

A Study of Commercial Solid Waste Generation and Composition in Phnom Penh City, CAMBODIA

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Abstract

This paper presents the findings of a study carried out in Phnom Penh city, Cambodia, on the basis of commercial solid waste. The waste samples were collected from hotels, restaurants, internet cafés, guesthouses, beer gardens, markets, schools, microfinances and shops from 22 July–28 August 2013. The objectives of this research are to determine waste generation rate, physical composition, and the level of recyclables remaining in the residual of waste stream and to evaluate the appropriate technology for waste treatment. The waste from 52 commercial sectors were daily collected and segregated into 23 categories. The results show that composition of commercial waste consist of 56.70% (biodegradable), 19.32% (plastic), 14.84% (paper), 8.14% (inorganics), 1.25% (textiles & shoes), 0.25% (rubber/leather), and 0.01% (wax). Waste generation rate (kg/cap/day) is 1.31 (internet cafés), 1.04 (restaurants), 0.84 (beer gardens), 0.51 (guesthouses), 0.33 (hotels), 0.23 (markets-family marts), 0.19 (ministries), 0.13 (council of ministers) and 0.11 (stores-phone, grocery and small cloth shops). In addition, schools and microfinance agencies produce waste less than 0.1. The most sorted wastes by those sectors are food waste, followed by glass bottle, paper, PET bottle, aluminium can and steels. The most recyclable remaining in unsorted waste is plastic, followed by paper, steels and aluminium can. Finally, treatment options for organic waste from commercial sectors in Phnom Penh were discussed.

Keywords: Commercial solid waste; Recyclables; Composition; Waste Generation Rate, Phnom Penh

1. Introduction

Increasing amount of municipal solid waste is one of the challenging issues in the developing countries, particularly in the fast growing cities and towns (Jin et al., 2006). Cambodia is one of the developing countries in Asia. Phnom Penh, the capital of Cambodia, keeps growing with its population, urbanization and changing lifestyle, and increasing waste each day. According to JICA's experts, the city's population will increase to 1.7 million by 2015, and at the end of 2020, the amount of municipal waste is expected to reach 353,906 tons. That is an awful lot of garbage, which even the new landfill, Dang Kor landfill, will be struggling to handle. This landfill is only the sanitary one started operating in 2009 while the old dumping site, Steung Mean Chey (SMC), was completely closed. However, Dang Kor landfill is located about 15 km from the city center which is much further than SMC which is about only 5 km from the center (from Wat Phnom).

The total amount of Municipal Solid Waste (MSW) of Phnom Penh is generated from households which is the largest (65.6%) and secondly from commercial sector (~25%). All kinds of collected wastes are disposed of at dumping site or landfill without separation or any pre-treatment. Collection efficiency is still unsatisfactory resulted in piles of wastes and scattered waste existing in the city (mostly in peri-urban). Illegal dumping and uncollected waste remain a major problem which leads to many social problems such as damage to urban infrastructures including drainage blockages and flooded roads.

The annual generation of waste increased from 0.136 million tons in 1995 to 0.36 million tons in 2008 and this value will soar 0.635 million tons in 2015 (JICA, 2005). The data received directly from landfill indicated that amount of waste is gradually increasing from 1,027 tons per day in 2009 to 1,381 tons per day in 2013. About 60% of waste generated was collected in Phnom Penh city in 2003 and 82.1% in 2009 with a generation rate of 13% (JICA, 2005) which expressed that collection efficiency, somehow, has been improved.

The study of commercial solid waste (CSW) has not broadly studied and the information is rare, even a study by JICA in 2005 slightly reported it. Therefore, the study of generation and composition of commercial waste is also important because it is the second largest portion of the waste after household waste. The result from this research can be the useful information to select the appropriate disposal methods (e.g., recycling, composting, landfilling or waste-to-energy via incineration) and to design a waste collection system. The target of the research focuses on hotels, restaurants, schools, shops, beer gardens, offices, internet cafés, guesthouses, and microfinances. The objectives of this study are to determine waste generation rate, physical composition, and the level of recyclables remaining in the residual of waste stream and to evaluate the appropriate technology for waste treatment.

1.1 Solid Waste Management in Phnom Penh

1.1.1 Waste collection service in Phnom Penh

There are three waste sources: municipal solid waste (household and commercial waste), hazardous waste (factory waste and industrial waste) and medical waste (hospital, clinic, etc.). And those collection services are conducted by three agencies: Municipality of Phnom Penh (MPP), SAROM trading Co. Ltd, and Phnom Penh Waste Management Authority (PPWMA), respectively. Due to lacking of financial resources for waste collection and disposal system, in 2002 MPP has franchised out solid waste collection service to a private waste hauler, CINTRI, and was completely provided in 2009 (urban and peri-urban) under monitoring/supervising of MPP. Since then storage and discharge practices of the waste have changed from burning, burying, dumping in back yard, disposing in water body, etc., to collection and disposal due to vacant space scarce caused by fast population growth and urbanization. However, municipal solid waste management (MSWM) in Phnom Penh performs still poor in both sanitary and environment because of minor illegal dumping and individual disposal. Improper operations are caused by a couple of factors including technical, economic, political, regulations and human resources. It seems that legal system arrangements and resources are the major challenges for improving MSWM in Phnom Penh (Kum et al., 2005; JICA, 2005).

