

# Management of Solid waste generation in cafeterias of Endayesus campus of Mekelle University, Ethiopia

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**ABSTRACT :** This study on the quantification and characterization of solid waste generated in selected private and government cafeterias in Endayesus campus of Mekelle university, Ethiopia was carried out during May to August 2018. The government cafeterias mainly provide service to students and the private cafeterias to the staff, some students and visitors of the university. Besides quantification and characterization of waste, information on waste management practices followed by the cafeterias were collected through a survey among cafeteria managers. It was found that the total waste generated by the cafeterias was 2076.2 kg per day and 0.211 kg per day per person, of which 98.4 per cent was of organic type. Further, an average of 505.34 numbers of plastic bottles was generated daily from the cafeterias. Whereas the average generation of waste per day per person of private cafeteria was 0.104 kg that from government cafeteria was 0.317kg. Government cafeteria was found to produce higher quantity of waste per person per day than private cafeteria. A positive correlation of 0.986 was obtained between number of customers and quantum of waste generated in cafeterias. Besides, the diversity of wastes was higher for private cafeteria than government cafeteria. Although quantitative waste reduction was noticed on Friday and Saturday it was not statistically significant. All waste items except left over food were found stored together as mixed waste in cafeterias before disposal. No waste segregation and processing of wastes were done in the campus. The necessity of waste segregation, recycling and reduction of food waste and recycling or reuse of plastic bottles is stressed in the study for better waste management.

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Mekelle university, Ethiopia has five campuses spread over the city of Mekelle. Endayesus is the Main campus. This campus has set up eight cafeterias to meet the food service needs of the university community, including teaching and supporting staff, students, daily labourers and visitors. These cafeterias generally function by self service of the customers but sometimes by table service. There are two

types of cafeterias functioning in the campus: Private cafeteria and Governmental cafeteria. Private cafeterias, offering a variety of food items to the staff, some students and visitors to the university, are owned by private entrepreneurs. These cafeterias work on six days of the week, namely, Monday to Saturday. Generally Saturday and Sunday are weekend holidays to the university. Mekelle university Endayesus campus is a residential

one where thousands of students stay in the dormitories and they are provided with food from cafeteria called governmental cafeteria which works on all days of the week. Obviously these cafeterias are major sources of solid waste generation in the campus. Other sources of solid waste are various offices, dormitories of students and business centers in the campus.

Similar to municipalities higher educational institutions generate solid wastes. Armijo de Vega *et al.* (2009) stated that universities as centers of learning have a moral and ethical obligation to act responsibly towards the environment by judiciously managing wastes generated in campuses. The present study on the generation and characterization of solid waste was undertaken, also keeping in mind the views expressed by Smyth *et al.* (2010) that “Prior to making an assessment of any solid waste management of any university campus, quantification and characterization of a campus solid waste stream is regarded as a critical first step towards developing successful and effective waste management strategies across university campuses”. A number of studies worldwide have been carried out on solid waste generation of university campuses and their management practices (Saadat *et al.*, 2012; Rajamanikam and Poyyamoli, 2014; Ezeah *et al.*, 2015 and Alias *et al.*, 2017). Higher education institutions are regarded as small municipalities due to their size, high population and many activities undertaken in their campuses (Zhang *et al.*, 2011). Literature review showed that only fragmentary studies have been conducted with respect to waste management in educational institutions of Ethiopia (Mengesha and Dessalegn, 2014; Aragaw *et al.*, 2016 and Kassaye, 2018). Evidently, these studies have not been concentrated on waste quantification or characterization. Likewise no such investigations are known from Mekelle university campuses. The objective of the present study, therefore, is to quantify and characterize the wastes generated from the cafeterias of Endayesus campus of Mekelle university. Data on waste characterization and quantification can be used in identifying the amount and potential of reusable and recyclable types of wastes and in further processing them for resource recovery. It is expected that the results of this research would provide the university administration, stakeholders and university community baseline information to develop suitable strategies for a better solid waste management system

in future.

