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Solid Waste Generation and Characterization Study in West Yangon University Campus and Development of a Management Plan

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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. Therefore, this study was conducted to estimate the waste generation rate and the composition of generated solid waste at West Yangon University academic buildings and food shops in the canteen to suggest a solid waste management plan. Thirty different sampling points (sixteen academic buildings and fourteen food shops) were selected in the campus and solid waste from those points was characterized for both term-time and semester break during August and October, 2012. The results showed that daily waste generation of West Yangon University during term-time was 280.9 kg/day and that during semester break was 108.4 kg/day. It was also found that food wastes constituted the largest share of 40 and 33 percent during term-time and semester break. The data and information gathered on waste generation and characterization studies were used to define the strategies for the Solid Waste Management Plan for West Yangon University. The components of waste management processes are: (1) waste segregation; (2) establishment of recyclable collection center; and (3) composting. By implementing solid waste management plan, 96 percent of total waste will be diverted from dump site in term-time (46% by recycling and 50% by composting) and 93 percent in semester break (49% by recycling and 44% by composting).

Keywords: Integrated Solid Waste Management, waste generation, waste characterization, waste segregation, composting

Introduction

Integrated Solid Waste Management (ISWM) systems 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

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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).

Many researchers have studied the solid waste management in university campuses all over the world. De Vega *et al.* (2008) found almost 65% of generated solid waste in university campus to be recyclable. Another research indicated that improved source separation performance could increase the recycle rate to 84% (w/w) in the concourse area (Mason *et al.*, 2004).

West Yangon University (WYU) is situated in Htantapin Township, western part of the Yangon Region. There are 16 academic buildings and 14 food shops in the campus. The university has a population of 7009 during term-time and that of 693 during the semester break (as of September, 2012). It is hoped that results obtained from this work would help policy makers in the institution for the development of sustainable waste management and environmental friendly waste disposal system.

The objectives of this study are (1) to estimate the waste generation rate of West Yangon University during term-time and semester break; (2) to characterize the composition of solid waste of West Yangon University; and (3) to develop the solid waste management plan.

Materials and Methods

Sampling Points of the Study

The sampling points were 16 academic buildings and 14 food shops in the canteen. The buildings were Building 1 up to Building 10, Building 12, , Building 14, Building A, Building B, Building C and Theatre 1. The buildings consist of lecture rooms, laboratories, offices, training centers, resource center, learning center and language labs. The wastes generated in the above areas

were collected once a day at a fixed time (2 pm) for 5 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.

Period of Study

Two periods were identified and selected for waste generation and characterization study. The first period was 'term-time' (6.8.2012 - 10.8.2012) when the campus was at its maximum population of all students and staff. The second period was 'semester break' (15.10.2012 - 19.10.2012) when there were basically no students in the campus, but the number of staff remained relatively unchanged.

Preparations for Waste Generation and Characterization Study

(1) A handcart was designated and prepared to transport the waste collected to the place where all the measurements were taken.

(2) Two workers were assigned to collect waste bags; one data recorder and two workers were assigned at the work-site to measure the weight and separate the waste into different categories.

(3) The following equipments and supplies were prepared:

Plastic bags	- 10 bags/sampling point x 31 sampling points x 2 sampling periods
Weighing scales	- to measure the weight of waste
Buckets	- to measure the volume of waste
Plastic sheet	- to spread waste for sorting
Gloves	- for workers to handle waste

(4) The names of buildings and food shops in the canteen were coded on plastic bags by markers.

(5) The coded plastic bags were distributed to the persons who are responsible for disposal of waste generated in each building and canteen.

(6) Data on student and staff population of West Yangon University were collected and recorded in the data sheets.

(7) The volume and weight of a bucket was measured and recorded.

Determination of Daily Waste Generation Rate

The waste bags were collected from buildings and canteen according to the pre-specified collection route and brought them to the work-site that was isolated from winds and separated from other activities. Each waste bag was weighed and recorded in the data sheets according to the names of buildings and food shops in the canteen. Then the waste generation rate was calculated by using the following equation:

Daily Waste Generation (kg/day) = Grand total weight for 4 days/4

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

Determination of Waste Density

The waste 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. The number of bucketful loads was recorded. The total volume and bulk density of the wastes 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 4 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 categories 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. Finally, all the wastes were properly dumped at the dump site and the equipments were cleaned. 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 West Yangon University.

Results and Discussion

Solid Waste Generation Rate

Solid waste generation was affected by the periods, among others, the daily waste generation of WYU during term-time was 280.9 kg/day and that during semester break was 108.4 kg/day as shown in Table 1 and Table 2. The solid waste generation rates of WYU during term-time and semester break were 0.04 kg/cap/day and 0.157 kg/cap/day respectively.