1.1.2 Waste collection and transport

At the present time, there is no uniform storage bins have been introduced in Phnom Penh. In general, plastic bags (usually reused plastic bags) are used to store household waste. Restaurants, hotels, schools, shops and offices generally use their own bins or containers in different sizes for on-site storage prior disposal; and industrial waste is normally kept in hauling containers before collection. However, under collaboration between PPM and CINTRI, in public places such as parks, gardens and some streets, the public trash bins are provided for temporary storage to avoid littering and to make city cleaner. In Phnom Penh, kerbside and bell collection are the common practices for household waste. However in particular places such as markets, hospitals and populated areas, waste containers with a capacity of 0.6 m³ were provided by CINTRI. Inconsistency in collection times and irregular schedules are also the problems for current collection practices (Seng et al., 2010; Kum et al., 2005). Mori (2000) indicated that waste collection service was available only in a particular places such as at residential areas (mainly with good infrastructure), shopping centers, restaurants, and hotels, all of which were covered by 70-80%. Although, recently the findings showed that collection service has been improving up to 90 %. The collection frequency and collection times are still under uncertainty (Mongtoeun et al., 2014).

1.1.3 Waste disposal

Collected waste (only MSW) is transported to an open dumping site, Steung Mean Chey (SMC), with the area of about 6.8 ha, located at 7 km from city center, and operated since 1965. This dumping site (nicknamed smokey mountain because the smoke occurs due to firing) was planned to close in 2007 due to its fullness. However, the new landfill has not yet finished. Therefore, this dumping site has continued to use until 2009. Since 20 July in 2009, a new landfill was operated at Dangkor site, called Dangkor Landfill, with an area of about 26 ha located about 15 km from city center. Currently, about 1200tons/day of waste is being disposed of in this new landfill at a cost of USD 0.75/ton which paid by CINTRI to MPP (JICA, 2005). The result of informal interview with the Phnom Penh municipal officer and CINTRI's officer in 2012 indicated that the amount of waste disposed at the landfill has increased to 1400 tons per day.

2. Materials and Methods

The study was conducted in Phnom Penh city focusing on commercial sectors. The samples were collected from food services (hotels, restaurants, internet cafés and beer gardens), offices (microfinances and ministries), schools (primary school, institute and university), shops (phone shops, cloth shops and groceries), markets (super

markets and familymarts) and guesthouses. This activities were undertaken during 22 July–28 August in 2013. The waste from 52 commercial sources were daily collected. Plastic bags in different sizes with the code were given to each source to keep their waste. Collected waste from each source were weighed and recorded. Separation analysis was conducted in 23 categories. The objectives of this research are to determine waste generation rate, physical composition, and the level of recyclables remaining in the residual of waste stream and treatment options have been evaluated as well.

3. Results

3.1 Commercial Waste Composition in Phnom Penh city

Fig 1 represents the composition of commercial waste in Phnom Penh city. The results showed that biodegradable waste is predominant, followed by plastics and paper; and inorganics. Commercial waste composition consists of 56.70% (biodegradable), 19.32% (plastic), 14.84% (paper), 8.14% (inorganics), 1.25% (textile & shoes), 0.25% (rubber & leather), and 0.01% (wax) (Fig 1).

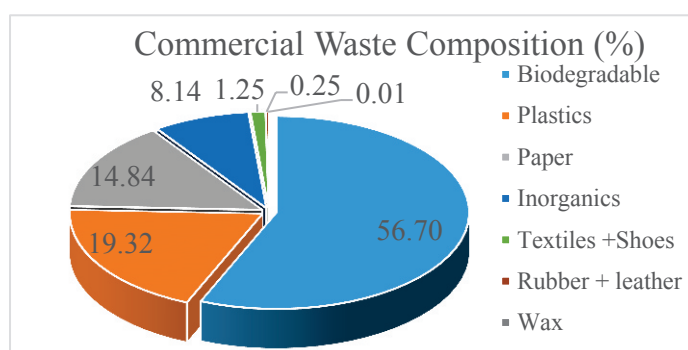


Figure 1. Composition of commercial waste

Table 1 shows the category and sub-category of commercial waste. The results of waste segregation indicate that food waste is the largest proportion (51.34%), followed by plastics (19.25%), paper (14.84%), yard waste (4.04%) and glass (4.02%). Content of food waste will be higher up to more than 60% if sorted food is included. The sorted food is used for animal feed that collected by farmers.

