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Municipal Solid Waste Management in Phuntsholing City, Bhutan

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Abstract

Municipal solid waste problem is a major concern in major cities in Bhutan. Despite the lack of reliable data on both waste composition and quantity, no studies have been conducted to identify problems and alternatives to improve the current system. The study objectives are: 1) to determine solid waste composition and generation rate; and 2) to investigate current solid waste management system. Six waste samples were selected in Phuntsholing city from three designated collection spots and from three collection vehicles and analyzed for their composition. Waste generation rate was computed from waste collected by collection vehicles. The investigation was carried out through interviews with municipal authorities, existing document reviews, and field observations. The organic fraction of solid waste composition comprised about 71 percent. The waste generation rate was estimated to 0.40 kg/capita.day. The current management system is inefficient, and recommendations are given to improve the current situation.

Keywords: municipal solid waste; management; Phuntsholing city; Bhutan

1. Introduction

Municipal solid waste management is man-made disaster and it depends to a great degree on greed and ignorance. In order to adopt an effective management, information on waste composition and quantity is the basis to understand the potential for waste recovery and successful management planning (Gidarakos *et al*., 2006; Ojeda-Benitez *et al*., 2003). Generally, the waste components such as glass, paper, plastics and metals are recyclable materials, while organic components can be composted (Sharholy *et al*., 2007; Ojeda-Benitez *et al*., 2003). To shift from existing conditions to a more sustainable management, there is critical need to review the existing conditions and identify its associated problems and alternative solutions.

Like other developing countries, Bhutan is facing problems of waste management. Particularly there is an emerging concern for the urban towns of Thimphu, a capital city, and Phuntsholing that exhibit the highest population growth and waste generation (NEC, 2000). In Phuntsholing, Phuntsholing City Corporation (PCC) has taken steps to manage local waste through waste management systems in 2005. However, the current management had remained ineffective whereby waste littering prevails in every corner of the city (Kuensel, 2006). Despite its concern to improve the existing situation, there is few reliable data on either waste composition or waste quantity, which is a prerequisite for over all waste management planning, and there are no suitable alternatives for its improvement.

Therefore, this study determines municipal solid waste generation and its composition and investigates the existing management system of Phuntsholing city in order to identify problems and provide recommendations for its improvement.

2. Materials and Methods

The study was conducted in November 2007 in Phuntsholing city located to extreme south of the country. The total land area of city is 22 km^2, which included 2 km^2 urban and 20 km^2 rural areas. It had a population of 22,500 people comprising 3,379 households. The study covered three areas/zones, namely area 1, main town, area 2, Royal Insurance Corporation of Bhutan (RICB), and area 3, Chukha Hydro Power Corporation (CHPC), areas which were within the territorial limits of current waste management service.

Table 1. Classification of waste components of municipal solid waste

Types of waste	Components
Putrescibles	Food waste (vegetables, meat scrap, egg shell, dairy products) and yard waste (leaves and grasses pruning and trimmings, branch and stems, crop residues, manure and others).
Paper	Newspaper, office paper, ledgers, magazines, books, cardboard.
Plastics	Plastic containers, bags, HDPE, PETE, other composites
LWTR	Leather, wood, textiles, rubber, threads, yarns, fabrics, cloths, others
Ferrous metals	Tins, steel cans, iron rods and all other ferrous metals
Non-Ferrous	Aluminum foils, aluminum cans and all other non-ferrous metals
Glass	Clear bottles, colored bottles, composite glass and others glasses
Inert	Stones, rocks, soils/fines, ash and others
Miscellaneous	Others that do not fit to any of the mentioned categories

Source: Gidarakos *et al*., 2006

Firstly, municipal solid waste generation and its composition were determined. Secondly, the investigation of current management system of Phuntsholing City Corporation was conducted covering all technical aspects of the management system.