Solid Waste Density

Based on survey, the solid waste density of WYU was 0.175 kg/l or ton/m^3 during term-time and 0.200 kg/l or ton/m^3 during semester break (Table 3, Table 4 and Table 5). The solid waste density is particularly important in planning process. Waste density information when coupled with waste generation rates, allows the volume of waste generated every day. With this volume, it is possible to estimate the size of garbage receptacle to accommodate all the waste generated each day.

Table 1. Solid Waste Generation Rate of WYU during Term-time, 2012

Sampling Area	No. of Population	Daily Generated Wastes (kg)				Total Weight (kg)	Daily Waste Generation (kg/day)	Generation Rate (kg/cap/day)
		Day 1	Day 2	Day 3	Day 4			
Class-rooms and Offices	7009	143	143	157	142	585	147	0.021
Food Shops	7009	137	133	134	134	538	134	0.019
Total	7009	280	276	291	276	1123	281	0.04

Table 2. Solid Waste Generation Rate of WYU during Semester Break, 2012

Sampling Area	No. of Popu-lation	Daily Generated Wastes (kg)				Total Wei-ght (kg)	Daily Waste Gener a-tion (kg /day)	Gener ation Rate (kg/ca p/day)
		Day 1	Day 2	Day 3	Day 4			
Class-rooms and Offices	693	49	47	46	48	191	48	0.069
Food Shops	693	64	61	59	59	243	61	0.088
Total	693	113	108	105	107	434	109	0.157

Table 3. Volume of Solid Waste Generated from WYU, 2012

Study Periods	Quantity	Day				Total	Aver-age
		1	2	3	4		
Term-time	No. of Bucket*	47	45	45	46	183	46
	Equivalent volume in liters	1645	1575	1575	1610	6405	1601
Semester Break	No. of Bucket*	17	15	16	14	62	15.5
	Equivalent volume in liters	595	525	560	490	2170	542.5

* The volume of the bucket is 35 liters.

Table 4. Bulk Density of Solid Waste Generated from WYU during Term-time, 2012

Day	Weight (kg)	Volume (l)	Bulk Density (kg/l or ton/m^3)
1	280	1645	0.171
2	276	1575	0.176
3	291	1575	0.185
4	276	1610	0.171
Total	112	6405	0.175
Average	280.9	1601.25	0.175

Table 5. Bulk Density of Solid Waste Generated from WYU during Semester Break, 2012

Day	Weight (kg)	Volume (l)	Bulk Density (kg/l or ton/m^3)
1	113.3	595	0.190
2	108.3	525	0.206
3	105.5	560	0.188
4	106.6	490	0.218
Total	433.7	2170	0.200
Average	108.4	542.5	0.200

Solid Waste Composition

The solid wastes collected were classified into 7 different categories. The composition of solid waste generated during term-time and semester break are shown in Table 6 and Table 7 respectively. Of these, food waste constituted the largest share of 40 percent during term-time. This was followed

by paper at 30 percent and then plastic at 15 percent and yard waste at 10 percent, with the rest divided among the rest of the materials for term-time. For the semester break, food waste constituted the largest share of 33 percent. This was followed by paper at 28 percent and then plastic at 15 percent and yard waste at 11 percent, with the rest divided among the rest of the materials.

Results for term-time showed that 46 percent of the waste (paper, plastic and glass) were materials with potential for recycling and 50 percent of waste (food waste and yard waste) were biodegradable materials. This indicated that if these recyclable materials were sent to market for recycling and biodegradable materials were converted into organic fertilizer, solid waste that goes to the dumpsite will be reduced by 96 percent. Similarly, results for semester break indicated that 93 percent of waste will be reduced if there were ready markets for recyclable materials and program for composting.

Table 6. Composition of Solid Waste Generated from WYU during Term-time, 2012

Category	Weight (kg)				Total (kg)	w/w % Composition
	Day 1	Day 2	Day 3	Day 4		
Paper	91.4	79.7	78.5	90.6	340.2	30
Plastic	40.3	40.9	36.2	51.2	168.6	15
Glass	2.7	2.9	3.7	1.9	11.2	1
Metal	0	0	0	0	0	0
Food Waste	106.3	118.4	126.3	98.5	449.5	40
Yard Waste	26.2	25.2	33.1	24.8	109.3	10
Miscellaneous	13.7	9.4	13.1	8.7	44.9	4
Grand Total	280.6	276.5	290.9	275.7	1123.7	100

Table 7. Composition of Solid Waste Generated from WYU during Semester Break, 2012

Category	Weight (kg)				Total (kg)	w/w % Composition
	Day 1	Day 2	Day 3	Day 4		
Paper	35.5	33.2	24.6	27.8	121.1	28
Plastic	17.7	17.5	13.4	16.3	64.9	15
Glass	3.1	3.7	5.4	4.8	17	4
Metal	2.6	1.6	3.5	1.1	8.8	2
Food Waste	34.7	32.5	37.9	38.8	143.9	33
Yard Waste	12.8	11.5	12.4	10.5	47.2	11
Miscellaneous	6.9	8.3	8.3	7.3	30.8	7
Grand Total	113.3	108.3	105.5	106.6	433.7	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 WYU. 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 8. 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 staff and students should be well informed on how to characterize the waste as indicated in Table 8.

