency (2006) defined bulky waste as large items of waste materials, such as appliances, furniture, large auto parts, trees, stumps, and in addition wooden pallets and waste tires might also be classified as bulky waste. England's Controlled Waste Regulations 1992 set out two criteria for bulky waste: exceeded 25 kg in weight and had a dimension larger than 0.75m × 1m (Curran et al., 2007). Other than these specific definitions, bulky waste was also described in more pragmatic ways. In communities where a refuse chute was commonly used, a separate collection system for over-sized waste was likely to exist as over-sized waste could cause blockage in the chutes. As a result, these over-sized waste matters might then be described as bulky waste. Another pragmatic definition for bulky waste was that it was any large item that was brought along when a resident moves house (Curran et al., 2006). This was the definition of bulky waste deployed by councils in England (Curran et al., 2006). The Seattle government in the US defined bulky waste as overflow municipal solid waste (MSW) materials set out for disposal in addition to those in a customer's regular can, cart or detachable collection service and might include items such as cartons, boxes, and crates. (Seattle Public Utilities, personal communication on 27<sup>th</sup> January 2009). Striving to provide the world's largest and most reliable sources of comparable statistics, the Organisation for Economic Co-operation and Development (OECD) however did not standardize the definition on bulky waste and neither did it collect bulky waste data from member countries (OECD, personal communication with H. Harjula on 5<sup>th</sup> October 2009). While acknowledging that bulky waste was included in the MSW streams of member states, OECD simply let member countries define it in any way they like (Environmental Performance and Information Division, 2008). In Hong Kong, owing to the wide-spread use of compactor refuse collection vehicles (RCVs), bulky waste was defined in Hong Kong as items which could not be handled by conventional compactor type refuse collection vehicles (Environmental Protection Department, 2008). Other working definitions of bulky waste included whether it could be lifted by two men or whether it could be fitted into the wheeled bin (Curran et al., 2006). Despite the mentioned specific and pragmatic understandings on bulky waste, it was still a nebulous term strongly

influenced by local practice. Thus, many waste management authorities (e.g., Singapore and Seattle) and professionals did not bother to specify the minimum dimension of bulky waste when they deployed the term (see for instance, Sekito et al., 2003; Environmental Protection Department 2008; Burnley et al., 2007). Rather, they understood the term based on common sense. For instance, the Singaporean National Environment Agency defined bulky waste as items such as construction debris, tree trunks, discarded furniture, wooden pallets and appliances such as washing machines and refrigerators (National Environment Agency, personal communication on 18<sup>th</sup> May 2009).

### **Review of available data on bulky waste arisings**

Bulky waste was often picked up and handled separately from non-bulky solid waste. Thus, theoretically, it should be easy to keep separate records for bulky waste arisings. Yet, a review on waste management literature showed that the quantities and composition of bulky waste were infrequently discussed and rarely studied with perhaps the exception of electrical and electronic waste which was traditionally classified under bulky waste but now considered a separate category on its own. One bulky waste study was conducted by Sekito et al. (2003) and they found that wood and metals were the two major materials in the bulky waste stream in Japan, followed by plastics. While agreeing that wood was the major material in the bulky waste stream of Hokkaido in Japan, Hwang et al. (2007) found that the second major material constituent was plastics rather than metal. Along side surveying a number of management issues on bulky waste disposal in England, Curran et al. (2007) estimated that, measured by weight, about 27% of bulky waste in England was furniture, about 28% was electrical appliances and the remaining represented miscellaneous items such as bicycle, kitchen units and construction waste. Thus, based on available data, wood was the most commonly found material in the bulky waste stream of these developed world cities and one of the major sources of wood waste in bulky waste was furniture. However, before this study, Hong Kong has not conducted any analysis on the composition of bulky waste. Therefore, one of the objectives of this study is to broadly determine the material composition of bulky waste in Hong Kong.

The proportions of bulky waste relative to total or the respective MSW streams for selected municipalities or countries are stated in Table 1. While some waste regimes were able to specify how much they were disposing, many others simply ignored bulky waste. For instance, personal communications with the waste authorities in Beijing and Singapore confirmed that the disposal or generation data for bulky waste in these two places were not available not to mention its composition (J. Deng, personal communication on 19<sup>th</sup> May 2009; Waste Management Department, personal communication on 24<sup>th</sup> January 2009).