## EXPERIMENTAL METHODOLOGY

### Sampling sites and sampling procedures:

Mekelle university endayesus campus is located in Tigray region of Ethiopia at longitude and latitude of 13°28'46.4"N 39°29'04.0"E. In Mekelle university Endayesus campus there are eight cafeterias *viz.*, Cafeteria 1 which is attached to the College of natural and computational science—CNCS, mainly catering to the staff of the college; Cafeteria 2 (*Almi*) located around the Student’s council, mostly serving non café students (students who didn’t get service in the government cafeteria, instead, received money in cash for food) and masters students; Cafeteria 3 (EIT-M) located around the Ethiopian Institute of Technology – Mekelle and used by staff members of the institute and some students; Cafeteria 4, Senior student’s cafeteria serving senior students of degree year two and above; Cafeteria 5 (*Dyana*), located in between the female and male student’s dormitory and most of its customers are undergraduate students; Cafeteria 6 (*Agri*), around the College of Dry land Agriculture and Natural Resources Management that gives service for staff members of the college and other customers; Cafeteria 7 (*Jambo*), found around the Institute of Climate and Society; Cafeteria 8 (Fresh) serving Muslim and fresh students. Of which two, Fresh (Cafeteria 8) and senior cafeteria (Cafeteria 4) are governmental and the rest six (cafeteria 1, cafeteria 2, cafeteria 3, cafeteria 5, cafeteria 6 and cafeteria 7) are private (Fig. A).

In the present study 4 cafeterias, three private (Cafeteria 1, Cafeteria 2, and Cafeteria 3) and one governmental cafeteria (Cafeteria 4) with all its three subdivisions were randomly selected. These cafeterias can represent all the 8 cafeterias (C1-C8) found in Endayesus campus.

Government cafeterias have large number of customers than the private ones. Government cafeterias served food for students only. The studied 3 private cafeterias catered to the academic staff, supportive staff, workers and daily visitors of the university in addition to a few students. The average number of customers in Cafeteria 1, cafeteria 2, cafeteria 3, cafeteria 4 (government), cafeteria 5, cafeteria 6, cafeteria 7 and cafeteria 8 (government) were, 475, 726, 97, 3799, 746,



Fig. A : Map of Mekelle University showing the location of eight cafeterias in Endayesus campus

423, 95, and 1910, respectively during 2017-18, the period of study.

Data on solid waste generation from the four cafeterias were collected, following the procedure of UNEP (2009). Data were recorded during May to August 2018 for Monday to Saturday from the selected 4 cafeterias. During May and June regular students and July and August summer students were present in the campus. Collections were done during evening time after the business was almost over. In all cafeterias all types of waste except food waste were stored in a mixed state in one container and the leftover food (food waste) in another container. After collecting the wastes, all the plastic water bottles were separated and counted. The remaining waste was weighed using a balance (mechanical platform beam scale or electronic balance) to get the total weight. Following this the total amount of waste was segregated into different types by hand sorting and their weights determined separately. Initially the total waste generated for six days was estimated, and then the average waste per day per person was calculated. For computing average of private cafeteria, C1 to C3 were considered together.

The actual quantity of total waste generated daily (observed data) was recorded for cafeteria 1 to cafeteria

4, and the waste generation was estimated for cafeteria 5 to cafeteria 8 based on average quantity generated per person per day of the former (C1-C4), as stated earlier, and the number of customers of the latter (C5-C8).

#### Statistical analysis:

For data analysis ANOVA (in order to find out differences between amounts of waste generation in governmental and private cafeterias), correlation analysis (to find out relationship between number of customers and the quantity of waste generation) and student's t-test (to find out differences in quantity of waste generated between days) were carried out (Cochran, 1997).

#### Survey among cafeteria managers:

A survey was held among the workers, administrators (managers) of the cafeterias at the time of collection of waste. The investigators asked questions such as number of customers, the type of prepared food, the nature of leftover food, practice of waste collection and storage, place of waste disposal and related information on waste disposal practices followed by them.

## EXPERIMENTAL FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

### Amount and characteristics of solid waste of Mekelle university campus:

*Amount of waste generated in cafeterias of Endayesus campus, Mekelle university:*

The amounts of solid waste generated on a daily basis in 4 cafeterias of Endayesus campus of Mekelle university are given in Table 1.

