Solid Waste Management System in UTP Academic Complex

by

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5713

Dissertation submitted in partial fulfilment of
the requirements for the
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CERTIFICATION OF APPROVAL

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ABSTRACT

The present work is a case study on solid waste collection and management in Academic Complex of Universiti Teknologi Petronas, Tronoh Perak. The implementation of a suitable solid waste management programme with appropriate methods of recycling as an inherent element is important to the alleviation of the problems associated with solid waste generation, handling and disposal and environmental conservation. The amount and types of domestic waste generated, management and processing of the waste generated, identification of existing problems related to the implementation of the recycling programme, formed the basis of this study. Surveys and on-site solid waste analysis were conducted in two different period; (1) Semester-break, (2) Semester-open to gather information on the solid waste collection practice of the university. The analysis was conducted in six related academic building according to different courses programme and in concrete laboratory (Building 13) based on weight-volume analysis method introduced by George Tchobanoglous, 1993.Aesthetically displeasing sites and a lack of public awareness were problems of major concern. The results was analysed and it has been found that paper, plastic and cardboard were dominating solid waste composition. An average of 6.1 kg of waste was disposed everyday in each building and 8.2 tonne of concrete waste has been generated. To cater with the problem faced and issue related to solid waste management in UTP, suggestions and recommendations have been made.

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1.0 INTRODUCTION

1.1 Background study

As far as environmental is concern, solid waste management is one of the field that need a constant attention and support. The treatment of solid waste has proved as one of the most complex and expensive problems nowadays. It getting worst as volume of waste generated from the household, factories, offices etc. continues to increase time by time. (Malaysia Quality of Life Report, 2002)

According to Malaysia Quality of Life Report, 2002, Malaysia's quality of life has improved by 8.4% from 1990 to 2000, but there were significant declines in environmental quality and public safety. Malaysia is a rapidly-developing country with a growing economy. The increases in material well-being and economic activity over the past 25 years have resulted in a growing waste problem, which has come to the attention of policymakers and local authorities as a problem for which their constituencies demand an immediate and sustainable solution.

This scope of study focus on solid waste generated at academic and administration building in Universiti Teknologi Petronas. With an approximate area of 400 hectare and 1000 number of staff, 500 lecturers and 7000 students, solid waste management process should be effective and thoroughly inspected to make sure the hygienic and conducive environment is preserve.

In UTP, solid waste management is under responsibility of Property Management & Maintenance Department, led by *Hj. Ir Aminudin M. Isa* as the *Senior Manager*. Two contractors appointed in handling solid waste; (1) Azaar Enterprise, (2) Livline Enterprise. Both contractors involved in solid waste handling storage, and processing at assigned place but transfer and transport of solid waste to disposal was appointed to Azaar Enterprise.

1.2 Problem Statement

The problems of solid waste management are growing, and have increased the socio-political awareness over recent years, all over the world. Similarly, in Malaysia, the significant environmental quality deterioration because of pollution and excessive use of resources are becoming a major issue of concerned. The amount of waste generated in Malaysia is increasing from year to year in response to the rapid population growth and escalating urbanization and industrialization in most municipalities. The population growth of Malaysia has increased from 23.27 million in 2001 to 26.75 million people in 2005 with an average annual growth rate of 1.6%. Similarly, the amount of waste generated has increased from 16,200 tonnes per day in 2001 to 19,100 tonnes per day in 2005 with an average of 0.8 kg per capita per day. (Ministry of Housing & Local Government, 2003)

Changes in lifestyle, particularly in the urban areas, have led to more severe waste problems. Packaging of convenient household goods is free flowing and carefree attitude of the society result in huge quantities of waste. Plastics, which are not degradable constitutes the higher proportion of modern day wastes. Most of the waste collected (about 95%) is disposed to landfill. The remaining waste is incinerated, recycled or dumped illegally. The increasing number of solid waste generated has result to a reduction in landfill capacity. The authorities also concern about the impact of landfill operation and the transportation of solid waste. (Ministry of Housing & Local Government, 2003)

Throughout the research, the author had notified several problems regarding solid waste management issues in UTP academic complex. Four major problems have been identified which are; (1) No segregation of wastes in the bin. All types of waste including recyclable material such as paper, aluminum and glass are being dump into the same bin. Food wastes also contribute to hygiene problems whereby it can attract flies and produce a health issue. (2) Uncertainty of waste collection schedule. The load truck did not have a specific waste collection even though they claimed to have collected the waste every day. (3) Inadequacy of waste tank provided in concrete lab as mentioned in Chapter 3.

There is only one container provided for 8.2 tonne of concrete waste. The tank also need to be placed near the lab where truck hauler will have an easy access to collect the waste.(4) Lack of motivation among students in term of reuse, reduce and recycling of solid wastes. Based on random survey conducted, the entire correspondent realized the importance of recycling. However, because of lack in enforcement, the effort was not so effective.

1.3 Objective and Scope of Study

The objective of this study is to identify the management process in handling solid waste generated, investigate the problems related to solid waste management and propose methods to enhance the current system in the university. The scope of study includes 6 academic buildings, according to each engineering faculty department;

(1) Building 1 – Information & Communication Technology/Business Information Systems (IT/IS)
(2) Building 3 – Chemical Engineering Department (CHEM)
(3) Building 13 – Civil Engineering Department (CVE)
(4) Building 16 – Petroleum Engineering Department (PE)
(5) Building 17 – Mechanical Engineering Department (MECH)
(6) Building 23 – Electrical Engineering Department (EE)

The amount and types of waste generated was monitored and the result should determine which approach to be implementing.

source. Processing at the source involves activities such as compaction and yard waste composting. (Bonnie R-M Raj, Iraj Zandi, 2000)

2.2.3 Collection

The functional element of collection includes not only gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be materials processing facility, a transfer station, or a landfill disposal site. (Bonnie R-M Raj, Iraj Zandi, 2000)

2.2.4 Separation, Processing and Transformation of Solid Waste

The recovery of separated materials, the separation and processing of solid waste components, and transformation of solid waste that occurs primarily in locations away from the source of waste generation are encompassed by these functional elements. The separation and processing of waste that have been separated at the source and the separation of commingled wastes usually occur at the materials recovery facility, transfer stations, combustion facilities, and disposal sites. Processing often includes the separation of bulky items, separation of waste components by sizes, using screens, manual separation of waste components, size reduction by shredding, separation of ferrous metals using magnets, volume reduction by compaction and combustion. Transformations processed are used to reduce the volume and weight of waste requiring disposal and to recover conversion products and energy. (Bonnie R-M Raj, Iraj Zandi, 2000)

2.2.5 Transfer and Transport

This functional element involves two steps: (1) the transfer of waste from the smaller collection vehicle to the larger transport equipment and (2) the subsequent transport of the wastes, usually over long distances to a processing or disposal sites. (Bonnie R-M Raj, Iraj Zandi, 2000)

2.2.6 Disposal

The final element in the solid waste management system is disposal. The disposal of wastes by landfilling or landspreading is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from materials recovery facilities (MRFs), residue from the combustion of solid waste, compost, or other substances from various solid waste processing facilities. (Bonnie R-M Raj, Iraj Zandi, 2000)

2.3 Composition of Solid Wastes

Composition is the term used to describe the individual components that make up a solid waste stream and their relative distribution, usually based on percent by weight. Information on the composition of solid wastes is important in evaluating equipment needs, systems, and management programs and plans.