Based on the data in Table 1, US had the highest proportion of bulky waste in the MSW stream. Yet, durable good figures of the US were derived from the materials flow approach and average appliance lifetimes were used in the computation of such figures. While there was a lack of actual bulky waste data for the nation as a whole, direct measurement on the number of bulky waste generated and discarded should be obtainable from individual cities. Yet, even the city of Seattle, touted as one of the two cleanest cities in the US, has imposed explicit charges on bulky item collections and offered rebates on the return of working old fridges and freezers, has not kept good records of the bulky waste arisings and composition in the city (Seattle Government, personal communication on 24<sup>th</sup> January 2009). Although it appears that the waste authorities mentioned in Table 1 “know” to a varying extent how much bulky waste they have, is their understanding correct? If not, what implications are there? In this paper, the situations in Hong Kong will be used as an example to illustrate the extent of discrepancy between the knowledge of the waste management and the reality. At the end of the paper, perceived problems from having an inaccurate estimate of bulky waste for a waste management regime will be discussed.

	Year	Quantity		Remarks
		% or number	Tonnes per year	
England	2003/4	<5% of the household waste arisings in England.	<1.2 million	Includes also street sweeping.
	2007	7.2% of the disposed household waste	n.a.	Include also special "one-off" municipal waste collections, garden bonfires and feeding food scrap to birds and other animals.
Ireland	2007	0.46% of MSW	15,507	MSW includes household, commercial and non-process industrial waste. Figures exclude WEEE and include only bulky waste at civic amenity sites only.
Wales	2001-2	5% of MSW	80,900	Includes carpet and underlay, furniture, white goods, large electronic goods, TVs, monitors and other waste electrical and electronic equipment only.
Sweden	1998	13.7% of all solid waste	1.053 million	Bulky waste in the household waste stream only
USA	2007	17.9% of MSW generated	41.2 million	Figures obtained by the materials flow methodology and represent durable good waste.
Seattle	2008	1700 bulky items and white goods	n.a.	The service area includes about 150,000 household customers and 6000 apartment buildings.
Seoul	2005	2.7 % of total domestic waste generated	113,461	Removal of bulky waste is charged at variable rates
Hachioji, Japan	2006	1.1% of total domestic waste generated	1920	Since TVs, refrigerators, washing machines and air-conditioners are subject to mandatory recycling, the bulky waste figures and collection arrangement does not include these 4 types of appliances.
Taipei	2006	0.9% of municipal solid waste generated	8955	Municipal solid waste here refers mainly to household waste plus waste from commercial sources with less than 30 litres per day of disposal.
Hong Kong	2007	0.66% of domestic waste disposed	15,330	Bulky waste delivered directly to landfills only.

Table 1. Bulky waste arisings in selected areas.

(Sources: Department for Environment, Food & Rural Affairs, 2005; Jones et al., 2008; South Korean Resource Circulation Division, personal communication on 25th March 2008; Environmental Protection Administration, 2007, EPD, 2008; Burnley et al, 2007; Björklund and Finnveden, 2007; Seattle Government, personal communication on 27<sup>th</sup> January 2009; Office of Solid Waste, 2008; Environmental Protection Agency, 2009)

### **The status of bulky waste in solid waste streams**

An unwelcoming fact is that the face values of bulky waste arisings from official sources (as reported in Table 1) may not be correct. First, the central waste agency usually relies on data provided by their local waste agencies who may not be in a position to supply the data at the required level of detail to compute aggregate statistics for the country. The Irish bulky waste data shown in National Waste Report 2007 is a case in point: a close scrutiny of Appendix D of the mentioned report revealed that the total of 15,507 tonnes of bulky waste in 2007 in fact was an aggregated non-electrical and electronic waste (non-WEEE) bulky waste figure from 11 local authorities only. Twenty-three other Irish local authorities reported nil non-WEEE bulky waste collected in their civic amenity sites for the whole year in 2007. However, it is certainly in contravention with common sense that a whole community generates no non-WEEE bulky waste in any single year. The only reasonable conclusion is that the source data were incomplete. However, readers of this report were not provided with any assessment on the extent of such underestimation. Yet, if waste officials or any users of the data take at face value of such figures seriously and therefore conclude that bulky waste is an insignificant proportion of the MSW stream (such as the cases of Hong Kong, Taipei and Ireland as shown in Table 1) and therefore there is not enough justification to invest resources to develop methodologies to more accurately estimate the arisings of bulky waste, then the truth will never be known. Thus, it is not hard to explain why bulky waste remains a neglected area in solid waste management research and study. Burnley (2007) commented that the waste collected by UK's civic amenity sites (usually containing a significant proportion of bulky waste) were inadequately surveyed or analyzed and therefore existing waste data and survey findings might not correctly reflect the true waste picture of the community concerned. This comment should warn waste management professionals against the possibility of unfounded complacency.

### **The flow and data computation for MSW and bulky waste in Hong Kong**

To fully understand the significance of this study, one must first understand the flow of MSW and bulky waste as well as the methodology used to compute such data. Bulky waste is included in the MSW stream in Hong Kong. Domestic bulky waste is

collected free of charge by the municipal cleaning team while bulky waste from the commercial and industrial waste streams is collected at the expense of the waste generators. While exceptions do exist, bulky waste is separately collected from non-bulky MSW and it is usually picked up by open-top vehicles such as non-compaction open flat-bed vehicles and uncovered caged vehicles or sometimes also by covered, box-type vehicles in Hong Kong. Standard compactor RCVs are seldom, if at all, used to carry large amount of bulky waste as the latter would damage the mechanical parts of the RCVs.