In cafeteria 1(CNCS) the amounts of waste generated were 25.31, 34.93, 42.55, 41.60, 27.07 and 19.31 kg in day no. 1, 2, 3, 4, 5 and 6, respectively. The highest amount of waste was generated in day no. 3 and the lowest in day no. 6. The daily average waste generation was 31.80 kg. In Cafeteria 2 (*Almi*) the amount of daily waste ranged from 23.60 kg to 54.0 kg. The highest amount was on day no. 4 (54.00 kg) and lowest on day no. 6 (23.60 kg). The average daily generation was 43.73 kg. In cafeteria 3 (E-ITM) the highest generations of wastes was recorded on day no.4 which accounted for 22.65 kg and the least recorded was on day no. 6 with 14.23 kg. The average daily generation was 18.06 kg. In cafeteria 4 (senior student's café) the highest amount of waste generated was on the fourth day which accounted for 1347.50 kg and the lowest on fifth day, that recorded as 1092.50 kg. An average of 1203.90 kg was generated per day, which was the highest compared to the other 3 cafeterias.

It can be noted from the Table 1 that there were daily differences in the quantum of waste generation in the cafeterias. The generation rate of waste of cafeterias 1, 2 and 3 (all private) was less on Saturday which was a holiday. In contrast, comparatively less waste generation was noticed on Friday in cafeteria 4 which may be

because the amount and type of food delivered to the students was different on that day (for breakfast only bread with tea was supplied, and not rice and *Injera firfir*; for dinner only half *injera* was given unlike full *injera* given on the other 5 days).

The average daily waste generation of all the three private cafeterias was 31.197 kg. On the other hand, the average daily waste generation of government cafeteria was 1297.49 kg, indicating that in cafeteria 4 there was considerably higher quantity of waste generation when compared to other 3 cafeterias. It may be recalled that cafeteria 4 was a governmental one and the other 3 were private cafeterias, in addition to the fact that it (cafeteria 4) had more number of customers.

### *Characteristics of the waste generated in cafeterias of Endayesus campus:*

The different categories of waste generated in terms of weight and percentage in 4 cafeterias are given in Table 2.

In cafeteria 1 the different types of wastes generated were plastic water bottles, plastic packaging, OTP peels and vegetables, leftover food, ash, egg shell, paper and paper board, glass and metal. The number of empty plastic water bottles ranging from half liter to two liter content was 538. Onion, tomato and potato (OTP) peels represented the highest quantity accounting to 92.00 kg, followed by leftover food (food waste) which weighed 77.50 kg. The other categories such as plastic packaging, ash, egg shell, paper and paper board, metal and glass accounted 6.71, 4.50, 5.27, 3.27, 0.82 and 0.70 kg, respectively. Totally 190.77 kg of solid waste was generated in cafeteria 1.

In cafeteria 2 ten types of waste were generated and the tenth waste type was grass. A total of 513 plastic water bottles were counted. OTP peels (mixed waste) and vegetables were the highest waste component

**Table 1 : Daily waste generated in the 4 cafeterias of Endayesus campus, Mekelle University**

| No. (Day)                   | Private Cafeteria 1 (kg) | Private Cafeteria 2 (kg) | Private Cafeteria 3 (kg) | Governmental Cafeteria 4 (kg) | Total weight( kg) |
|-----------------------------|--------------------------|--------------------------|--------------------------|-------------------------------|-------------------|
| 1 (Monday)                  | 25.31                    | 44.45                    | 14.64                    | 1145.20                       | 1229.60           |
| 2 (Tuesday)                 | 34.93                    | 42.47                    | 15.91                    | 1129.40                       | 1222.71           |
| 3 (Wednesday)               | 42.55                    | 53.35                    | 22.15                    | 1233.50                       | 1351.55           |
| 4 (Thursday)                | 41.60                    | 54.00                    | 22.65                    | 1347.50                       | 1465.75           |
| 5 (Friday)                  | 27.07                    | 44.53                    | 18.80                    | 1092.50                       | 1182.90           |
| 6 (Saturday)                | 19.31                    | 23.60                    | 14.23                    | 1275.30                       | 1332.44           |
| Total (Average) weight (kg) | 190.77(31.80)            | (262.40)43.73            | 108.38(18.06)            | 7223.40(1203.90)              | 7784.95(1297.49)  |