George Tchobanoglous (*Integrated Solid Waste Management, 1993)* has categorized institutional source (schools, universities, hospitals, governmental centers) to have the following types of solid waste; paper, cardboard, plastics, wood, food waste, glass, metals, special waste (including bulky items, consumer electronics, white goods, yard waste collected separately, batteries, oil, and tires). Tchobanoglous (*Environmental Engineering, 1985*) also introduced sampling procedures to predict the composition of solid wastes. Because of the heterogeneous nature of solid wastes, determination of the composition is not an easy task. To asses the total mix of wastes components, the load-count and the mass-volume methods of analysis are recommended. The following technique is recommended where it is desired to assess the individual components within a given waste category.

1. Unload a waste load in a controlled area away from other operations.
2. Quarter the waste load.
3. Select one of the quarter and quarter that quarter.

available, weight data are also recorded. Unit generation rates are determined by using the field data and where necessary published data.

2.4.2 Weight-Volume Analysis

This method of analysis is similar to load-count analysis with the added feature that the mass of each load is also recorded. Unless the density of each waste category is determined separately, the mass distribution by composition must be derived using average density values. In this method, both volume and weight are used for the measurement of solid waste quantities. Unfortunately, the use of volume as a measure of quantity can be misleading. To avoid confusion, solid waste quantities should be expressed in terms of weight.

2.4.3 Material Mass Balance Analysis

The materials mass balance can be formulated as follows:

1. General word statement:

Rate of accumulation of material within the system boundary	=	Rate of flow of material into the system boundary	-	Rate of flow of material out of the system boundary	+	Rate of generation of waste material within the system boundary

2. Simplified word statement:

Accumulation = inflow – outflow + generation

3. Symbolic representation:

$$\frac{dM}{dT} = \sum M_{in} - \sum M_{out} + r_w$$

where :

Step 3: Analyse work procedures

Identify and examine current work procedures for handling materials or energy inputs and outputs:

- For each input, identify and list all procedures in its receipt, handling, storage and use, and
- For each output, identify and list all procedures in its production storage, handling and removal (or disposal).

This step will help to identify points at which changes can be made to minimise waste and/or improve office efficiency and reduce costs.

Step 4: Identify waste management opportunities

Review the analysis of work procedures in Step 3 to find the points at which wastes or contaminants arise. Then identify the opportunities for waste management:

- Eamine the need for the item and particularly its specification — are recyclables being excluded from use or not,
- Examine each point for opportunities to avoid, reduce, reuse or recycle waste,
- Examine the office process to see if changes such as electronic mail for correspondence, can be made to reduce raw material use that leads to waste, and
- For each opportunity, identify any associated costs and savings as well as any special requirements.

It may be that, with current technology, some waste cannot be avoided without excessive cost. The possibility of tax concessions for environmental expenditure should also be explored at this point.

Step 5: Examine the feasibility of each opportunity

Each of the opportunities identified in Step 4 must be examined for its feasibility:

- determine the timeframe, cost, benefits and practicality of each opportunity,
- allocate a priority to each opportunity on the basis of:
    - environmental benefit,
    - net cost,
    - timeframe, and

o practicality,

- list as many of the high priority opportunities as you think you can implement, these are the options.

Tthe savings from implementing one option may be used to offset the costs of another. It is the sum of the whole that is the key to a green office. Try to target as many materials and resources as possible.

Step 6: Draw up a waste management plan

For each option on the priority list:

- Decide on appropriate goals, which should be:
  - o specific, measurable and achievable,
  - o practical and uncomplicated, and
  - o consistent with the organisation's overall policies,
- Decide on a timeframe for each option,
- Set out the necessary steps to implement the option, and
- Nominate the staff responsible for implementation.

Submit the plan to management and staff for endorsement.

Step 7: Implement the waste management plan

When management has endorsed the plan:

- implement each option in accordance with its timeframe,
- monitor progress on a continuing basis and report progress regularly to management and staff, and
- apply any corrective action that is necessary to ensure that goals will be met.

It may become necessary to review goals from time to time, especially if there are unforeseen changes to technology, or other circumstances. Generally, however, goals should not be changed except as a last resort.

3.0 SITE STUDY

University Teknologi Petronas (UTP) is a private university and wholly owned by Petronas. The campus is built on a 4 km² (1,000 acre) site strategically located at Bandar Seri Iskandar, Tronoh, Perak, Malaysia. The scope of this study is mainly on the Academic & Administration complex of UTP.

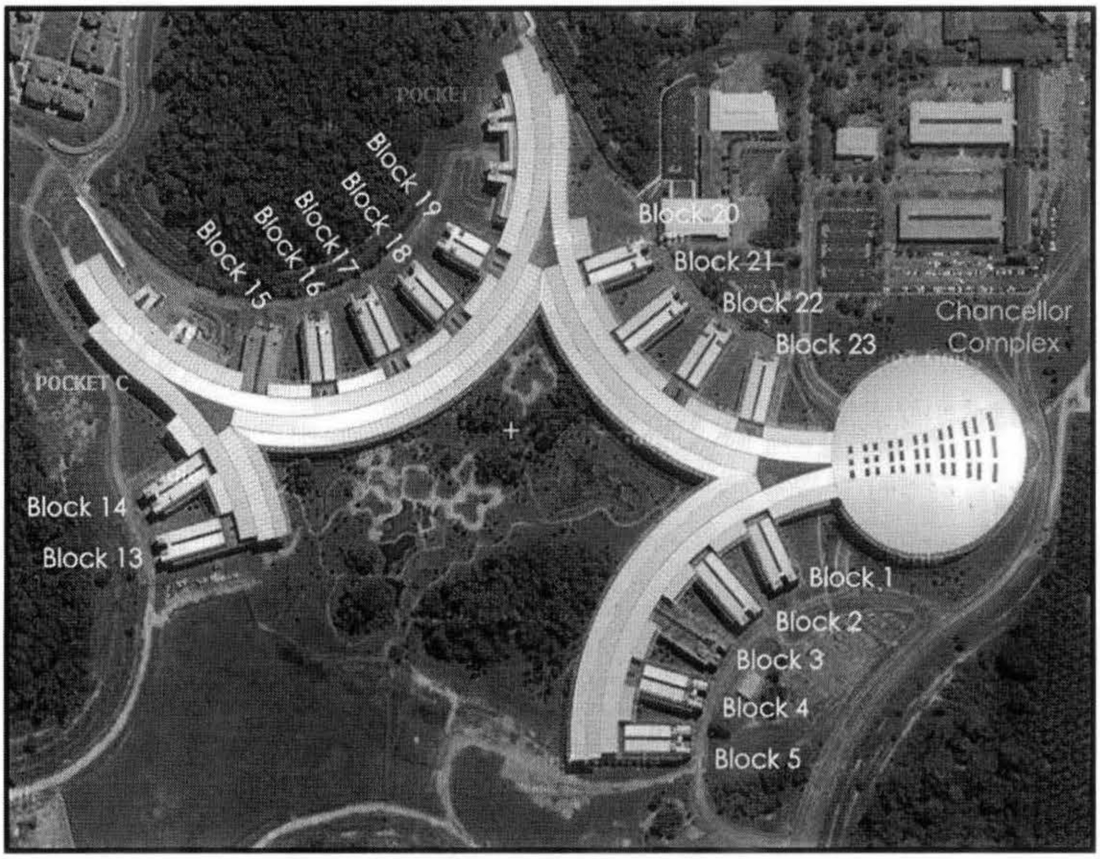


Figure 3.1: UTP Academic Complex layout

Pocket C is an orange building with a slanting foyer look. Cafeteria, clinic, bookshop, prayer rooms and security office are located at the ground floor of the building. The first and second floor of the building consists of 2 computer-aided design theatres and 4 lecture theaters.