Annual statistics for the amount of MSW and bulky waste disposed in Hong Kong is published in “Monitoring of Solid Waste in Hong Kong” which is accessible to the public on the Internet. The weight figures for MSW are obtained from compiling records from weighbridges in landfills and major RTSs in Hong Kong. Figure 1 shows the composition of MSW in Hong Kong from 1989-2007. Evident from Figure 1, bulky waste is considered a standalone item in the MSW stream. Communication with the Environmental Protection Department (EPD) of Hong Kong confirmed that it has not conducted any analysis on the material composition of bulky waste.

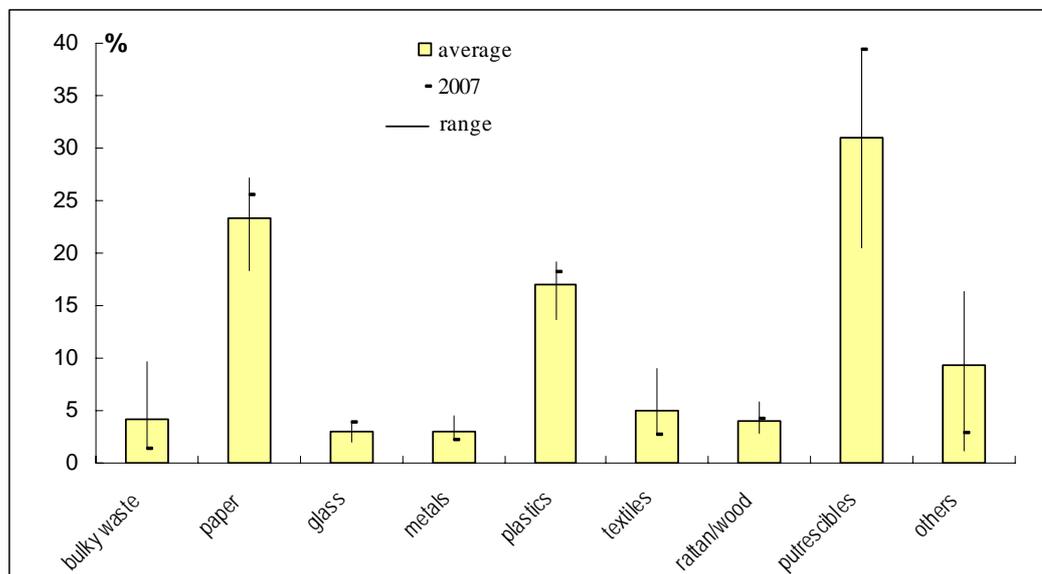


Figure 1. MSW composition of Hong Kong (1989-2007) (Sources: EPD, 1992-2008)

In Hong Kong, all MSW (including bulky waste) is disposed in either one of the three landfills either directly or indirectly through a network of refuse transfer stations

(RTSs). Figure 2 depicts the material flow of bulky and non-bulky MSW in Hong Kong based on the 2007 official figures released prior to this study. The pre-study official figure showed that about 1.43% [or 135 tonnes per day (tpd)] of MSW was bulky waste (see also Figure 1). During a pilot observation conducted by the authors in three urban RTSs in Hong Kong, it was discovered that even in a typical situation as described by RTSs’ staff, a significant proportion of MSW disposed Hong Kong was bulky waste. It led the research team to hypothesize that there might be more than 135 tpd of bulky waste in the MSW stream of Hong Kong. This prompted us to conduct this research. At the same time, an enquiry was made at EPD on the data computation method of bulky MSW. The response was that the amount of bulky waste reported in the official statistics actually referred *only* to bulky waste disposed directly in landfills (see Figure 3). Concurrently, the original version of the 2007 “Monitoring of Solid Waste in Hong Kong” was replaced by the current version (see EPD, 2008) and the original version was no longer made available to the public. It was then evident that all MSW received in RTSs in Hong Kong (ie., waste flow A in Figure 3) is recorded as non-bulky MSW by the waste authority of Hong Kong regardless of its true nature. Waste flow A will be mixed with non-bulky MSW in the RTSs and become waste flow B (Figure 3) once arrived at landfills. Therefore, any bulky waste, even if present will not be distinguishable and will not be labeled or recorded as such.