Table 1. Commercial waste category and waste sub-category in Phnom Penh

Waste Category	Percentage (%)
Organic	
Food	51.34
Yard wastes	4.04
Wood/bamboo	0.39
Charcoal	0.14
Paper	
Recyclable	2.89
Non-recyclable	11.95
Plastics	
PET bottle	1.60
HDPE	3.51
Film plastic	0.08
Plastic bag	13.31
Foam plastic	0.75
Textiles & shoes	1.15
Rubber & leather	0.23
Wax	0.01
Others	0.79
Inorganic	
Electronics	0.12
Stone, ceramic, soil	1.40
Battery	0.05
Ashes, dirt	0.61
Glass	4.02
Steel	0.64
Aluminum	0.40
Others	0.55

Waste composition by category and sub-category of commercial waste varied in Phnom Penh city. The highest percentage in waste stream is food waste (~70%) followed by plastic and paper contain similar proportion (~30%). This result is similar to a previous research of household solid waste conducted by [Mongtoeun \(2014\)](#). However, restaurants, beer gardens, internet cafés, groceries and 3-star hotels produce more food waste between 60%-70%. On the other hand, ministries, council minister, microfinance agencies and large guesthouse produce less food waste which account for 30%-40%.

3.2 Commercial Solid Waste Generation by Source

[Table 2](#) shows waste generation from commercial sectors by source. The waste generation (kg/cap/day) was 1.31, 1.04, 0.84, 0.51, 0.33, 0.23, 0.19, 0.13, and 0.11 for internet cafés, restaurants, beer gardens, guesthouses, hotels, markets (family marts), ministries, council of ministers and stores (phone, grocery and small cloth shops), respectively. On the other hand, schools and microfinance agencies produce waste with less than 0.1 ([Table 2](#)). [Byer et al \(2006\)](#) indicated that 3-star hotels in Halong city, Vietnam, produced same amount of waste (0.43kg/guest/day) as 3-star hotels in Phnom Penh city.

Table 2 Waste generation by source

Generation Sources	kg/cap/day
Microfinance agencies	0.08
Internet cafés	1.31
Restaurants	1.04
Guesthouses	0.51
Beer Gardens	0.84
Hotels (3-star and small)	0.33
Markets (family marts)	0.23
Stores (phone, grocery and small cloth shops)	0.11
Schools (Universities, primary schools and institutes)	0.03
Ministries	0.19
Council of Ministers	0.13

Table 3 presents the fluctuation of waste discharge of each source with the day of the week. The data in table 3 below doesn't include sorted waste from each source. The results indicated that waste generation rate for beer gardens and markets was high at the weekend, while microfinances didn't produce waste Sunday and schools showed low generation at the weekend because most schools were closed, however some schools were opened for private classes as well, but with fewer classes. Hotels and internet cafes showed low generation rate on Sunday, while guesthouses and shops didn't show any variation, however, restaurants showed high generation on Sunday. Overall, waste generation from commercial sector haven't shown much variation between each day.

Table 3. Waste generation rate (kg/source) by day

Sources	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Beer gardens	41.30	31.40	38.41	49.50	46.21	53.89	50.40
Guesthouses	10.27	8.33	9.64	9.94	10.37	7.34	10.71
Hotels	23.74	22.35	25.56	26.65	21.56	23.09	18.49
Internet cafés	34.43	32.83	27.55	32.83	29.49	30.50	28.30
Markets	6.39	10.33	9.78	9.51	13.21	10.80	12.37
Restaurants	60.21	50.50	61.94	59.95	66.85	60.37	86.36
Microfinances	15.10	13.98	14.95	11.02	8.80	8.50	0.00
Schools	26.12	29.75	20.64	26.23	20.65	19.01	9.86
Stores	2.79	3.44	2.65	3.28	4.03	2.16	2.50
Average	24.48	22.54	23.45	25.43	24.57	23.96	24.33

3.3 Waste sorting rate, sorted waste and recyclable materials by sources

Table 4 presents the waste sorting rate of each source. The results indicate that internet cafés and restaurants sorted well, mainly food because they discharged the food for animal feed, followed by market (family mart), schools, beer gardens and guesthouses. On the other hand, hotels, stores, and micro finances did not sort well. Due to the difficulty in data collection, waste sorting rates of ministries and council of ministers were unknown.