Pocket D is a blue building with the same architectural design as Pocket C. The ground floor of the building is where cafeteria, the UTP Gallery, and the Student Card Centre are located. The first floor and second floor are seated by six lecture theatres.

Along the perimeter of each semi-circle, there are several buildings at the outer of the new academic complex. There are 16 buildings are available and are in use now. The numbered buildings are generally similar in design. The ground, first and second floor of the buildings consists of laboratories and discussion rooms. The third floor of the buildings is always the lecturers' offices.

The chancellor complex houses the chancellor hall, the information resource centre (library), security department, finance department and some of the other important administrative department offices.

The author has done a survey of UTP waste management in the academic building area. Based on functional elements of SWM, the survey can be divided into waste handling and collection, storage, transfer and transport, and lastly disposal.

3.1 Waste Generation, Handling and Storage

Solid waste generated in the academic complex comprises of several categories such as domestic waste, laboratory waste, food waste, pharmaceutical waste and office waste. UTP has applied several approaches on handling solid waste issue. Every building including the pockets and chancellor complex provided with a waste storage container. (Figure 3.2)

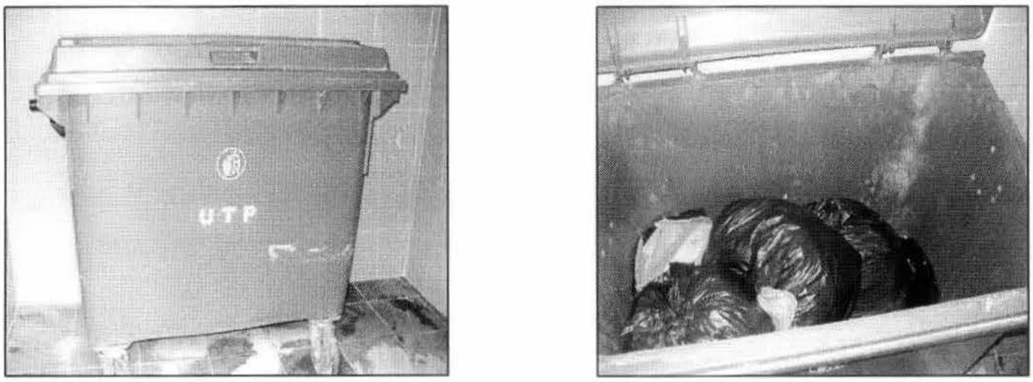


FIGURE 3.2: WASTE CONTAINER PLACED IN EACH BUILDING

Fig 3.2 (a) Waste Container in Block 1 *Fig 3.2 (b) Solid Waste in container*

In laboratories, there are two type of waste produced. First, is waste in form of liquid and second is solid waste. Liquid waste such as chemical solution was been handled properly and stored in a special container. It will be collected based on collect-per-call basis. Solid waste such as glass and rubber are stored safely to make sure there are no casualties happen.

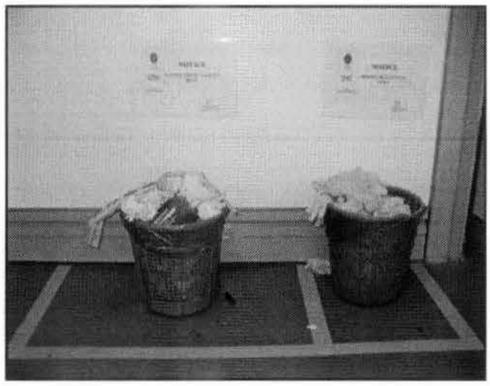


FIGURE 3.3: EXAMPLE OF WASTE GENERATED IN LABORATORY

Fig 3.3 (a): Glass type of waste stored in

Fig 3.3(b): Photo of bin provide in laboratory

Fig 3.3(c): Rubber type of waste

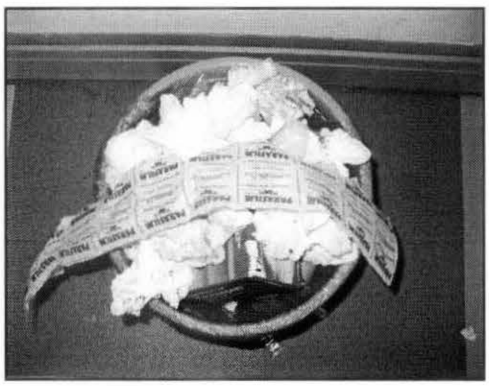


Fig 3.3(d): Paper type of waste

3.2 Waste collection, transfer, and disposal

Collection of waste is carried out by the contractor (Azar Enterprise) appointed by the university. The contractor has placed 2 to 3 cleaner personnel in each block and building. The janitors are supposed to collect all the solid waste in the garbage bins throughout the building and gather them all in the container provided. A lorry will come and collect the garbage everyday at 11 am (Figure 3.4). Then they will be disposed at the landfill in Batu Gajah. (Figure 3.5). The landfill has been operating for 8 years since 2000 when the District Council of Kinta Barat approved a 6-hectar land to be use. Located in Batu Tiga, this landfill still able to sustain wastes from all over the district and yet to be reclaim.

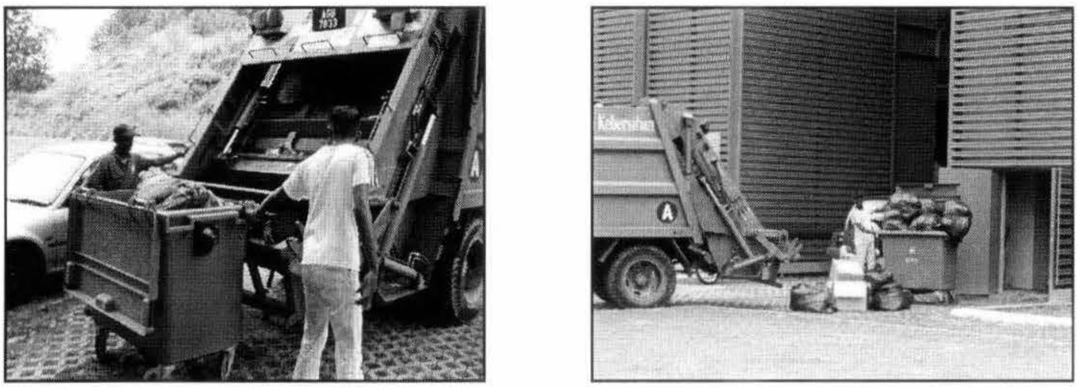


FIGURE 3.4: COLLECTION OF WASTE BY AZAR ENTERPRISE

However some villagers nearby had complained about the non-strategic location of this landfill. They claimed that this landfill is very close with their residential and they are having some difficulties regarding the bad odour that comes from the landfill. The landfill used to be a tin mine field and there are there mine lake observed in the landfill area. Leachates that are drain or seep through the water table underground the landfill is worried could enter the lake and the small river nearby.