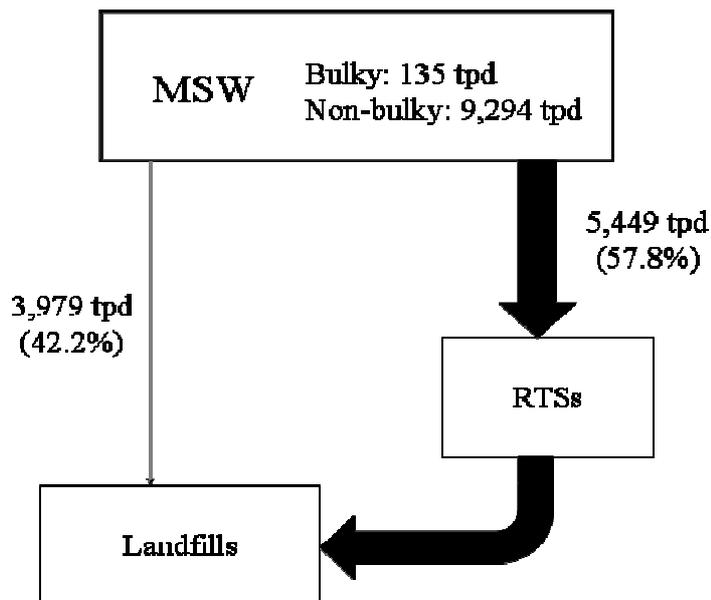


Figure 2. Material flow for bulky and non-bulky MSW of Hong Kong (based on 2007 pre-study official figures).

The extent of data distortion may not be significant if there is negligible proportion of bulky waste disposed of in RTSs. In this study, however, we would like to show that bulky waste was a lot more voluminous than it was previously assumed in Hong Kong. In a way, we are also following up Burnley et al.'s (2007) insight and make use of the data from the first-ever systematic survey on bulky waste in Hong Kong to illustrate the adversities of not seriously studying bulky waste arising and disposal. Given that bulky waste has a very different physical composition from the rest of the MSW and that a significant amount of bulky waste was ignored, the official MSW arising and composition data in Hong Kong should be deployed with care. If the misleading figures are taken as the reliable and correct estimates and used by public agencies and academic communities for important decision making, the consequence can be profound.

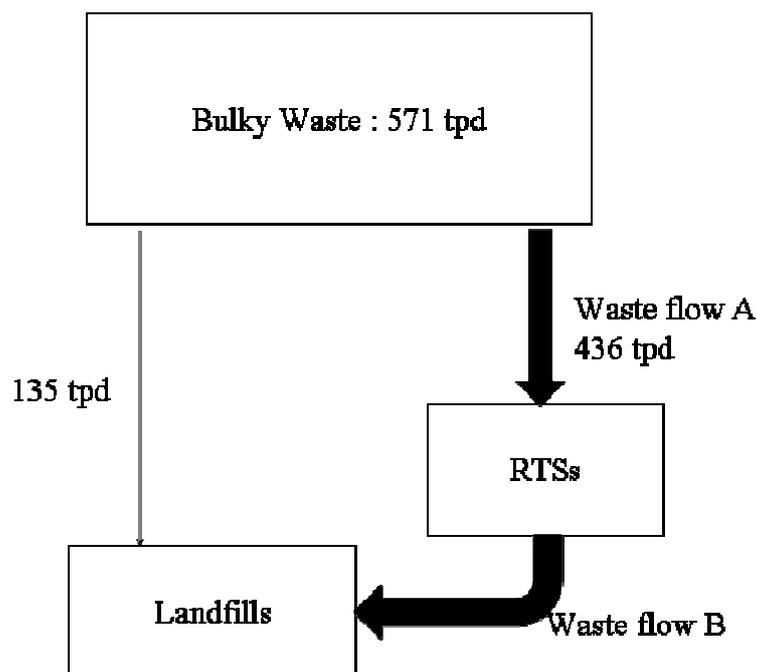


Figure 3. Bulky waste flow in Hong Kong substantiated with findings from the present study.

## Methodology

### *Sampling sites*

There are 13 active RTSs in Hong Kong. Their throughputs in 2007 are stated in Table 2. In this study, the missing bulky waste data were obtained by conducting systematic manual observation in the six urban RTSs in Hong Kong (Facilities 1 to 6, Table 2). Based on 2007 data, the aggregated throughput of these six facilities represented 98.4% of the municipal total. Thus, notwithstanding the limitations that will be discussed in the last part of this paper, we consider the coverage of this research adequate.

