Study on Development of Solid Waste Management Plan for Amarapura Township

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Abstract

Integrated Solid Waste Management (ISWM) systems are one of the greatest challenges for sustainable development. But for any ISWM system to be successful, the first step is to carry out waste generation and characterization studies. In order to suggest a solid waste management plan for Amarapura Township, this study was conducted to estimate the waste generation rate and the composition of generated solid waste. Seventy five (75) households from different income levels 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. Procedures for waste characterization involved analyzing the quantity and quality of daily generated wastes. The total quantity of solid wastes generated in Amarapura Township is about 72.4 tons/day or 0.351 kg/capita/day. It was also found that food waste constituted the largest share of 42 percent. The data and information gathered on waste generation and characterization studies were used to define the strategies for the Solid Waste Management Plan for Amarapura Township.

Keywords: Integrated Solid Waste Management, waste generation, waste characterization, composition, food waste

Introduction

Integrated Solid Waste Management (ISWM) systems are one of the greatest challenges for sustainable development (De Vega *et al*., 2008). ISWM can be defined as the selection and application of suitable techniques, technologies management programs to achieve specific waste management objectives and goals (Tchobanoglous *et al*., 1993). A hierarchy in waste management can be used to rank actions to be implemented programs within the community. The US Environmental Protection Agency (1995) has defined this hierarchy as source reduction, reuse, recycling, recover and responsible disposal. For any ISWM system to be successful, the first step is to carry out waste generation and characterization studies (De Vega *et al*., 2008).

Changes in lifestyle have led to more severe waste problems. Packaging of convenient household goods is free flowing and carefree attitude of the society resulted in huge quantities of waste. Plastics, which are not degradable constitutes a high proportion of modern day wastes. Most of the waste collected is disposed to landfill. The increasing amount of solid wastes generated has resulted in a reduction in landfill capacity (De Vega *et al*., 2008).

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.

Taking such issues and problems into consideration, data on waste generation rate, waste density and waste composition are urgently needed to formulate the Solid Waste Management Plan to systematize and improve the solid waste management system of the township.

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Amarapura Township is one of the Mandalay's developed satellite townships. Amarapura is now developing very rapidly. With the rapid increase in urbanization and the rapid population growth, it encounters significant increase of solid waste generation that causes adverse effects to human health and the environment. At present, the township consists of 2 town propers and 42 villages with a total area of 80.16 sq.mile (207.62 sq.km) and a population of 206,328 in 2018.

The objectives of this study are (1) to estimate the waste generation rate of Amarapura Township; (2) to characterize the composition of solid waste of Amarapura Township; and (3) to develop the solid waste management plan.

Materials and Methods

Selection of Sample Areas and Sample Households

The sampling areas were selected from Htan Taw village 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.

Seventy five (75) households were randomly selected from Htan Taw village for sampling. Similar researches in Pacific countries recommended 50-100 sample households (WHO, 1996).

1) 25 households for high income class were selected from the area where houses are mainly made of concrete structure;
2) 25 households for middle income class were selected from the area where houses are primarily made of wooden structure; and
3) 25 households for low income class are selected from the area where houses are essentially made of bamboo.

The wastes generated in the above areas were collected within a day at a fixed time (8:00 A.M) for 8 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 2 or more days before.

Requirements for Waste Generation and Characterization Study

1) Transport of waste - a handcart had been designated and then prepared to transport the waste collected to the place where all the measurements were taken.
2) Workers - a worker was assigned to push the handcart; three collection workers to collect and load the waste on to the vehicle; two data recorder and two workers at the work-site to measure the weight and volume of waste, and separate the waste into different categories.
3) Equipment and supplies:

Plastic bags	- 8 bags/household x 75 households
Weighing scale	- two units
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 (High income households 1-25, middle income households 26-50, low income households 51-75).

5) Coding of plastic bags by markers - according to the numbers assigned to households.

6) Data sheets - 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 to how they should carry out their specific assignments.

Determination of Daily Waste Generation Rate

The waste bags were collected from houses according to the pre-specified collection route. In order to make this collection process efficient, the collection workers were instructed to collect the bags and place them at a certain location prior to loading on the handcart. The wastes were then brought to the place where all the measurements were taken. Each waste 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 Waste Generation (kg/day) = Grand total weight for 7 days / 7

Daily Generation rate (kg/cap/day) = Daily Waste Generation / Total population

Determination of Waste Density

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 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 (liter) = the sum of daily total volume for 7 days

Bulk density (kg/l) = grand total weight / grand total volume

Determination of Waste Composition

The wastes were separated on the plastic sheet into seven different types as: (1) paper; (2) plastic; (3) glass; (4) metal; (5) food waste; (6) yard waste; and (7) miscellaneous. The separated wastes were then placed into different buckets for weight measurement. 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 equation below:

% waste composition = weight of each type of waste / weight of total waste x 100

Development of Proposed Waste Management Plan

The data and information gathered on waste generation and characterization studies were used to define the strategies for the Proposed Solid Waste Management Plan for Amarapura Township. The components of waste management processes are: (1) waste segregation; (2) establishment of recyclable collection center; and (3) composting.