Fig 3.5 (a): Signboard of Kinta Barat District Landfill

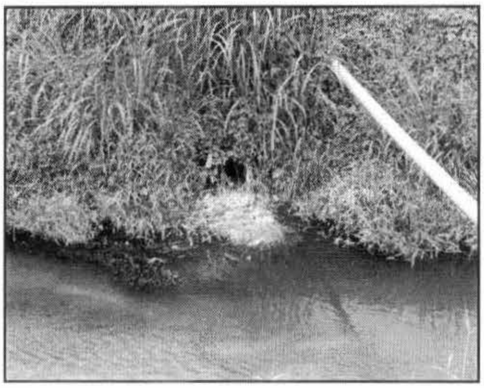


Fig 3.5 (b): Leachate flowing into the river

Fig 3.5 (c): Photo of waste at the landfill

Fig 3.5 (d): Landfill near a transmission line.

FIGURE 3.5: PHOTOS OF LANDFILL AT BATU 3, BATU GAJAH

For a heavy weight waste such as concrete waste, there has been a problem in transporting it to the dumping site. The contractor did not want to take risk of damaging their vehicle because of heavy weight of the concrete. They only provide a truck if the lab technician request them to take the concrete waste. This results in inadequacy space of the container and excessive dumping of concrete waste material (Figure 3.6).

FIGURE 3.5: INADEQUACY OF CONCRETE WASTE CONTAINER TANK AT CONCRETE LABORATORY (BLOCK 13)

4.0 METHODOLOGY

4.1 Research project work flow

The research has involved several steps and stages. The summary of the research project work flow can be review in the chart (Figure 4.1)

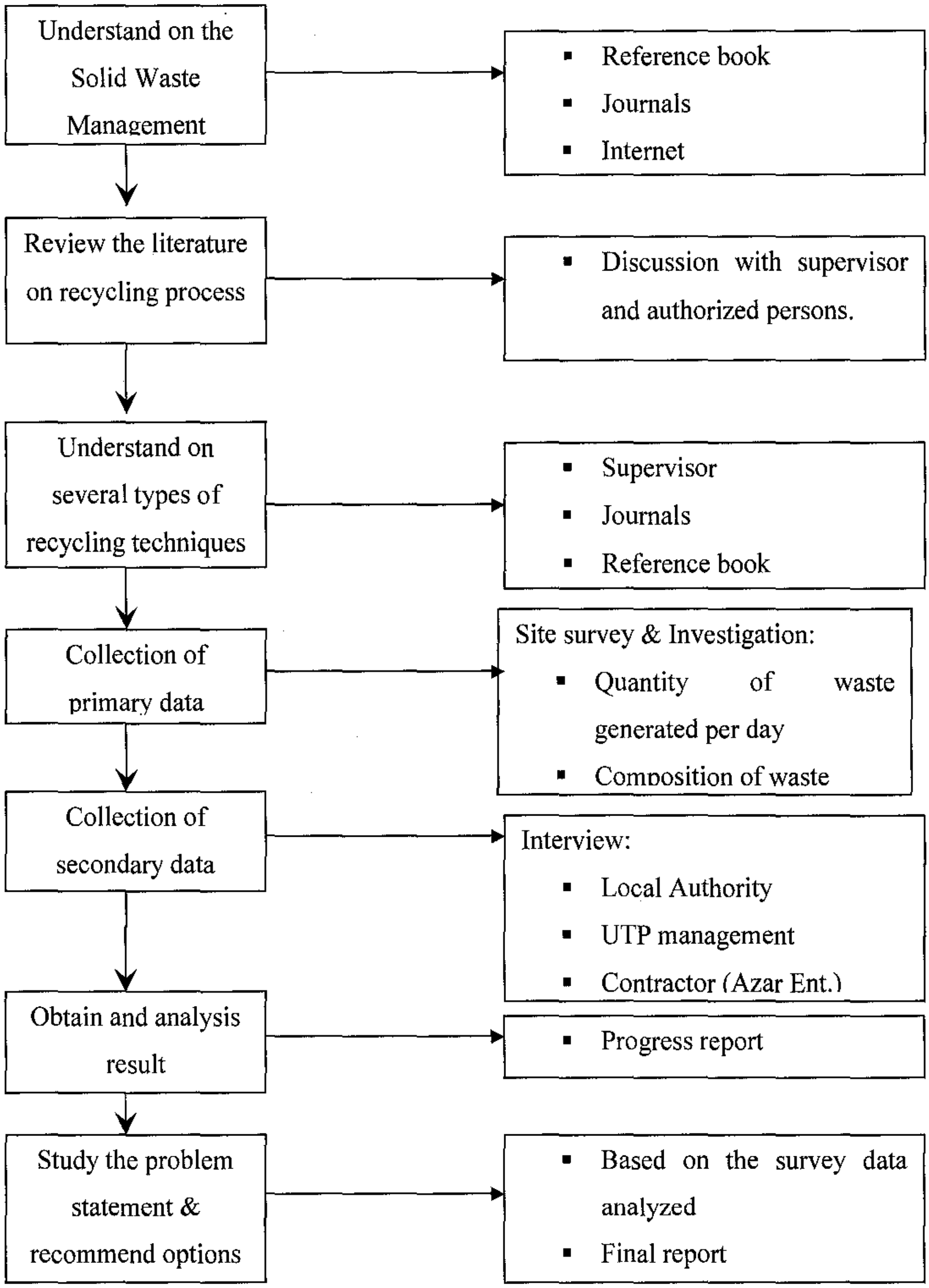


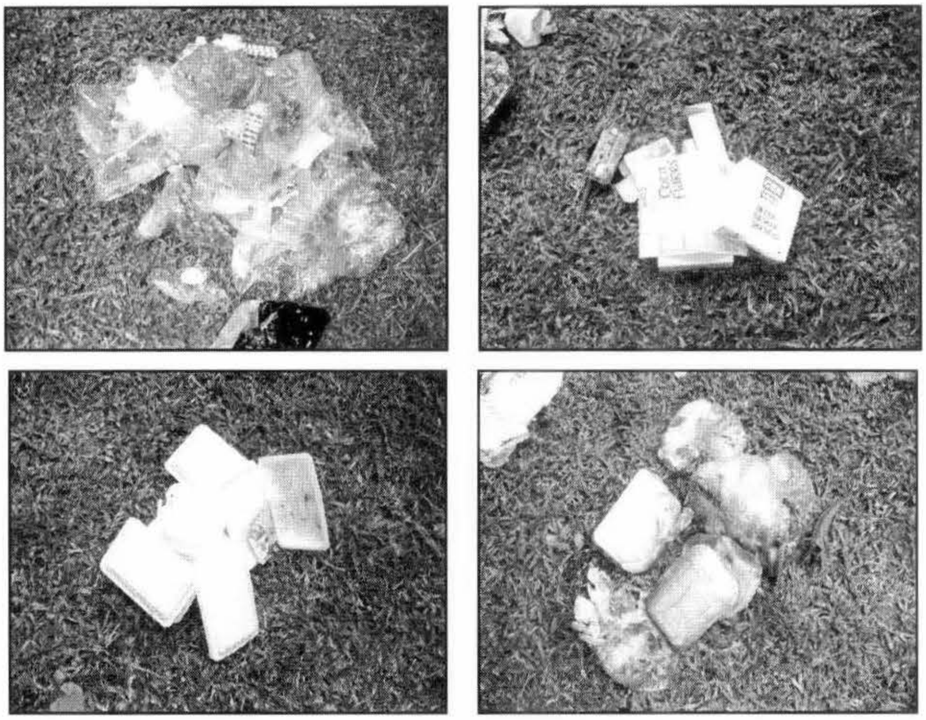
FIGURE 4.1: RESEARCH PROJECT FLOW

4.2 Method of Solid Waste Analysis in UTP Academic Complex

One of the objectives in this study was the composition and quantities of solid waste generated daily in UTP academic buildings. The author has divided that task into two different periods; (1) during semester break, (2) and during academic session semester. This was given more distribution that is comprehensive on solid waste analysis. The author used the combination of methods introduce by George Tchobanoglous. The workflow can be translated into this diagram:

(Unload the waste)

(Quarter the quartered waste load)



(Separate the waste into preselected components)

Find the weight, volume and mass of total and each waste component.

