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# Solid Waste Generation and Characterization Studies in Yangon, Myanmar*

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## Abstract

Solid waste generation rate and characteristics such as density and composition are very important factors in solid waste management planning. Waste generation rate determines the volume required for on-site storage, transportation, transfer facilities and disposal of solid wastes while waste characterization determines the appropriate methods for collection and disposal and the identification of the recycling and resource recovery potential of solid wastes. This paper discusses the solid waste generation and characterization studies in Yangon, Myanmar in 2005. Seventy five (75) households from different income levels in South Okkalapa Township were randomly selected for sampling. The wastes generated were collected once a day at a fixed time for eight successive days to allow variation in waste generation over a week. The total quantity of solid wastes generated in Yangon is about 1,912 tons/day or 0.465 kg/capita/day. In terms of the solid waste characteristics, the bulk density is 0.25 kg/l or 250 kg/m$^3$ that is composed mainly of kitchen wastes and garden trimmings (65 percent); plastics, papers and cardboards (18 percent), and; glass, cans, leather and rubber, and textile (17 percent). This information serves as input to the formulation of the strategic solid waste management plan for Yangon City.

Keywords : *solid waste management, waste generation rate, waste characterization, waste density, waste composition.*

## Introduction

Solid waste management is one of the most important factors considered in environmental planning and management especially for large urban communities. As a fast growing urban center, Yangon City needs proper environmental planning focusing on solid waste management in taking the road to sustainable development. With the continuous rise in population size and living standards, the City encounters significant increase of solid

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waste generation that causes adverse effects on human health and the environment.

Yangon City is made up of 33 townships with an area of 306.28 sq. miles (794.65 $km^2$) with a population of 4.11 million in 2004 (Department of Population, 2005). The current waste management system is not adequately fitted to cope with the present situation due to lack of planning, capacity building, people's low level of awareness on environmental management, and other limitations. Therefore, Yangon City is in need of Strategic Solid Waste Management Plan to systematize and improve the solid waste management. Solid waste generation rate and characteristics such as density and composition are very important factors for the solid waste management planners.

The waste generation rate allows the volume required for on-site storage, transportation, transfer facilities and disposal of solid waste to be estimated. With the bulk density information, the appropriate methods for collection and disposal can be determined. Waste density data coupled with waste generation rate, allow the payload capacity of the collection equipment to be estimated. When this payload capacity is then divided by the number of trips feasible for the various regions of the city, it is possible to estimate the number of vehicles required to be on the collection routes each day. Again, with the bulk density information, the total volume that can be accommodated by the disposal sites can be estimated. By dividing that volume by volume of daily waste intake, then it is possible to estimate the life span of the disposal sites. The waste composition information is also very useful in identifying the recycling and resource recovery potential of the waste of a city.

## Materials and Methods

Daily residential solid waste generation rates in kg/capita/day; bulk density of solid waste generated in $kg/m^3$; and composition of solid waste generated in percentage by weight were determined.

**Selection of Sample Areas and Sample Households**

The survey areas were selected from South Okkalapa Township where there are different classes of income level. The high income residential area, the middle income residential area and the low income residential area were defined based on the types of the house ownership. The location of survey areas are shown in Figure 1.

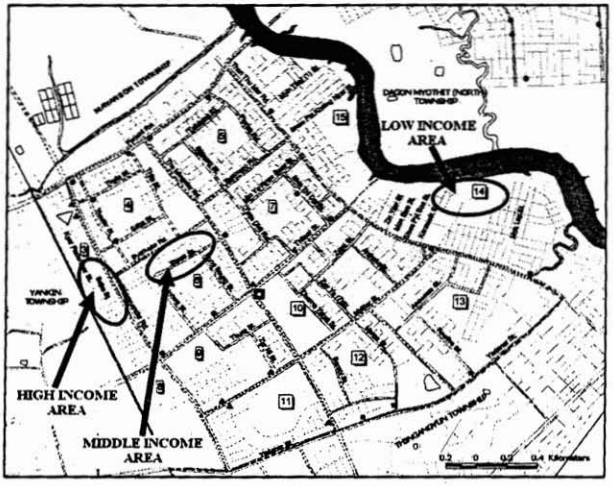


Figure 1. Location map of study area in South Okkalapa Township for the determination of solid waste generation and characteristics, Yangon City

Similar researches in Pacific countries recommended 50-100 sample households (WHO, 1996).