Results and Discussion

Solid Waste Generation Rate

Daily generated waste of households by income level is shown in Table (1). It was found that total daily generated waste of higher income class is the highest and lower income level class is the lowest.

Table (1). Daily Generated Waste of households by income level, Amarapura Township, 2018

Income Class	Daily Generated Waste							Total (kg)
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	
High	56.3	54.6	53.3	56.5	59	61.2	60	400.9
Middle	45.2	44.1	47.5	49.6	47.5	47.8	48.7	330.4
Low	39.3	36.1	33.6	30	35.1	35.1	35.1	244.3
Grand Total	140.8	134.8	134.4	136.1	141.6	144.1	143.8	975.6

The solid waste generation survey on 75 households showed a waste generation rate of 0.351 kg/capita/day for Amarapura Township as shown in Table (2). Population as of 2018 is 206,328. Therefore, the amount of waste generated from the whole Township can be calculated as 72.4 tons per day (0.351 kg/cap/day x 206,328 = 72.4 tons/day). Solid waste generation is affected by income level, among others, the waste generation rate of high income class is the highest at 0.444 kg/cap/day, the middle income class at 0.330 kg/person/day, and low income class is 0.279 kg/person/day as shown in Table (2).

Comparing Amarapura's waste generation rate with other townships shows that Amarapura's figure is still low. For example, solid waste generation rate per person of South Okkalapa Township is 0.465kg/cap/day, which according to Seinn Lei Aye(2005), is the average for townships in Yangon.

Table (2). Solid waste generation rate of households by income level, Amarapura Township, 2018

Income Class	No. of Sample Households	No. of Household Members	Total (kg)	Generation Rate (kg/cap/day)
High	25	129	400.9	0.444
Middle	25	143	330.4	0.330
Low	25	125	244.3	0.279
Grand Total	75	397	975.6	0.351

In spite of the solid waste generation rate of Amarapura Township was lower than the other areas, the Pollution Control and Cleansing Department (PCCD) of the Mandalay City Development Committee (MCDC) should make necessary plans and actions for this township to maintain/reduce waste that goes to the dumpsites or it will become a serious problem as what other areas in developing countries are now experiencing.

Solid Waste Density

Based on the survey, the solid waste density of Amarapura Township is 0.24 kg/l or 240 kg/m^3 or 0.24 ton/m^3 (Table 3 and Table 4). This value reflects density at the pick-up point. The solid waste density is particularly important in planning process. Waste density information when coupled with waste generation rates expressed by weight, allows 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 township, it is possible to estimate the number of vehicles required to be on collection routes each day. The bulk density is also very important in the estimation of lifespan of the final disposal sites.

By using the bulk density value of 0.24 ton/m^3, the daily waste generation of 72.4 tons, will have a volume of 302 m^3. The average capacity of collection vehicle is 10 m^3 and each vehicle usually makes three round trips a day. Therefore, 11 vehicles are required to collect all the waste generated from Amarapura Township everyday.

Table (3). Waste volume generated from 75 households per day, Amarapura Township, 2018 (in buckets or liter/day)

Quantity	Day							Total	Average
	1	2	3	4	5	6	7		
No. of Bucket*	16	15	15	15.5	17	19	18.5	116	16.6
Equivalent volume	560	525	525	542.5	595	665	647.5	4060	580

*The volume of the bucket is 35 liters

Table (4). Average bulk density of waste generated from 75 households per day, Amarapura Township, 2018

Day	Weight (kg)	Volume (l)	Bulk Density (kg/l or ton/m^3)
1	140.8	560	0.25
2	134.8	525	0.26
3	134.4	525	0.26
4	136.1	543	0.25
5	141.6	595	0.24
6	144.1	665	0.22
7	143.8	648	0.22
Total	975.6	4061	1.70
Average	139.4	580	0.24

Solid Waste Composition

The collected solid wastes were classified into 7 different materials (Table 5). Of these, food waste constitutes the largest share of 42 percent. This is followed by yard waste at 33 percent, and then plastic at 10 percent and paper at 5 percent, with the rest divided among the rest of the materials.

Table (5). Waste composition and weight for 75 households by day, Amarapura Township, 2018

Category	Weight (kg)							Total (kg)	% Compo-sition
	Day1	Day2	Day3	Day4	Day5	Day6	Day7		
Paper	10.5	7	8.9	6.2	5.2	8.1	8.3	54.2	5
Plastic	15.7	13.2	12.7	14.3	12.9	14.4	14	97.2	10
Glass	0.5	3.5	4	2.5	1.9	3.6	2.6	18.6	2
Metal	0	3	1.2	0	0	5.2	0.9	10.3	1
Food Waste	57.2	55.7	59.9	56.4	60.9	56.4	61.7	408.2	42
Yard Waste	44.5	42.8	43.7	46.6	51.1	45.6	47.6	321.9	33
Miscellaneous	12.4	9.6	4.0	10.1	9.6	10.8	8.7	65.2	7
Grand total	140.8	134.8	134.4	136.1	141.6	144.1	143.8	975.6	100

Result showed that 75 percent of the waste (food waste and yard waste) 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 waste that goes to the dumpsite will be reduced by 75 percent. Reducing even one half of the waste will mean double the life span of the dumpsites. Plastic, glass and paper and cardboard constitute 18 percent of the solid waste materials. This will cause further reduction of waste emptied into the final disposal if there are ready markets for these recyclable materials.