Marked the samples as done so that there would not be overlapping in the next test.

Because of tight schedule, the test was conducted systematically. There a three samples needed for each building. Each and every samples need to be test of their quantities and composition. In each alternate day, one sample from three buildings is tested (one sample does not mean one bag of waste, but it means the total waste that have been generated on that day). For example, on Monday, bags of solid waste marked as **Sample 1** is tested from Building 1, going to Building 3 and lastly to Building 13. Then, on Wednesday, same procedure applied to **Sample 2** except the route will be from Building 13, going to Building 3 and lastly to Building 1 to avoid irregularities based on truck collection routing. Similarly, on Friday **Sample 3** was tested. However, during academic semester session, the test was conducted in two days for one sample. This is because the waste generation has greatly increased. In other word, the test was conducted three days per week for two weeks to complete in semester break period and four weeks in academic semester period. To make it clear, the schedule for sampling was shown in Table 1:

Table 1: Schedule of waste sampling

	Week 1			Week 2		
	Building 1	Building 3	Building 13	Building 16	Building 17	Building 23
Sample 1	☆ →	☆ →	☆	☆ →	☆ →	☆
Sample 2	☆	← ☆	← ☆	☆	← ☆	← ☆
Sample 3	☆ →	☆ →	☆	☆ →	☆ →	☆

5.0 RESULTS & DISCUSSIONS

The results of the solid waste composition and quantities analysis were computed into two categories; (1) Semester-break, (2) Semester-open. Volume of one bag of solid waste = $0.10625m^3$.The volume and weight of the solid waste are as follows:

5.1 Concrete Lab Waste (Building 13)

Excessive concrete waste generation and improper management of the waste has been addressed in Chapter 3 (Figure 3.5). This is a special case and the load generation study has been conducted separately from ordinary solid waste.

5.1.1 Estimation of concrete waste in the container

The volume of concrete waste tank container = 2.1m x 1.5m x 1.0 m

=$3.15\ m^3$

The density of normal concrete = $2{,}446\ kg/m^3$

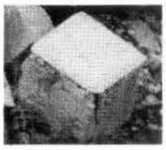
$$\rho = \frac{m}{V}$$

Mass of concrete waste in the container = $2{,}446\ kg/m^3 \times 3.15\ m^3$

= 7,705 kg

5.1.2 Estimation of excessive concrete waste nearby the container:

Mass of concrete cube = 2.4kg x 33 = 79.2kg



Mass of cocrete cylinder = 3.77 kg x 19 = 71.63kg

Mass of other types of concrete waste = 350kg

Total concrete waste = 7,705+79.2+71.63+350 = **8,206kg = 8.2 tonne**

Shui, Zhonghe ; Xuan, Dongxing ; Wan, Huiwen ; Cao, Beibei (2008) have produced a technical report on rehydration reactivity of recycled mortar from concrete waste experienced to thermal treatment. In this report, they have issued the importance of treating concrete waste. It is desirable to completely recycle concrete waste in order to protect the natural resources and reduce the environment pollution.

The recycling of concrete wastes in construction has been investigated extensively in the past decades due to the environment pollution and exhaustion of natural resources. In some countries, many technologies for recycling concrete wastes have been developed and some recycling specifications have been established as well. In the process of the practical reutilization, to recycle concrete waste requires further breaking and crushing of demolished concrete. Generally, two typical grades of crushed concrete aggregates can be produced and classified by size gradation. One is the coarse recycled concrete aggregates (CRCA), part of which can be used in new concrete or road base materials. The other is the fine recycled concrete aggregates (FRCA) or recycled mortar from crushed concrete waste whose sizes are smaller than 5 mm. (Shui, Zhonghe ; Xuan, Dongxing ; Wan, Huiwen ; Cao, Beibei, 2008)

A method for recycling concrete waste includes the steps of:

a) heating the concrete waste to provide a measure of fragility to the concrete waste;

b) milling and sieving the heated concrete waste to separate coarse aggregate from the concrete waste; and

c) milling and sieving a remaining portion of the concrete waste remaining after separation of the coarse aggregate to separate the remaining portion of the concrete waste into a cement-containing fraction and fine aggregate.

Further studies of recycling need to be done in the future in order to manage the concrete waste to reduce the excessive concrete waste in Building 13.

From the raw data, several parameters of solid wastes were obtained and analyzed for a better understanding of their management.