	Public MSW (tpd)	Private MSW (tpd)	Total (tpd)
1. Island East Transfer Station (IETS)	739	95	834
2. Shatin Transfer Station (STTS)	942	0	942
3. Island West Transfer Station (IWTS)	431	69	500
4. West Kowloon Transfer Station (WKTS)	1857	221	2078
5. North Lantau Transfer Station (NLTS)	61	104	164
6. North West New Territories Refuse Transfer Station (NWNTRTS)	808	39	847
7. Seven Outlying Islands Transfer Facilities (OITFs)	78	6	84
Sub-Total	4916	534	5449 (57.8%)
8. MSW disposed of directly at landfills (including bulky waste)		3,979 (42.2%)	

Table 2. Daily throughputs of all RTSs and landfills in Hong Kong in 2007. (tpd – tonnes per day; Environmental Protection Department, 2008)

Two rounds of observations were conducted in Facilities 1 - 6. Each round of observation consisted of concurrently watching the disposal of bulky waste in these 6 RTSs for seven continuous days. The first round of surveys was conducted from 13th to 19th August, 2008 and the second round from 3<sup>rd</sup> to 9<sup>th</sup> January, 2009. The duration of

our observation in the RTSs were constrained by the waste authority's decision (see last column of Table 3). In all cases, we were not allowed to observe the whole period of operation for all RTSs studied. Upon discussion with the control room staff in the 6 RTSs, we learnt that the un-observed hours were the low-use periods of the RTSs and only small amounts of bulky waste were disposed during those periods. Thus, it is not likely that the presence of non-observing hours will present a significant source of error for this study. Yet, since we are not able to observe the full hours of operations of the RTSs, findings from this study only indicate the best estimated minimum for bulky waste arisings in Hong Kong.

RTS	Opening hour of RTS	Observation hours of this study
IETS	7:30am-11:30pm	8:30am -8:00pm (Mon-Fri) 9:00am -7:30pm(Sat, Sun and Public Holidays)
IWTS	7:30am-11:30pm	8:30am -7:30pm (Mon-Fri) 8:30am -7:00pm (Sat, Sun and Public Holidays)
STTS	7:00 am-11:00pm	8:00am-7:30pm
NLTS	7:00am-11:00pm	8:30am -8:00pm (Mon-Fri) 8:30am -7:00pm (Sat, Sun and Public Holidays)
WKTS	4:30am-11:30pm	8:00am-8:30pm
NWNTRTS	7:30am-7:00pm	8:30am -6:00pm

Table 3. Operation hours and observation duration in RTSs.

#### *Data acquisition and method*

Observations were conducted by the authors and surveyors who were recruited and trained with the observation technique and procedures, waste management jargons, and how to take field records prior to the field observation. It was possible to estimate the content of bulky waste in RTSs in Hong Kong through manual observation from a distance of less than 7 meters (the best case) or between 15-20 meters (in 5 RTSs) because bulky waste was mostly collected by open-top vehicles with the content directly visible and identifiable especially during the tipping process. If non-bulky MSW was also found in open-top refuse collection vehicles, its proportion was visually determined and discounted from the calculation. Bulky waste may also be hauled to RTSs in non-

compacted box type vehicles. If this is the case, the discharge phase of these vehicles will be closely watched. Visual equipment, either a pair of binoculars or an electronic video camera were provided to help observers to see more clearly in the RTSs, in addition to viewing the waste tipping process of the trucks through the RTSs' CCTV systems. As a result, our observation focused only on all non-compaction RCVs, with most of them being open-top RCVs and ignored the bulky waste in standard RCVs. Despite it is our belief that we covered the overwhelming majority of bulky waste disposed of at the six urban RTSs, we admitted that some bulky waste disposed of in RTSs was not covered in this study. Thus, the amount estimated from this study should be considered a conservative figure.

In order to save human power, in the first round of observation, video recorders were set up in two RTSs (namely, STTS and NWNTRS, the only two RTSs judged suitable for video-recording) to video taped bulky waste tipping process. Unfortunately, owing to the viewing angle, not all the key attributes, in particular the registration number of the bulky waste vehicles, could be recorded in the video clips. In addition, instrument failure occurred on 16th August, 2008 (Saturday) causing loss of data from 10:18am to 7:30pm for STTS of that day. Learning from previous mistakes, all observations in the second round were conducted by direct observation and no video-recording was used. As a result, the number of missing data in the second round of observation was greatly reduced (see **Results and Discussion**).

The following data of each bulky waste containing vehicle were recorded by the surveyors as far as possible: the car registration number, the tipping time, the ownership of the vehicle (government or private), the major type of bulky waste disposed (classified into landscape waste, furniture, wooden pallets, wooden board, e-waste, and others) and the (visually) estimated percentage of non-bulky waste (if any). The car registration number and the tipping time were to be provided to the waste authority of Hong Kong for obtaining the net weight of bulky waste disposed of in the RTSs by the relevant vehicles.