Development of Proposed Waste Management Plan

The data and information gathered on waste generation and characterization studies were used to define the strategies for the Proposed Solid Waste Management Plan for Amarapura Township. The components of waste management processes are:

(1) Waste segregation;

(2) Establishment of recyclable collection center;

(3) Composting.

(1) Waste Segregation

Segregation is the classification and separation of wastes that goes into the waste stream. If certain materials are kept separate, these materials can be recycled or recovered for their highest and best use. Segregation must be done at the point source. The waste may be classified as recyclable, biodegradable and non-biodegradable/special wastes as shown in Table 6. Recyclable wastes include paper, cardboard, plastic, glass, metal, bottles, cans, leather, rubber and textile. Biodegradable wastes mainly include food wastes and yard wastes. Non-biodegradable/special wastes include florescent lights, incandescent bulbs, sharps and needles, medical bottles, chemical waste and toilet waste. For the waste

segregation strategy to be successful, the people should be well informed on how to characterize the waste as indicated in Table 6.

Actions for Waste segregation

- Waste segregation activities should be implemented at offices, schools, markets, township and village area.
- The solid waste containers should be properly marked or identified as recyclable, biodegradable and non-biodegradable/special.
- Waste characterization table (Table 6) should be posted on the wall above the waste containers in order to characterize the waste easily.
- Sense of public awareness should be created among people.
- Fines and penalties should be set out to the households if their wastes are not properly segregated.

(2) Establishment of Recyclable Collection Center

Collection centers, which receive recyclable materials, such as paper, plastic, glass and metals, in bulk and smaller volume, are encouraged to be set up. The center will be sited within the village and township. An incentive system should be a part of the scheme to motivate the people to drop the recyclable waste in the collection centers. By sending all the recyclable waste to collection center, 18 percent of total waste will be reduced to send to the dumpsite.

Actions for Setup of Recyclable Collection Center.

- The people must be encouraged to deposit their recyclable solid waste at the collection center.
- The materials received are classified according to market specifications and deposited in designated containers.
- There must be cash payments for every material delivered depending on the marketability of the material.

(3) Composting

Compost is organic material that can be used as a soil amendment or as a medium to grow plants. Mature compost is a stable material with content called humus that is dark brown or black and has a soil-like, earthy smell. It is created by combining organic wastes (food wastes and manures) in proper ratios into piles, rows, or vessels; adding bulking agents (rice straw or dry leaves) as necessary to accelerate the breakdown of organic materials; and allowing the finished material to fully stabilize and mature through a curing process (Bruijstens *et al*., 2008). Composting can produce 0.25 tons of compost from 1.0 tons of organic waste (Enayetullah *et al*., 1996).

Table (6). Waste Characterization as a Basis for Waste Segregation for Amarapura Township Management System

Recyclable Waste	Biodegradable Waste	Non-biodegradable/Special Waste
1. Paper	1. Food Waste	1. Fluorescent lights
2. Cardboard	- Fruit peelings	incandescent bulbs
3. Plastic	- Vegetable trimmings	2. Sharp & needles
4. Glass	- Soft shell	- Blades/shavers
5. Metal	- Fish entrails	- Syringes
- Aluminum cans	- Fowl	- Medical/intravenous
- Iron	- Food leftover	3. Medical bottles/vials
6. Bottles/cans	2. Yard Waste	4. Chemical waste/
7. Leather/ rubber	- Leaves	chemical containers
8. Textile	- Branches	5. Toilet waste
	- Weeds	- Sanitary napkins
	- Grasses	- Tissue papers
	- Animal manure	- Disposable diapers

These composts are very useful fertilizer. These composts not only increase the productivity but also increase the fertility of the land. The use of the compost fertilizer also reduces the agricultural pollution. After meeting the demand of the household for gardening purpose, these composts may also be supplied to the local farmers. The economic viability of compost is given in Table 7. The potential amount of compost produce will be 522 kg per month. The economic benefic will be Kyats 339,300 per month.

The success of this system is coupled with the efficient collection of segregated wastes. Aside from economic benefit, 75 percent of total waste will be reduced to send to the dumpsite by composting all the organic wastes.

Actions for Composting.

- The space for composting should be set beside the dump site.
- The technology of composting should be clearly disseminated to the composting workers.
- The market for organic fertilizer should be developed.

Table (7). Economic Benefits of Composting of Amarapura Township

Amount of Organic Waste (kg/day)	Amount of Compost (kg/day)	Amount of Compost (kg/month)	Price of Compost* (Kyat/kg)	Total price of Compost (Kyat/month)
104.3	26.075	522	650	339,300

* 1000 Kyats for 1 viss of compost which is available at Myae-Padaythar Garden.

Conclusion

Amarapura Township does not presently 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 Solid Waste Management Plan is a 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 solid waste management plan for Amarapura Township.

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