5.2 Semester-Break

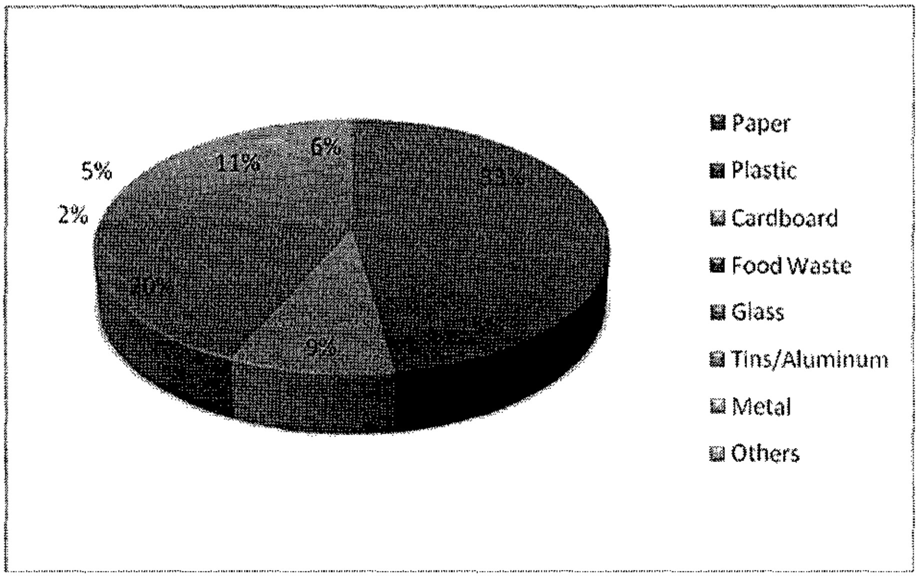


FIGURE 5.1: WASTE COMPOSITION DURING SEMESTER BREAK

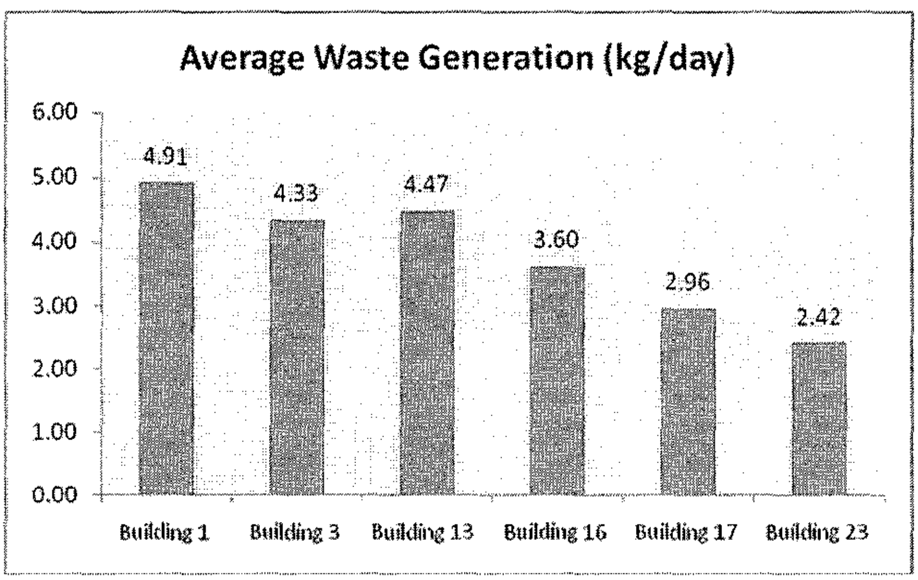


FIGURE 5.2: AVERAGE WASTE GENERATION DURING SEMESTER BREAK

From Figure 5.1 it is clearly indicate that paper has the most percentage on the total of solid waste (33%), follow by food waste (20%), plastic (15%), metal (11%), cardboard (9%), uncategorized waste (6%), tins/aluminium (5%) and glass (2%). This is an average value from all six buildings. However, the actual percentage varied for each building. Note that Sample 1 has a higher value from Sample 2 and Sample 3 because it is the accumulation from the previous generation and thus does not visualize the waste generation per day. From Figure 5.2, the average weight of waste generated per day (kg/day) also varies from each building with Building 1 (4.91kg/day), Building 3 (4.33kg/day), Building 13 (4.47kg/day), Building 16 (3.6kg/day), Building 17 (2.96kg/day) and Building 23 (2.42kg/day). Building 1 shows a high waste generation per day because there was an amount of metal found and merely because of some construction that took place in that area. The total average value of waste generated per day in all building is 3.78 kg/day.

5.3 Semester-Open

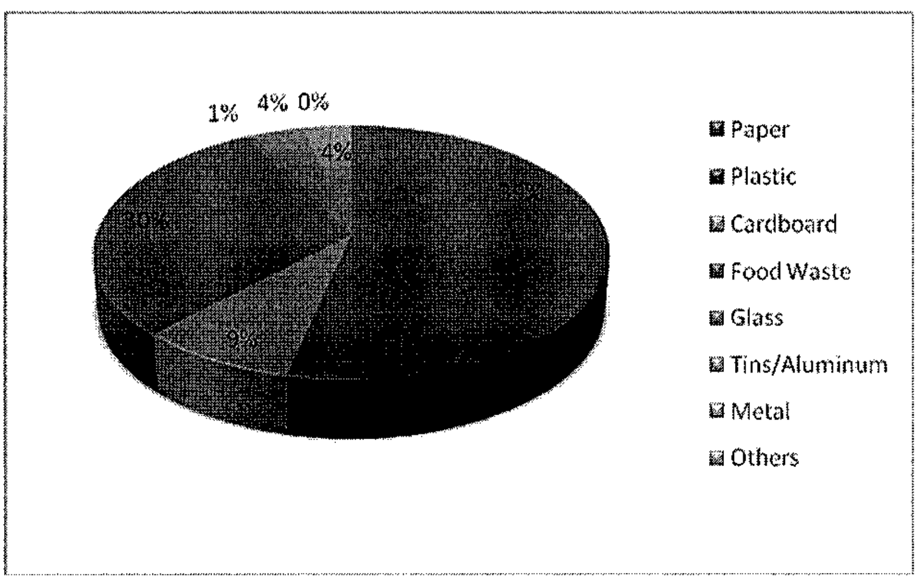


FIGURE 5.3: WASTE COMPOSITION DURING ACADEMIC SEMESTER PERIOD

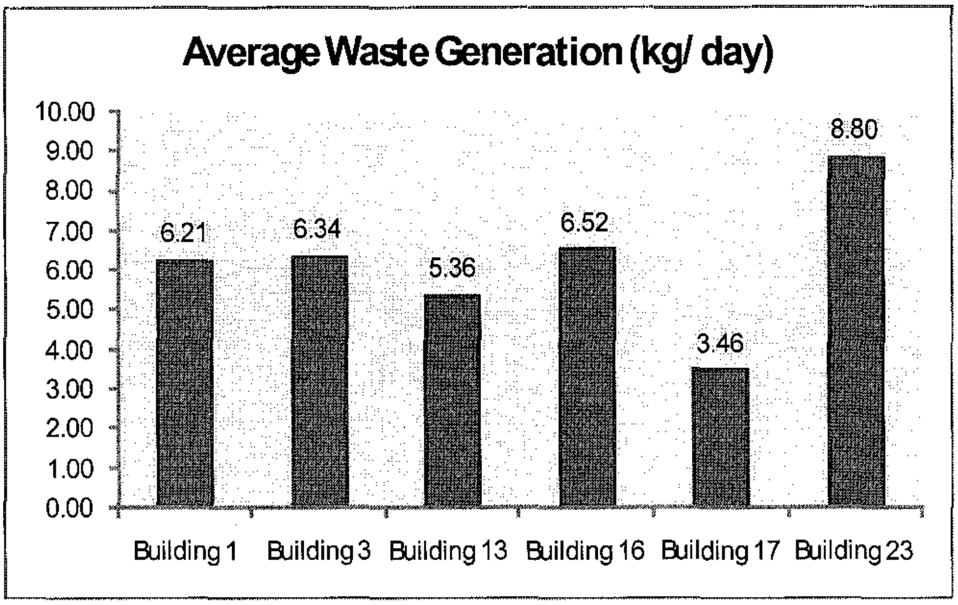


FIGURE 5.4: AVERAGE WASTE GENERATION DURING ACADEMIC SEMESTER PERIOD

From Figure 5.3 it still show that paper is the largest composition with an increase to 39%, follow by food waste (30%), plastic (15%), cardboard (9%), uncategorized waste (4%), tin/aluminium (4%), Glass (1%) and no metal found during the test. The test was conducted with a constraint environment. Compared to the waste generated in semester break, the generation of waste has greatly increased and it took longer time for the author to conduct the test (Figure 5.4). Different result was achieved in term of waste generation in Building 1 (6.21kg/day), Building 3 (6.34kg/day), Building 13 (5.36kg/day), Building 16 (6.52kg/day), Building 17 (3.46kg/day) and a significant increase to Building 23 (8.8kg/day). This is because Building 23 caters the waste generated from Academic Complex and the building itself.