To obtain data on waste generation, the actual weight of waste collected from the three areas for disposal during one week period (29th October to 4th November, 2007) was recorded. The study assumed that all the actual amount of waste generated was collected for disposal. The per capita waste generation was then computed taking into account of population, provided by PCC.

To determine waste composition, six samples were collected from three designated collection spots and three vehicles that transported the waste to the disposal site, which represented the waste stream generated from three respective existing waste collection areas (Sharholy *et al.,* 2007; Cascadia Consulting Group, Inc., 1996; 2004; 2006). The waste samples were obtained manually and sorted into its prescribed waste components (Table 1), which were then weighed and the mean composition was determined.

To acquire information regarding technical management, initially, the prescribed questionnaire guide was provided to officer in charge of MSW, mainly engineers. The existing documents and records were also reviewed and to obtain in-depth information, they were personally interviewed. Field observation and interviews with waste workers, drivers and supervisors were also conducted to investigate the existing condition of service provided by PCC. This investigation acquired the information regarding waste storage facilities, waste collection and transportation, waste treatment and waste recovery practices and final waste disposal methods.

3. Results and Discussion

3.1. Municipal solid waste generation and composition in Phuntsholing

Waste generation rate was estimated to 0.40 kg/capita.day which indicated waste generation of 8,967 kg/day and 3,272 tons/year (Table 2). The waste generation rate has increased from 0.31 kg/capita.day in 2000 (NEC, 2000) to 0.40 kg/capita.day in 2007 indicating an increase rate of 3.8% per year. Actually, the quantity of waste collected is different from the quantity generated from the source. Therefore, we assumed that the waste generated from all sources was equal to waste collected by the vehicle for disposal. This assumption was reasonable to some extent because there were no waste separation at source, which would have lead to diversion of recyclable waste to recycling facilities. In practice, there was waste diversion due to waste collection by the waste scavengers from the waste storage areas. Obviously, most of the waste at the backyards always remained uncollected and there was open burning both at source of generation and collection spots indicating that actual waste generation was higher than actual waste collected for disposal.

Table 2. Waste generation by areas in Phuntsholing city

Areas	Waste generation (tons/day)	Waste generation (tons/week)	Waste generation (tons/year)
No.1	4.341	30.387	1,584
No.2	2.696	18.872	984
No.3	1.930	13.510	704
Total	8.967	62.769	3,272

Table 3. Waste composition in Phuntsholing city

Type of waste	Waste quantity		Recyclable waste	
	(tons/year)	(%)	(tons/year)	(%)
Organic				
Putrescibles	1,014	31.0	-	-
Paper	668	20.4	668	20.4
Plastics	353	10.8	353	10.8
LWTR[a]	285	8.7	-	-
Inorganic				
Ferrous metal	75	2.3	75	2.3
Non-ferrous	82	2.5	82	2.5
Glass	353	10.8	353	10.8
Inert[b]	275	8.4	-	-
Misc.[c]	167	5.1	-	-
Total	3,272	100.0	1,531	46.8

[a] Leather, Wood, Textile and Rubber
[b] Stones, ash, soils, construction and demolition waste.
[c] Nappies, sanitary napkins, other materials that do not fit into any of the mentioned categories.

The total organic fraction of the waste composition made up the largest fraction, 70.9% (2,320 tons/year) of the total, putrescible waste was 31.0% followed by paper 20.4%, plastics 10.8% and leather, wood, textiles and rubber (LWTR) 8.7%. The total inorganic materials comprised 24.0% (784 tons/year), which constituted glass 10.8%, ferrous metal 2.3%, non-ferrous metal 2.5%, and inert (stones, ash, soil, construction and demolition waste) 8.4%, while other miscellaneous materials constituted 5.1% (167 tons/year) (Table 3). The organic component of putrescible waste was mainly food and yard waste which can be recovered through composting. This component is a bit higher comparing with 25% of putrescibles in Thimphu municipal solid waste (Penjor, 2007). The most commonly recyclable materials namely ferrous metal, non-ferrous metal, paper, plastic and glasses, constituted 46.8% of the total waste, which indicates 1,531 tons/year of waste can be recovered through recycling. Our data indicate that a high percentage (77.8%) can be recovered through composting and recycling while the rest can be disposed in landfill.