### **Computation rules**

The number of bulky waste truckloads observed and their major constituents are given in Table 4. The following computation rules were used to work out the estimated

quantities (3<sup>rd</sup> and 5<sup>th</sup> columns of Table 4) of the four major types of bulky waste observed:

- i) If the bulky waste load was dominated by only one major bulky waste constituent, it was assumed that 80% of the weight of the whole truckload belongs to that material; for the remaining 20% of the weight, it would be counted as other bulky wastes.
- ii) If the bulky waste load was dominated by 2 to 4 types of major bulky waste constituents, it was assumed that all constituents take an equal share of the bulky waste disposed for that truckload. Thus, if a 3-tonne truckload of bulky waste was seen to contain landscape waste and wooden pallets and furniture, it was assumed that there was one tonne of landscape waste, one tonne of wooden pallets and one tonne of furniture waste in the load. Expanded polystyrene (EPS) waste even if found to be mixed in substantial proportion in a bulky waste truckload would be ignored. This is because the density of EPS waste is very low and based on our findings, its share in all bulky waste is negligible. For instances, in some of our records, a full load of EPS waste weighed 0.1 tonne or even less.

It is acknowledged that these computation rules do not necessarily reflect the truth. Yet, computation rules as such are indispensable to obtain useful estimates owing to the lack of other practicable means to directly measure and analyze large number bulky waste loads in this context.

	First round		Second round	
	Truckloads <sup>a</sup>	Weight (tonnes)	Truckloads <sup>a</sup>	Weight (tonnes)
Total observed (a)	1986	4521	1949	4788
Main waste in the load:				
- Landscape waste (b)	334	394.5 (8.7%)	374	323.15 (6.7%)
- Wooden Board (c)	777	670.4 (14.8%)	739	655.47 (13.7%)
- Wooden Pallet (d)	952	948.2 (21.0%)	857	735.53 (15.4%)
- Furniture (e)	525	470.5 (10.4%)	641	594.55 (12.4%)
- Other bulky wastes (including over-sized expanded polystyrene, plastics, cardboards, ceramics, glass etc.) (f)	70	676.8 (15.0%)	54	641.2 (13.4%)
- Non-bulky MSW (g)	890	1360.6 (30.1%)	908	1838.3 (38.4%)
Bulky waste wrongly classified as non-bulky MSW (tonnes/day)		452		439
Waste covered in this study (expressed as a % of total MSW received by the 6 RTSS)		11.8%		12.7%

Table 4. Bulky waste disposed of in the 6 RTSSs in Hong Kong.

(Keys: (a) = (b)+(c)+(d)+(e)+(f)+(g) for the tonnage of waste materials. <sup>a</sup> Since some truckloads were dominated by more than one bulky waste component mentioned, the aggregate of the breakdown will exceed the total number of truckloads observed.)

## Results and Discussion

In the first and second rounds, we observed a total of 1,986 and 1,949 truckloads of bulky waste vehicles in the six RTSSs respectively. However, for some 29% of the truckload in the first round and 8.8% in the second round, the exact amount of bulky waste tipped (in tonnes) in the RTS was not known owing to one of the following reasons:

- i) Inability to record their car registration numbers (due to blocking of views, insufficient lighting, insufficient time to take record etc.) and therefore, the waste

- authority in Hong Kong was not able to provide the weight of the waste tipped from those vehicles to us; or
- ii) The car registration numbers were recorded and forwarded to the waste authority in Hong Kong but there were mismatches between the surveying teams' and EPD's records regarding the periods these vehicles were present in the RTSs.

In either case, they were classified as missing data. In this study, we deployed a commonly used imputation method to replace missing data with the mean values of the data series (namely, 2.28 tonnes in the first round and 2.46 tonnes in the second round). It was also discovered in the observation that for the first and second round of survey, about 890 and 908 loads of open-top trucks contained both bulky and non-bulky form of MSW at varying degree respectively. Based on visually determined field records, it has been estimated that in the first round, non-bulky MSW in the 890 truckloads of waste amounted to about 1,360.6 tonnes, accounting for about 30% of all the waste observed to be disposed together with bulky waste in the six RTSs during the period. The data for second round observation is shown in Table 4. We however did not record the very small proportion of bulky waste found in standard compactor type RCVs.

In addition, the estimates on the quantities of major bulky waste constituents in Table 4 represent situations where the contents of the bulky waste can be identified. However, it is not always easy to identify the contents of bulky waste at a distance particularly in the rather dim environment inside RTSs. The surveyors were instructed to record only those cases with high certainty. Thus, the quantities estimated in Table 4 for the four major bulky waste types are the most conservative (the minimum) estimates. It is likely that there are actually more wooden board, wooden pallet, furniture and landscape waste in the disposed bulky waste stream in Hong Kong than what is indicated here. Even with these uncertainties in mind, it is evident from Table 4 that about 45-55% of the bulky waste tipped in the RTSs in Hong Kong is actually wood-based materials. This is translated into about 342.3 tpd of wood-based waste on average in Hong Kong for 2008-9 and they represent wood waste off the official waste statistics. In addition, it is estimated that about 436.4 tpd of bulky waste are wrongly classified as non-bulky MSW in Hong Kong and they are all first disposed of in RTSs (i.e., waste flow A in Figure 3). Thus, total bulky waste in Hong Kong should amount to about 571 tpd, nearly 320%

more than the official figure. Figure 3 is a schematic diagram for the material flow of bulky waste based on 2007 waste figures and the extra data obtained from this study. Based on the 2007 MSW data published by the waste authority of Hong Kong, a more accurate estimate on the proportion of wood waste in the MSW stream should be 7.7% instead of 4.1% as estimated by the waste authority.