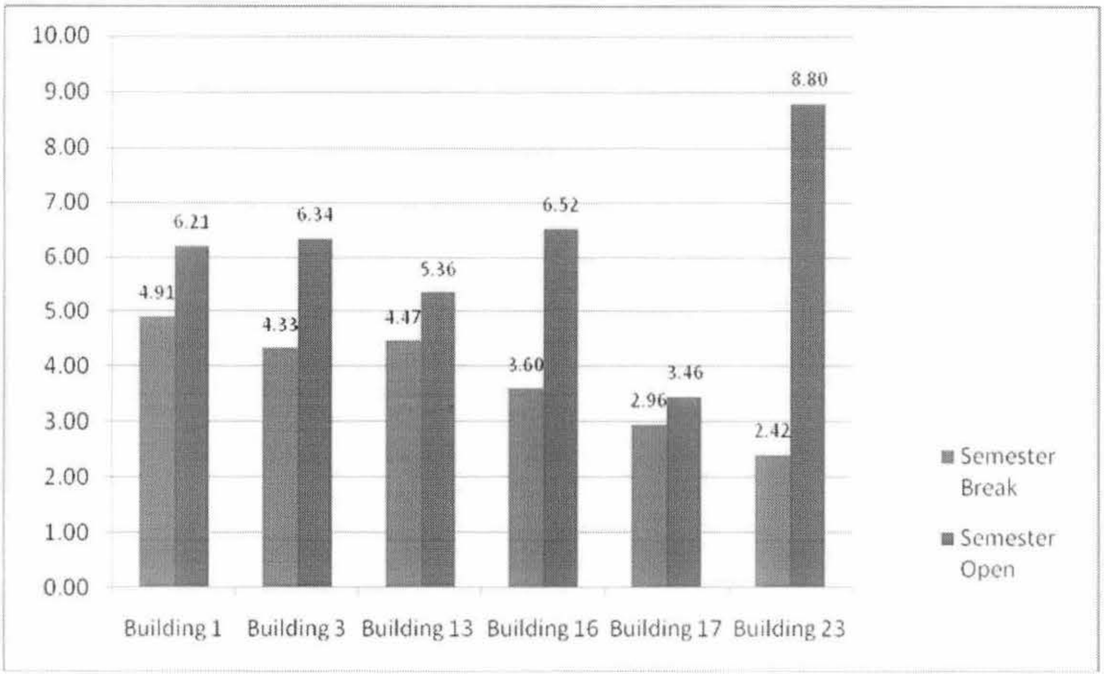


FIGURE 5.5: COMPARISON OF WASTE GENERATION DURING SEMESTER-BREAK & SEMESTER PERIOD

Figure 5.5 shows the comparison of waste generated during semester break and semester open. Clearly, there has been a significant increase for waste generated during academic semester session in all department buildings. This is obviously because of population increase in the number of student that contributes to the waste generation. Building 23 has been a dominant in this waste generation because it cater not only wastes from the building itself but also the wastes from the chancellor complex including the library. However, this waste load distribution does not take concrete waste in Building 13 into consideration, as its amount is way much higher (8.2 tonne) compared to the other buildings.

6.0 RECOMMENDATIONS & CONCLUSION

Based on problems stated, several approaches and recommendation have been developed for UTP academic complex. A suitable approach related to alleviate the problems and to provide a better waste management are as follow:

- Reorient and retrain staff & lecturers and make them partners in recycling efforts.
- Reorganize the system of providing recycling containers and recyclable collection services to a mandatory/routine university-wide system. This should include provision of at a minimum, newspaper, mixed office paper, corrugated board, and beverage container in all buildings.
- Standardize the location, size and design of recycling containers and collection schedules at buildings.
- Provide bins or other containers for recyclables in all academic department offices, pocket halls and classes.
- Evaluate outsourcing possibilities for collection, sorting and marketing of commingled recyclables from the academic complex.
- If collecting and selling commingled recyclables is profitable, UTP may consider provide commuter-recycling stations on the major spots.
- Newspaper and "office pak" mixed paper are collected separately in bags or boxes. Recycling bins are located near each trash dumpster.
- Provide extra bin or container for the waste that identified excessive.
- Make a public commitment to "environmentally conscious" practices.
- Default settings on all university photocopy machines/printers should provide double-sided printing.
- Further studies of recycling need to be done in the future in order to manage the concrete waste to reduce the excessive concrete waste in Building 13.
- Reduce newspaper waste through on-line subscriptions for readership programs.

- Explore the potential of UTP to provide and support recycling programs on a long-term basis.

In conclusion, all the recommendations above should be taken into consideration by UTP management so that it can help to make a better waste management. All wastes that were produced everyday will keep increasing unless we do something to reduce, reuse or recycle them. We have to bear in our mind that environment is our responsibility and that we have to protect it so that the future generation will not suffer because of our doings.

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APPENDICES

Appendix 1: Semester-Break Solid Waste Analysis

Building: 1
Department: IT/IS
Total Volume (m3): 1.38125
Total Weight (kg): 14.725

Composition	Sample 1	Sample 2	Sample 3
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	3.77	1.14	0.39
Plastic	0.83	0.06	0.47
Cardboard	1.17	0	0
Food Waste	1.05	1.105	0.62
Glass	1.07	0	0
Tins/Aluminum	0	0	0.42
Metal	0	0	1.15
Others	1.13	0.32	0.03
TOTAL	**9.02**	**2.625**	**3.08**
No of Bags	8	2	3

Building: 3
Department: CHEM
Total Volume (m3): 1.16875
Total Weight (kg): 12.99

Composition	Sample 1	Sample 2	Sample 3
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	1.79	0.26	0.12
Plastic	2.05	0.15	0.04
Cardboard	0.78	0	0
Food Waste	2.58	0.03	0.25
Glass	0	0	0
Tins/Aluminum	0.33	0	0
Metal	4.21	0	0
Others	0.06	0.32	0.02
TOTAL	**11.8**	**0.76**	**0.43**
No of Bags	9	1	1

Building: 13
Department: CVE

Total Volume (m3): 0.95625
Total Weight (kg): 13.415

Composition	Sample 1	Sample 2	Sample 3
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	3.56	1.44	0.88
Plastic	0.71	0.06	1.47
Cardboard	0	0	1.23
Food Waste	1.02	1.105	0.65
Glass	0	0	0
Tins/Aluminum	0.62	0	0.05
Metal	0	0	0
Others	0.13	0.32	0.17
TOTAL	**6.04**	**2.925**	**4.45**
No of Bags	4	2	3

Building: 16
Department: PE
Total Volume (m3): 0.85
Total Weight (kg): 10.81

Composition	Sample 1	Sample 2	Sample 3
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	2.01	0.87	0.22
Plastic	1.56	0.33	0.64
Cardboard	0.95	0	0
Food Waste	0.42	0	1.06
Glass	0.02	0	0
Tins/Aluminum	0.81	0	0
Metal	1.13	0	0
Others	0.13	0.11	0.55
TOTAL	**7.03**	**1.31**	**2.47**
No of Bags	5	1	2

Building: 17
Department: MECH

Total Volume (m3): 0.85
Total Weight (kg): 8.88

Composition	Sample 1	Sample 2	Sample 3
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	2.61	0.09	0.44
Plastic	0.69	0.61	0
Cardboard	1.17	0	0
Food Waste	1.05	0.43	0.21
Glass	0	0	0
Tins/Aluminum	1.06	0	0.05
Metal	0	0	0
Others	0.13	0.32	0.02
TOTAL	**6.71**	**1.45**	**0.72**
No of Bags	5	2	1