1) 25 households for high income class were selected from the 3rd Ward area where houses are mainly made of concrete structure;
2) 25 households for middle income class were selected from the 6th Ward area where houses are primarily made of wooden structure; and

3) 25 households for low income class are selected from the 14th Ward area where houses are essentially made of bamboo.

The wastes generated in the above areas were collected once a day at a fixed time (8:00 A.M.) for eight successive days to allow variation in waste generation over a week. The samples on the first day were discarded as they may contain waste accumulated from two or more days before.

**Preparations in Determining Solid Waste Generation and Characterization**

1) Transport of waste - an open truck had been designated and then prepared to transport the waste collected to the dump site where all the measurements were taken.
2) Workers - a driver and an assistant worker were assigned for the transportation of the waste; one collection worker for each sample area to collect and load the waste on to the vehicle; a data recorder and two workers at the dump site to measure the weight and volume of waste, and separate the waste into different categories.
3) Equipment and supplies – the following were prepared:
   Plastic bags - 8 bags/household x 75 households
   Weighing scale - two units with an accuracy of 100 grams
   Buckets - to measure volume of waste and for weighing
   Plastic sheet - to spread waste for sorting
   Gloves - for workers to handle waste
4) Assignment of numbers to households - for purpose of data recording and analysis, numbers were assigned to 75 households: 1-25 as high income households, 26-50 as middle income households and 51-75 as low income households.
5) Coding of plastic bags - according to the numbers assigned to households, plastic bags were coded by markers.
6) Data sheets – data sheets were prepared to record the collected data.
7) Survey of family size - the number of persons in each household was recorded in the data sheets.

8) Determination of collection route – the collection route was defined on a map.
9) Determination of volume and weight - the volume and weight of a bucket was measured and recorded.
10) Instruction to workers - the workers were instructed as to how they should carry out their specific assignments.

**Procedural Steps**

1) The plastic bags were collected from houses according to the pre-specified collection route. In order to make this collection process efficient, the workers in each sample area were instructed to collect the bags and place them at a certain location prior to loading on the truck. The wastes were then brought to the dumpsite.
2) Each plastic bag were weighed and recorded in the data sheets according to the numbers assigned to households. Then the waste generation rate was calculated by using the following equation:
   Daily Generation Rate = grand total weight for 7 days / total no. of people in 75 households / 7 (kg/person/day)
3) 25 plastic bags were randomly selected from the collected sample and the household numbers of these bags were recorded in the data sheets for volume and bulk density measurements.
4) The plastic bags were opened and the contents were placed in the bucket until it became full. The bucket was then emptied and the contents were spread over the plastic sheet. This process was repeated until all the bags were emptied. Counting of the numbers of times the bucket was filled was also recorded for the volume and bulk density estimation. The total volume and bulk density of the waste were calculated by using the following equations:
   Daily total volume = no. of bucketful loads x volume of the bucket
   Grand total volume = the sum of daily total volume for 7 days (liter)
   Bulk density = grand total weight / grand total volume (kg/l)
5) The wastes were separated on the plastic sheet into nine different types as: a) kitchen wastes; b) garden trimmings; c) plastic; d) paper and

cardboard; e) glasses; f) cans; g) leather and rubber; h) textile and i) miscellaneous. The separated wastes were then placed into different buckets for weight measurement.

6) The weights of each type of waste were measured and recorded in the data sheet for the composition measurement. The waste composition was calculated by using the following equation:
% waste composition = weight of each type of waste / weight of total waste x 100
7) All the wastes were properly dumped and the equipment used were cleaned.
8) Steps (1) to (7) were repeated everyday for the duration of the study.

## Results

### Solid Waste Generation Rate

The solid waste generation survey on 75 households in South Okkalapa Township showed a waste generation rate of 0.465 kg/capita/day for Yangon City (Table 1). Population in Yangon City as of 2004 is about 4.11 million. Therefore, the amount of waste generated from whole City can be calculated as 1911.86 tons per day (0.465 kg/cap/day x 4.11 million = 1911.86 tons/day).

Solid waste generation is affected by income level, among others, the waste generation rate of high income class is the highest at 0.572 kg/cap/day, the middle income class at 0.463 kg/cap/day, and low income class is 0.371 kg/cap/day (Table 1).