### **Limitation of the Study**

Being the first-ever systematic empirical study on bulky waste in Hong Kong and constrained by financial resources as well as the conditions set out by the waste authority, this study has several limitations.

First, while we did use the weight of each truckload of bulky waste to do the calculation, we were not able to directly measure the specific amount of non-bulky waste that was in the waste loads. Visual estimation was the only available method and admittedly it was no more than an approximation. Second, we were not able to study bulky waste disposed in landfills and the outlying RTSs in Hong Kong owing to the lack of human resources and the inability to get approval from the waste authority to conduct such survey on landfills in Hong Kong at the time of writing. We were also not able to study or record the part of bulky waste disposed in standard compactor type RCVs owing to the difficulties in seeing the waste during its discharge from a fully enclosed compactor type RCV. In addition, due to instrument failure, the majority of the bulky waste disposed in STTS on 16<sup>th</sup> August was excluded. As a result, the amount of bulky waste that goes unnoticed in Hong Kong's waste statistics should be more than what is mentioned in this paper. Yet, we do not know the size of this gap. Third, we were not able to verify how valid the two computation rules were. While our original research plan was to directly sort and measure bulky waste disposed at RTSs in Hong Kong, this suggested approach was turned down by EPD for fear that our research would cause disruption to the operation of the busy RTSs. Thus, we could only make observation at a distance to get the data and as a result, computation rules must be used to derive the composition of bulky waste.

Given all the constraints mentioned and in order to render the interpretation of our data consistent and intelligible, we have adopted a conservative approach, ie., we deploy

rules and assumptions that will make our estimates smaller than the actual amount of the waste type in question. As a result, computation rule i) was adopted. In summary, we have done whatever we can to enable meaningful interpretation of our data despite the limitations.

## **Conclusion**

Evident from this study, the official data of 1.43% of MSW being bulky waste for Hong Kong is a serious underestimation of bulky waste arisings in Hong Kong. A closer-to-the-truth figure should be 6.1% (or 571 tpd) of all MSW disposed in Hong Kong based on 2007 MSW statistics. However, for years, the official waste statistics have misled the public to believe that the proportion of bulky waste is but an insignificant quantity. Not until very recently did the waste authority of Hong Kong clarify that the official bulky waste figures did not include bulky waste disposed in RTSs which was unfortunately the main disposal points of bulky waste in Hong Kong. Furthermore, within the underestimated 436.4 tonnes of bulky waste disposed in RTSs in Hong Kong per day, some 342.3 tonnes (over 78%) are wood-based materials. As a result, the official estimate of 4.1% of wood component in MSW in 2007 (EPD, 2008) was another obvious underestimation. Should the 342.3 tpd of wood-based materials be included, the percentage of wood in MSW should be 7.7% (using 2007 MSW statistics), almost double of what has been estimated. To understand the scale of underestimation, it suffices to point out that owing to the space and transport constraints in Hong Kong, the designed capacity of a recycling plant that suits Hong Kong will be somewhere between 200-300 tpd. In other words, the noted omission alone sufficiently disqualify a wood waste recycling plant from planning consideration because according to official statistics, there were only 384 tonnes of wood and rattan waste available from the MSW stream in 2007 regardless of their recovery potential (EPD, 2008).

The fact that many waste management regimes do not maintain records of bulky waste arisings and composition is an indication that they may have overlooked a waste stream with a high proportion of good quality recyclable materials and thus have missed valuable opportunities to reduce and recycle waste. Evident from the present study, unrecorded or mis-recorded bulky waste data can be substantial enough to

invalidate official records of solid waste composition which are often the basis for decision makers and waste management professionals to make waste management facility planning decisions and policies. Users of officially published data should understand that they have the right to know how the data are derived. Assuming that since they are government-published data and therefore must be (reasonably) accurate is too complacent.

Would unreliable official waste data be actually more common than people have thought? Given the lessons learnt from Hong Kong, any responsible waste authority should thoroughly and critically review its data and data collection method to ensure data on which important decisions are to be made are reliable. On the whole, this study has advanced the understanding on the composition and flow of bulky waste in Hong Kong.