Building: 23
Department: EE
Total Volume: 0.6375
Total Weight (kg): 7.26

Composition	Sample 1	Sample 2	Sample 3
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	2	0.6	0.21
Plastic	0.2	0.12	0.09
Cardboard	0.15	0.3	0.42
Food Waste	1.56	0.22	0.03
Glass	0	0	0
Tins/Aluminum	0.05	0	0
Metal	1.2	0	0
Others	0.06	0.02	0.03
TOTAL	**5.22**	**1.26**	**0.78**
No of Bags	4	1	1

Appendix 1.1: Average waste quantities (kg/day) & Waste composition (%) for each building

Composition	Building 1		Building 3		Building 13		Building 16		Building 17		Building 23		Sub-TOTAL	
	Ave. Weight (kg/day)	Percentage	Ave. Weight (kg/day)	Percentage	Ave. Weight (kg/day)	Percentage	Ave. Weight (kg/day)	Percentage	Ave. Weight (kg/day)	Percentage	Ave. Weight (kg/day)	Percentage	**Total Weight (kg)**	**Percentage**
Paper	1.77	36%	0.72	17%	1.96	44%	1.03	29%	1.05	35%	0.94	39%	**1.24**	**33%**
Plastic	0.45	9%	0.75	17%	0.75	17%	0.84	23%	0.43	15%	0.14	6%	**0.56**	**15%**
Cardboard	0.39	8%	0.26	6%	0.41	9%	0.32	9%	0.39	13%	0.29	12%	**0.34**	**9%**
Food Waste	0.93	19%	0.95	22%	0.93	21%	0.49	14%	0.56	19%	0.60	25%	**0.74**	**20%**
Glass	0.36	7%	0.00	0%	0.00	0%	0.01	0%	0.00	0%	0.00	0%	**0.06**	**2%**
Tins/Aluminum	0.14	3%	0.11	3%	0.22	5%	0.27	8%	0.37	13%	0.02	1%	**0.19**	**5%**
Metal	0.38	8%	1.40	32%	0.00	0%	0.38	10%	0.00	0%	0.40	17%	**0.43**	**11%**
Others	0.49	10%	0.13	3%	0.21	5%	0.26	7%	0.16	5%	0.04	2%	**0.22**	**6%**
TOTAL	**4.91**	**100%**	**4.33**	**100%**	**4.47**	**100%**	**3.60**	**100%**	**2.96**	**100%**	**2.42**	**100%**	**3.78**	**100%**

Appendix 2: Semester-Open Solid Waste Analysis

Building: 1
Department: IT/IS
Total Volume (m3): 2.01875
Total Weight (kg): 18.644

Composition	Sample 1	Sample 2	Sample 3
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	2.3	3.25	1.64
Plastic	1.254	1.02	2.21
Cardboard	0	0	0.21
Food Waste	1.2	1.6	0.69
Glass	0	0.65	0
Tins/Aluminum	2.31	0	0
Metal	0	0	0
Others	0.3	0	0.01
TOTAL	**7.364**	**6.52**	**4.76**
No of Bags	10	5	4

Building: 3
Department: CHEM
Total Volume (m3): 1.9125
Total Weight (kg): 19.03

Composition	Sample 1	Sample 2	Sample 3
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	3.3	2.4	2.3
Plastic	1.5	0.1	0.04
Cardboard	0.7	1.31	2.5
Food Waste	1.2	1.1	1.25
Glass	0	0	0
Tins/Aluminum	0.2	0	0.6
Metal	0	0	0
Others	0.01	0.02	0.5
TOTAL	**6.91**	**4.93**	**7.19**
No of Bags	5	5	8

Building: 13
Department: CVE

Total Volume (m3): 1.4875
Total Weight (kg): 16.07

Composition	**Sample 1**	**Sample 2**	**Sample 3**
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	2.3	2.5	2.4
Plastic	0.7	0.6	1.6
Cardboard	0	0.1	0.6
Food Waste	1.6	0.9	2.1
Glass	0	0	0
Tins/Aluminum	0	0.06	0.2
Metal	0	0	0
Others	0.16	0.24	0.01
TOTAL	**4.76**	**4.4**	**6.91**
No of Bags	4	4	6

Building: 16
Department: PE
Total Volume (m3): 1.9125
Total Weight (kg): 19.56

Composition	**Sample 1**	**Sample 2**	**Sample 3**
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	2.6	5.6	1.5
Plastic	1.5	0.15	0.9
Cardboard	0.6	0	0
Food Waste	2.6	2.6	1.4
Glass	0	0	0
Tins/Aluminum	0	0	0
Metal	0	0	0
Others	0	0.11	0
TOTAL	**7.3**	**8.46**	**3.8**
No of Bags	7	8	3

Building: 17
Department: MECH
Total Volume (m3): 0.85
Total Weight (kg): 10.38

Composition	Sample 1	Sample 2	Sample 3
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	0.54	0.3	1.1
Plastic	0	0.5	0.4
Cardboard	0	0	0
Food Waste	2.3	1.5	1.02
Glass	0	0	0
Tins/Aluminum	0.32	0	0
Metal	0	0	0
Others	1.1	1.3	0
TOTAL	**4.26**	**3.6**	**2.52**
No of Bags	4	3	1

Building: 23
Department: EE
Total Volume (m3): 2.7625
Total Weight (kg): 26.41

Composition	Sample 1	Sample 2	Sample 3
	Weight (kg)	Weight (kg)	Weight (kg)
Paper	4.1	2.1	2.3
Plastic	2.3	1.2	0.4
Cardboard	1.2	0.7	1.6
Food Waste	3.2	3.7	3.1
Glass	0.1	0	0
Tins/Aluminum	0	0	0.3
Metal	0	0	0
Others	0.06	0.02	0.03
TOTAL	**10.96**	**7.72**	**7.73**
No of Bags	10	8	8

Appendix 2.1: Average waste quantities (kg/day) & Waste composition (%) for each building

Composition	Building 1		Building 3		Building 13		Building 16	
	Ave. Weight (kg/day)	Percentage	Ave. Weight (kg/day)	Percentage	Ave. Weight (kg/day)	Percentage	Ave. Weight (kg/day)	Percentage
Paper	2.40	39%	2.67	42%	2.40	45%	3.23	50%
Plastic	1.49	24%	0.55	9%	0.97	18%	0.85	13%
Cardboard	0.07	1%	1.50	24%	0.23	4%	0.20	3%
Food Waste	1.16	19%	1.18	19%	1.53	29%	2.20	34%
Glass	0.22	3%	0.00	0%	0.00	0%	0.00	0%
Tins/Aluminum	0.77	12%	0.27	4%	0.09	2%	0.00	0%
Metal	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Others	0.10	2%	0.18	3%	0.14	3%	0.04	1%
TOTAL	6.21	100%	6.34	100%	5.36	100%	6.52	100%

Building 17		Building 23		Sub-TOTAL	
Ave. Weight (kg/day)	Percentage	Ave. Weight (kg/day)	Percentage	**Total Weight (kg)**	**Percentage**
0.65	19%	2.83	32%	**2.36**	**39%**
0.30	9%	1.30	15%	**0.91**	**15%**
0.00	0%	1.17	13%	**0.53**	**9%**
1.61	46%	3.33	38%	**1.84**	**30%**
0.00	0%	0.03	0%	**0.04**	**1%**
0.11	3%	0.10	1%	**0.22**	**4%**
0.00	0%	0.00	0%	**0.00**	**0%**
0.80	23%	0.04	0%	**0.22**	**4%**
3.46	100%	8.80	100%	**6.12**	**100%**