Table 4. Sorted and unsorted waste ratio from each source

	Micro finances	Internet cafés	Restaurants	Guesthouses	Beer Gardens	Hotels	Family marts	Stores	Schools	Ministries	Council of Ministers
Sorted Waste (%)	1.9	51.5	33.3	15.0	16.1	9.7	18.7	5.8	16.4	N/A	N/A
Unsorted Waste (%)	98.1	48.5	66.7	85.0	83.9	90.3	81.3	94.2	83.6	N/A	N/A

Table 5 presents sorted waste by the sector for selling and recyclable materials in remaining unsorted waste from commercial sector. The results indicate that main sorted waste is food waste, followed by glass bottles, PET bottles, paper, aluminum can, and steel is the lowest. While recyclable materials remaining in the waste stream show that paper is the largest, followed by HDPE, PET, steel, and aluminum can is the lowest (see details in table 5). Food waste for animal feed is discharged from internet cafés and restaurant which is collected by farmers. However, due to irregularity of collectors for food waste, some owners have refused to give food waste anymore.

Table 5. Generation rate, sorted waste and recyclable materials

Generation sources	Sorted waste by the sector for selling (%)						Recyclable material in remaining in unsorted waste (%)				
	Food	Paper	PET bottles	Steel	Aluminum can	Glass bottles	HDPE	Paper	PET bottles	Steel	Aluminum can
Microfinances	0.00	0.0	1.0	0.0	1.0	0.0	4.1	14.2	2.5	0.2	0.1
Internet cafés	42.2	1.3	0.7	1.7	0.7	5.0	0.6	0.5	0.6	0.6	0.0
Restaurants	23.4	1.0	0.7	0.2	1.1	6.8	1.5	0.4	0.5	0.3	0.5
Guesthouses	0.0	0.0	8.9	0.4	5.8	0.0	3.1	1.8	1.2	0.8	0.7
Beer Gardens	0.0	0.0	0.3	0.3	0.4	15.1	6.7	2.2	5.4	1.2	0.3
Hotels	0.0	0.3	6.7	0.1	2.6	0.0	4.6	3.1	0.7	1.0	0.2
Family marts	0.0	1.9	1.6	0.2	4.1	10.9	1.8	4.2	2.4	0.3	0.4
Stored	0.0	3.1	1.2	0.0	1.5	0.0	1.7	3.0	1.2	0.8	1.9
Schools	0.0	5.5	7.2	2.6	1.1	0.0	5.8	1.4	1.5	0.4	0.1
Ministries	0.0	0.0	0.0	0.0	0.0	0.0	2.0	7.4	1.3	0.6	0.1
Council of Ministers	0.0	0.0	0.0	0.0	0.0	0.0	1.7	2.2	1.2	0.6	0.1

4. Discussions

Data yielded by the study of commercial waste generation and composition can be used to identify waste amount generated and recyclable materials from each source. In addition, treatment technologies can be evaluated. For better waste management in the city, the study on amount of waste generation and composition is very important to select a proper management system. Based on the result of characterization, a set of reducing, recovering, and recycling of the food waste become a way to reduce the waste amount going to landfills. We propose some methods in treating commercial solid waste in Phnom Penh, such as separation activities of food waste for animal feed, composting, and bio-digestion. Especially, composting of recyclable food waste might be the most appropriate option among others for SWM in Phnom Penh since it is low cost and simple. Furthermore, composting has many environmental benefits: improving soil health and structure; reducing the consumption of fertilizers and pesticides. An additional benefit of food waste utilization can lead to reduction of GHG emission because composting generates CO₂ more than CH₄ due to the condition of aerobic digestion. Incineration of the waste is generally an effective method to treat organic waste. As for household waste, referring to the result of household solid waste study conducted by Mongtoeun (2012), it was indicated that calorific value was too low (less than 1000kcal/kg) to incinerate the waste stably. It is supposed that incinerating the commercial food waste is also inappropriate but doing the paper and plastic waste which are sorted from commercial waste is possible.

5. Conclusions

This study surveyed the waste characterization of commercial sectors, such as hotels, restaurants, schools, shops, beer gardens, offices, internet cafés, guesthouses, and microfinance agencies, in Phnom Penh. The waste from 52 commercial sources were daily collected and the collected waste from each source was weighed, then segregated into 23 categories and recorded. As the result of waste characterization analysis conducted in 23 categories, we found that organic waste contained food waste predominantly. Sorted waste by source was mainly food, followed by glass bottles, PET bottles, papers, aluminum can and steel. And potential for recyclable materials are food (largest), followed by plastics, paper, steel and aluminum can. Aluminum can was well sorted in most sectors. PET bottle is well sorted in guest houses, schools, and hotels. It is concluded that sorting activities were high for internet cafés, restaurants and school, but less sorted in hotels, stores, and micro finances. Based on these results, we discussed countermeasures to reduce the commercial waste.

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