Table1. Solid waste generation rate of households by income level, Yangon City, 2005

| Income Class | No. of Sample Households | Total Household Members | Daily generated Waste (kg) | | | | | | | Total (kg) | Generation Rate (kg/cap/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | | |
| High | 25 | 129 | 87.7 | 61.3 | 78.3 | 64 | 72.7 | 75.6 | 76.7 | 516.3 | 0.572 |
| Middle | 25 | 136 | 61.2 | 61 | 56.2 | 72.2 | 68.6 | 56.8 | 64.5 | 440.5 | 0.463 |
| Low | 25 | 145 | 42.6 | 51.7 | 57.6 | 55.4 | 51.8 | 54.7 | 62.4 | 376.2 | 0.371 |
| Grand total | 75 | 410 | 191.5 | 174 | 192.1 | 191.6 | 193.1 | 187.1 | 203.6 | 1333 | 0.465 |

**Solid Waste Density**

Based on survey in South Okkalapa Township, the solid waste density of Yangon City is 0.25 kg/l or 250 kg/$m^3$ or 0.25 ton/$m^3$ (Table 2 and Table 3). This value reflects density at the pick-up point.

Table 2. Waste volume generated from 25 households per day, Yangon City, 2005 (in buckets or liter/day)

| Quantity | Day | | | | | | | Total | Average |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | |
| No. of Bucket* | 7 | 7 | 9 | 7.5 | 7 | 8.5 | 9 | 55 | 7.9 |
| Equivalent volume in liters | 238 | 238 | 306 | 255 | 238 | 289 | 306 | 1870 | 267 |

* The volume of the bucket is 34 liters.

**Solid Waste Composition**

The solid wastes collected were classified into 9 different materials (Table 4). Of these, kitchen wastes constitute the largest share of 47 percent. This is followed by garden trimmings at 18 percent, and then plastics at 10 percent and paper and cardboard at 8 percent, with the rest divided among the rest of the materials (Figure 2).

Table 4. Waste composition and weight for 25 households by day, Yangon City, 2005.

| Category | Weight (kg) | | | | | | | Total | % Com- |
|---|---|---|---|---|---|---|---|---|---|
| | Day1 | Day2 | Day3 | Day4 | Day5 | Day6 | Day7 | (kg) | position |
| Kitchen waste | 28.3 | 29.4 | 31.6 | 31.6 | 29 | 36.4 | 32 | 218.3 | 47 |
| Garden trimming | 13.7 | 12.7 | 13.8 | 8.5 | 11.8 | 9.5 | 14.9 | 84.9 | 18 |
| Plastic | 7.3 | 4.7 | 5.4 | 6.5 | 6 | 6.5 | 8.7 | 45.1 | 10 |
| Paper & cardboard | 4.6 | 6.2 | 6.2 | 7.1 | 4.1 | 4.5 | 5.3 | 38.0 | 8 |
| Glass | 3.3 | 4.6 | 4.2 | 2.2 | 4 | 3.4 | 5.2 | 26.9 | 6 |
| Cans | 3.9 | 5.2 | 3.6 | 3.5 | 5.4 | 2 | 2.9 | 26.5 | 6 |
| Leather & rubber | 1.2 | 2.2 | 0 | 1.4 | 0.2 | 1.2 | 0.3 | 6.5 | 1 |
| Textile | 0.3 | 0.2 | 0.5 | 0.2 | 0 | 0.3 | 1 | 2.5 | 1 |
| Miscellaneous | 1.2 | 1.6 | 1 | 1.3 | 2.9 | 2.6 | 2.3 | 12.9 | 3 |
| Grand total | 63.8 | 66.8 | 66.3 | 62.3 | 63.4 | 66.4 | 72.6 | 461.6 | 100 |