Actions for Waste segregation

- Waste segregation activities should be implemented at offices, classrooms, laboratories, training centers, library and campus area.
- The solid waste containers should be properly marked or identified as recyclable, biodegradable and non-biodegradable/special.
- Waste characterization table (Table 8) 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 staff and students.
- Fines and penalties should be set out to the Departments and canteens 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 University campus. An incentive system should be a part of the scheme to motivate staff, students and janitors to drop the recyclable waste in the collection centers. By sending all the recyclable waste to collection center, 46 percent of total waste in term-time and 49 percent of that in semester break will be reduced to send to the dumpsite.

Actions for Setup of Recyclable Collection Center

- The staff, students and janitors 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).

Table 8. Waste Segregation Table for WYU Waste 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

The composts are very useful fertilizer. The 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 university for gardening purpose, these composts may also be supplied to the local farmers. Composting can produce 0.25 tons of compost from 1.0 tons of organic waste (Enayetullah *et al.*, 1996). The economic viability of compost is given in Table 9. From Table 6 and Table 7, the daily organic waste (food waste and yard waste) generation of West Yangon University during term-time and semester break can be calculated as 139.7 kg/day and 47.8 kg/day. Therefore, the potential amount of compost produce will be 34.9 kg per day in term-time and 12.0 kg per day during semester break. On an average, there are 20 working days in a month and the amount of compost produced will be 698 kg/month in term-time and 240 kg/month in semester break. Therefore, the economic benefic will be Kyats 272,220 per month in term-time and Kyats 93,600 per month in semester break.

The success of this system is coupled with the efficient collection of segregated wastes. Aside from economic benefit, 50 percent of total waste in term-time and 44 percent of that in semester break 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 9. Economic Benefits of Composting of WYU Wastes

Period of Compost-ing	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)
Term-time	139.7	34.9	698	390	272,220
Sem-break	47.8	12.0	240	390	93,600

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

Conclusion

In the study, thirty different sampling points (sixteen academic buildings and fourteen food shops in the canteen) were selected in the campus and solid wastes from those points was characterized for both term-time and semester break during August and October, 2012. The results showed that daily waste generation of WYU during term-time was 280.9 kg/day and that during semester break was 108.4 kg/day. The solid waste generation rates of WYU during term-time and semester break were 0.04 kg/cap/day and 0.157 kg/cap/day respectively. By implementing solid waste management plan, 96 percent of total waste will be diverted from dump site in term-time (46% by recycling and 50% by composting) and 93 percent in semester break (49% by recycling and 44% by composting). Aside from waste reduction, the economic benefic will be Kyats 272,220 per month in term-time and Kyats 93,600 per month in semester break.

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References

Bruijstens, A.J., W.P.H. Beuman, M.V.D. Molen, J.d. Rijke, R.P.M. Cloudt, G. Kadijk, O.O.D. Camp, S. Bleanus (2008) *Biogas*.

De Vega, C.A., S.O. Benítez and M.E. Ramírez Barreto (2008) "Solid Waste Characterization and Recycling Potential for a University Campus" *Journal of Waste Management*, vol. 28: S21-S26. DOI: 10.1016/j.wasman.2008.03.022

Enayetullah, I. and A.H.M. Sinha (1996) "Waste Concern: Concerned with Waste" *Earth Magazine*.

Mason, I.G., A. Oberender and A.K. Brooking (2004) "Source Separation and Potential Re-use of Resource Residuals at a University Campus" *Journal of Resource. Conservation and Recycling*, vol. 40, pp. 155-172.

Tchobanoglous, G., H. Theisen and S. Vigil (1993) *Integrated Solid Waste Management: Engineering Principles and Management Issues*. New York: McGraw-Hills Inc.

USEPA (United States Environmental Protection Agency) (1995) *Decision Maker's Guide to Solid Waste Management,* Volume II. Office of Solid Waste Municipal and Industrial Solid Waste Division, Washington, D.C.

Ozeler, D., U.Yetis and G. N. Demirer (2006) "Life Cycle Assessment of Municipal Solid Waste Management Methods: Ankara Case Study", *Environment International*, vol. 32, pp. 405–411.

Sonesson, U., A. Bjo¨rklund, M. Carlsson and M. Dalemo (2000) "Environmental and Economic Analysis of Management Systems for Biodegradable Waste", *Resources, Conservation and Recycling*, vol. 28, pp. 29–53.

Winkler, J. and B. Bilitewski (2007) "Comparative Evaluation of Life Cycle Assessment Models for Solid Waste Management", *Waste Management*; vol. 27, pp. 1021–1031.