3.2. Municipal solid waste management in Phuntsholing city

3.2.1. Waste storage

Phuntsholing City Corporation had provided mainly three types of waste storage bins at various designated collection spots for temporary storage of waste (Table 4). They consisted of metallic sheet trolley bins, metallic sheet swing bins and masonry concrete bins as shown in Fig. 1. Trolley bins of open type (capacity 1.38 m^3) had wheels; they made up 42.0% of the total. Swing bins (capacity 0.55 m^3) had lids and were placed on a stand, they constituted 16.9%. The remainders were concrete bins of fixed type without any cover and they had an average capacity of 4.26 m^3. In all, 168 waste storage bins with a total capacity of 242.86 m^3 were distributed in the city.

Currently, provision of each type of waste storage bin had various constraints especially trolley and concrete bins. Trolley bins were heavy built weighing about 180 kg, which could not be easily taken to workshops. Moreover, they were not suitable during rainy season due to its open nature. Even worse, replacement of such bins was difficult, as they had to be imported. Without lids, they attracted flies, insects and rodents, and generated odors. Furthermore, their locations were fixed in place. However, the swing bins were comparatively convenient to use particularly during rainy seasons as they had lids.

Estimated total volume of generated waste was 32 m^3 per day, while the existing total volume of containers provided to the city was 8 times higher (243 m^3). Moreover, our field investigations revealed open waste storage areas and illegal open dumping of waste. This reveals that the current MSW management system is not appropriate.

Table 4. Waste storage bins and its capacity in Phuntsholing city

Type of waste storage bins	Capacity of bins (m^3/bin)	Numbers of bins	Total capacity of bins (m^3)
Ms trolley bins	1.38	74	102.12
Ms swing bins	0.55	70	38.50
Masonry concrete bins	4.26[a]	24	102.24
Total	-	168	242.86

[a] Average capacity (Ranges from 4.00 - 4.52 m^3)
Source: PCC, 2007

(a) Trolley bin (b) Swing bin (c) Concrete bin

Figure 1. Three different types of waste storage bins provided by PCC

3.2.2. Collection and transportation

Waste collection and transportation service is achieved by curbside pick up or stationary container service system. However, in addition, there is also door-to-door waste collection service whereby individuals directly load into collection vehicles from their own dust bins, a procedure which requires much time. Irregular timing of vehicle arrival results in other easy disposal options, such as dumping in open spaces. Therefore, curbside waste pick up was more practical and effective if there was adequate provision of waste storage bins that could be easily lifted for waste unloading.

Pertaining to the waste collection capacity and utilization of vehicles, there are two compactor trucks with a capacity of 9.0 and 5.1 m^3, respectively, and one flat-bed open truck of 6.0 m^3, for waste collection on twice daily. The total waste collection capacity was thus 40.2 m^3/day. However, current waste collected from the compactor trucks was only 12.4 and 7.8 m^3/day, while flat-bed open truck had 11.8 m^3/day on average (Table 5). Thus, total volume of waste collected was 32.0 m^3/day, which is 80% of the total vehicle capacity. A breakdown by type of vehicle reveals that the capacity utilization of the open truck was 98%, compared to the compactor trucks, which had 69 to 76%, respectively. Thus, improving the capacity utilization of the existing vehicle and selection of appropriate collection vehicles would reduce the demand for more frequent collections.

Many households did not have convenient access to roads and in addition they had to ensure timely arrival of collection vehicle for their waste disposal especially those who use direct loading. Due to poor timing, they were likely to use dumping in open spaces. Therefore, direct waste collection by existing large collection vehicle through scheduled routing was not very effective. In fact, provision of smaller waste collection vehicles, according to the existing road condition, may prove to be more effective.