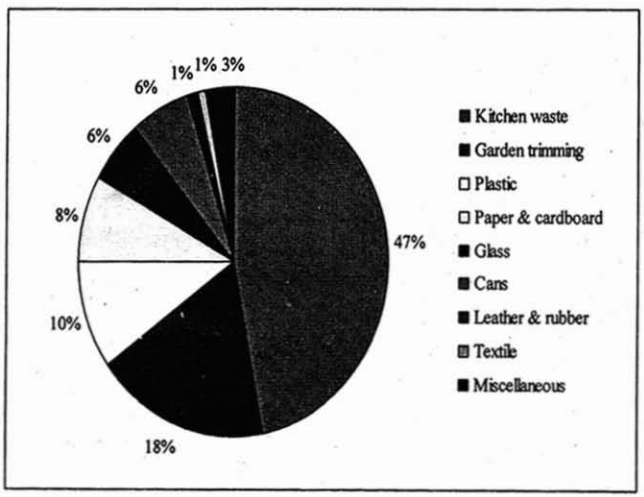


Figure 2. Generated solid waste materials by percentage

## Discussions

### Solid Waste Generation Rate

Comparing Yangon's waste generation rate with other large urban centers shows that Yangon's figure is still low. For example, the per capita waste production of Metro Manila is 0.65 kg/cap/day, which according to Mendoza, et. al, (1997), is the average for metropolitan areas in developing countries. As shown in Table 5, except for Monterey, Mexico the per capita generation of Yangon City at 0.465 kg is still far below the average per capita waste generation of metropolitan areas. Therefore, the Pollution Control and Cleansing Department (PCCD) of the Yangon City Development Committee (YCDC) should make necessary plans and actions to maintain/reduce waste that goes to the dumpsites or it will become a serious problem as what other metropolitan areas in developing countries are now experiencing.

Table 5. Average per capita generation of municipal solid waste of Yangon City in comparison with selected metropolitan areas of the world.

| City | Waste Generation Rate (kg/cap/day) |
|---|---|
| Yangon | 0.465* |
| Metro Manila | 0.65 |
| Bangkok | 0.95 |
| Jakarta | 0.9 |
| Mexico City | 0.83 |
| Monterey, Mexico | 0.44 |
| Buenos Aires | 0.80 |
| Caracas | 0.80-0.90 |
| Rio de Janeiro | 1 |
| Santiago | 0.7 |
| Sao Paulo | 1 |

* Computed based on the survey of 75 households in South Okkalapa Township (2005)

Source: Mendoza et al. (1997)

**Solid Waste Density**

By using the bulk density value of 0.25 ton/$m^3$, the daily waste generation of 1912 tons, will have a volume of 7648 $m^3$. The average capacity of collection vehicle is 8 $m^3$ and each vehicle usually makes three round trips a day. Therefore, 319 vehicles are required to collect all the waste generated from the city everyday but, according to the 2005 data of PCCD, the city has only 160 vehicles that are operational, so, the shortage is 159 vehicles.

The estimated total volumes that can be accommodated by the Final Disposal Sites (FDS) of the city are shown in Table 6. The estimation of lifespan is based on the volume that can be accommodated divided by the daily volume of the garbage six months after disposal by open dumping. Cointreau (1986) has reported that after disposal by open dumping and resting within the dump for six months, the garbage had naturally consolidated to a density of about 1,110 kg/$m^3$. At present, Le Ywar and Nga Moe Yeik FDS have reached full capacities but they are still being used because of the difficulties to look for the new disposal sites. Therefore, the appropriate new FDS for East and South Districts should necessarily be selected and introduced in Yangon City urgently.

Table 6. Estimated capacity and lifespan of final disposal sites, Yangon City, 2005.

| FDS | Area (ha) | Depth (m) | Estimated Capacity ($m^3$) | Daily Waste Intake*($m^3$) | Estimated Lifespan (Year) | Year Estab-Lished | Remaining Time (Year) (As of 2005) |
|---|---|---|---|---|---|---|---|
| Le Ywar | 5.59 | 5 | 279500 | 236 | 3.2 | 2001 | 0 |
| Nga Moe Yeik | 1.39 | 5 | 69500 | 190 | 1 | 2003 | 0 |
| Htein Pin | 22.3 | 5 | 1115000 | 190 | 16 | 2003 | 14 (2019) |

* The bulk density of waste is 1100 kg/$m^3$ (6 months after disposal by open dumping)

**Solid Waste Composition**

Solid waste characterization results showed that 65 percent of the waste (kitchen wastes and garden trimmings) are biodegradable materials and the rest are materials with potential for recycling. This indicates that if these biodegradable materials were converted into organic fertilizer, solid wastes that go to the dumpsite will be reduced by 65 percent. Reducing even one half of the waste will mean double the life span of the dumpsites. Plastics, paper and cardboard constitute 18 percent of the solid waste materials. This will cause further reduction of waste emptied into the final disposal sites if there are ready markets for these recyclable materials in the city. In terms of the implications of the results obtained, the solid waste management plan therefore should give more focus on the activities that address the issue on reduction and recycling of the waste materials.

## Conclusion

Yangon City presently does not have a solid waste management plan and the current practice is not systematic. In order to solve the present and future solid waste problems and implement sustainable management, the Strategic Solid Waste Management Plan is a very vital requirement. The results of the studies obtained on solid waste generation rate, density and composition will serve as input to the formulation of the strategic solid waste management plan for Yangon City.

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