### **Acknowledgements**

This research is supported by the Public Policy Research grant (project no. HKBU2001-PPR5-BIOL) and the Marginally-Funded Post-Graduate Fund (on Persistent Toxic Substances) from the Research Grants Council of Hong Kong. Last but not the least, the authors would like to express gratitude to the four anonymous reviewers for their constructive and detailed comments.

## References

- Björklund, A.E. and G. Finnveden, 2007. Life cycle assessment of a national policy proposal – The case of a Swedish waste incineration tax. *Waste Management* 27, 1046-1058.
- Burnley, S.J., 2007. A review of municipal solid waste composition in the United Kingdom. *Waste Management* 27, 1274-1285.
- Burnley, S.J., J.C. Ellis, R. Flowerdew, A.J. Poll, and H. Prosser, 2007. Assessing the composition of municipal solid waste in Wales. *Resources, Conservation and Recycling* 49, 264-283.
- Curran, A., S. Heaven, and I.D. Williams, 2006. An evaluation of Council Bulky waste collection services in England. *CIWM Scientific and Technical Review* 7, issue 1, 12-25.
- Curran, A., I.D. Williams, and S. Heaven, 2007. Management of household bulky waste in England. *Resources, Conservation and Recycling* 51, 78-92.
- Department for Environment, Food and Rural Affairs, 2005. *Municipal Waste Management Survey 2003/04*, London. From DEFRA <<http://www.defra.gov.uk/environment/statistics/wastats/archive/mwb200304.pdf>>.
- Environmental Performance and Information Division, 2008. *OECD Environmental Data: Compendium 2006-2008 – Waste*, Working Group on Environmental Information and Outlooks, Organization for Economic Co-operation and Development, March. <[www.oecd.org/dataoecd/22/58/41878186.pdf](http://www.oecd.org/dataoecd/22/58/41878186.pdf)> (accessed 30 September, 2009).
- Environmental Protection Administration, 2007. *Statistics Database*. <<http://210.69.101.110/WEBSTATIS/webindex.htm>> (in Chinese).
- Environmental Protection Agency, 2006. *Terms of Environment: Glossary, Abbreviations and Acronyms*. <<http://www.epa.gov/OCEPAterms/bterms.html>>.
- Environmental Protection Agency, 2009. *National Waste Report 2007*. Wexford.
- EPD, 1992. *Monitoring of Solid Waste 1989-1990*. Hong Kong: Government Printer.
- EPD, 1993. *Monitoring of Solid Waste 1991-1992*. Hong Kong: Government Printer.
- EPD, 1995. *Monitoring of Solid Waste 1993 and 1994*. Hong Kong: Government Printer.
- EPD, 1996. *Monitoring of Solid Waste in Hong Kong 1995*. Hong Kong: Government Printer.

- EPD, 1997. Monitoring of Solid Waste in Hong Kong 1996. Hong Kong: Government Printer.
- EPD, 1998. Monitoring of Solid Waste in Hong Kong 1997. Hong Kong: Government Printer.
- EPD, 1999. Monitoring of Solid Waste in Hong Kong 1998. Hong Kong: Government Printer.
- EPD, 2000. Monitoring of Solid Waste in Hong Kong 1999. Hong Kong: Government Printer.
- EPD, 2001. Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2000. Hong Kong: Government Printer.
- EPD, 2002. Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2001. Hong Kong: Government Printer.
- EPD, 2003. Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2002. Facilities Planning Group, Hong Kong.
- EPD, 2004. Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2003. Facilities Planning Group, Hong Kong.
- EPD, 2005. Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2004. Waste Reduction Group, Hong Kong.
- EPD, 2006. Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2005. Waste Reduction Group, Hong Kong.
- EPD, 2007. Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2006. Environmental Infrastructure Division, Hong Kong.
- EPD, 2008. Monitoring of Solid Waste in Hong Kong: Waste Statistics for 2007. Environmental Infrastructure Division, Hong Kong.
- Hwang, I.H., T. Matsuto, N. Tanaka, Y. Sasaki, and K. Tanaami, 2007. Characterization of char derived from various types of solid wastes from the standpoint of fuel recovery and pre-treatment before landfilling. *Waste Management* 27, 1155-1166.
- Jones, A., S. Nesaratnam, and A. Porteous, 2008. The Open University Household Waste Study: Key findings from 2007. Milton Keynes, 7<sup>th</sup> February.  
<<http://www.defra.gov.uk/environment/statistics/waste/research/download/ou-rpt-200802.pdf>>.

Office of Solid Waste, 2008. Municipal Solid Waste in the United States: 2007. Facts and Figures. EPA530-R-08-010. U.S. Environmental Protection Agency, November.

Sekito, T., N. Tanaka, and T. Matsuto, 2003. Study on composition and particle characteristics of shredded municipal waste for the improvement of separation efficiency in a municipal bulky waste processing facility. *Waste Management and Research* 21, 299-308.