3.2.3. Treatment and recovery

In the city, there is no waste treatment or recovery facilities established by neither the City Corporation, nor private companies. However, there exist some informal recycling facilities within the city that accepted major recyclable items such as metals, glass, plastics, rubber and papers. A total average 30,840 kg of waste were recovered in 2006 (PCC, 2007). The waste recovery practice involved informal waste scavengers at the disposal site who were allowed to collect what they wanted.

Recoverable waste taken from the waste stream is presented in Table 3. Putrescible waste (food and yard wastes) constituted about 31.0% (1,014 tons/year), which can be composted and used as soil conditioner. Further, total common recyclable materials including paper, plastic, metals and glass constituted 46.8 % that can be recovered. Our field survey also revealed that rubber items were a major fraction in LWTR components. Thus, more than 77.8% (2,545 tons/year) of the total waste generated were recoverable. However, currently only about 30,840 kg of total waste was recovered in 2006. Therefore, it is important to improve waste recovery as an alternative to increase the life of existing landfill site.

Table 5. Waste collection vehicles in Phuntsholing city

Vehicle	Frequency (trips/d)[a]	Capacity of vehicle (m^3/trip)[a]	Total collection capacity (m^3/d)	Average volume of waste collected (m^3/trip)	Total volume of waste collected (m^3/d)
Compactor truck no.1	2	9.0	18.0	6.2	12.4
Compactor truck no.2	2	5.1	10.2	3.9	7.8
Open truck no.1	2	6.0	12.0	5.9	11.8
Total	6	-	40.2	-	32.0

[a] Information provided by PCC

3.2.4. Waste disposal

Waste collected from three areas was disposed at Toribari, a newly constructed sanitary landfill site 9 km from the city. Waste disposal to this site started in 2005. It was constructed with an expected life span of 10 years and it has a total land area of 1.512 hectares (PCC, 2007).

The daily operation of the waste disposal comprised hydraulic automatic unloading of the collected waste from the vehicle to the disposal site. Unloaded waste was spread out with bulldozer. Two informal waste scavengers were assigned by PCC to separate the recyclable items. The dry waste was open burnt, followed with or without compaction using the compactor (roller) to reduce the volume of waste. There was a single layer of liner provided for final cover and soil cover at the top. There was also provision of bottom liner. Around the disposal site, there was drainage constructed for surface water diversion. There was also leachate collection system through a perforated HDPE piping system and leachate was stored in a concrete storage facility.

However, there was inadequate quality control of the liner system, which is likely to cause release of leachate into the ground water. Moreover, provision of small inadequate leachate collection systems, the absence of a leachate treatment system and a ground water monitoring system might cause contamination of ground water and nearby streams. Therefore, the capacity of the leachate collection system needs to be enlarged.

Another problem is the air pollution from open burning of the waste at the disposal site. This procedure is often adopted to reduce the volume of waste but it releases toxins and carcinogens especially from plastic materials. However, the best option to reduce waste volume and extend life of existing disposal site would be to improve waste recovery through recycling and composting.

4. Conclusions

The waste generation rate from the field survey in November 2007 showed increasing trend. The organic components can be possibly composted and used as soil conditioner, while other recyclables can be recovered through recycling processes. As such, there is high potential for waste reduction through waste recovery.

The technical aspects of solid waste management focused on the existing waste storage, collection and transportation, treatment and recovery, and disposal system. Lack of proper planning has led to inappropriate use and distribution of waste storage bins throughout the city. Waste collection and transportation need better scheduling to improve under capacity utilization of vehicle. Moreover, despite prevalence of high waste recovery potential through composting and recycling, there was lack of or/and improper methods of waste recovery practices. At the final disposal site there were problems especially concerning the contamination of ground and surface water due to uncontrolled leachate, and air pollution by open burning.

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