**Table 2 : Characteristics of wastes generated in four cafeterias of Endayesus campus, Mekelle University**

| Sr. No. | Waste category                                     | Private Cafeteria 1 | Private Cafeteria 2 | Private Cafeteria 3 | Governmental Cafeteria 4 | Total number/weight (%) |
|---------|--|---------------------|---------------------|---------------------|--------------------------|-------------------------|
| 1.      | Plastic water bottles (No.)                        | 538                 | 513                 | 465                 | -                        | 1516                    |
|         |  | Weight              | Weight              | Weight              | Weight                   |                         |
|         |  | kg (%)              | kg (%)              | kg (%)              | kg (%)                   |                         |
| 2.      | Plastic packaging                                  | 6.71 (3.5)          | 8.80(3.4)           | 2.28 (2.1)          | -                        | 17.79(0.2)              |
| 3.      | Onion, tomato and potato peels(OTP) and vegetables | 92.00 (48.2)        | 122.50(46.7)        | 47.70(44)           | 562.40 (7.8)             | 824.60(10.6)            |
| 4.      | Leftover food (food waste)                         | 77.50 (40.6)        | 85.50(32.6)         | 52.30(48.2)         | 6619.00 (91.6)           | 6834.30(87.8)           |
| 5.      | Egg shell  | 5.27 (2.8)          | 5.33(2)             | 1.37 (1.3)          | -                        | 11.97 (0.2)             |
| 6.      | Paper and paper cardboard                          | 3.27 (1.7)          | 7.95(3)             | 0.55 (0.5)          | -                        | 11.77(0.2)              |
| 7.      | Glass  | 0.70 (0.4)          | 1.00(0.4)           | 0.45 (0.4)          | -                        | 2.15(0)                 |
| 8.      | Metal  | 0.82 (0.4)          | 1.07 (0.4)          | 0.28 (0.3)          | -                        | 2.17 (0)                |
| 9.      | Grass  | -                   | 9.25 (3.5)          | 0.45(0.4)           | -                        | 9.70(0.1)               |
| 10.     | Ash  | 4.50(2.4)           | 21.00 (8)           | 3.00 (2.8)          | 42.00(0.6)               | 70.50(0.9)              |
|         |  | 190.77 (100)        | 262.40(100)         | 108.38(100)         | 7223.40 (100)            | 7784.95(100)            |

followed by leftover food waste weighing 122.50 kg and 85.50 kg, respectively. Besides, ash and grass accounted for 21.00 and 9.25 kg, respectively. The other five types weighed as follows: plastic packaging 8.80 kg; paper and paper cardboard 7.95 kg; egg shell 5.33 kg; metal 1.07 kg and glass 1.00 kg. Total waste generation was 262.40 kg.

In cafeteria 3 also ten categories of waste were generated. The highest generated waste was leftover food which accounted for 52.30 kg and the second was OTP peels weighing 47.70 kg. Ash, Plastic packaging, egg shell, paper and paperboard, glass, grass and metal weighed 3.00, 2.28, 1.37, 0.55, 0.45, 0.45 and 0.28 kg, respectively. Totally 108.38 kg of waste was generated; in addition 465 numbers of plastic water bottles were recorded.

In cafeteria 4 only three types of waste were generated: (1) OTP peels, (2) leftover food and (3) ash. The major component of leftover food was *injera* (local traditional food item), the next being bread (*Dabo*) and rice. Their (1, 2 and 3) weights were 562.40 kg, 6619.00 kg and 42 kg, respectively. Over all 7223.40 kg waste was generated.

Totally from the four cafeterias 1516 plastic bottles were generated. The largest solid waste generated waste type was Left over food followed by OTP and vegetable peels which accounted for 6834.30 kg and 824.60 kg, respectively. Both these two types of organic waste constituted 98.4 per cent of the total waste. Ash, plastic packaging and egg shell were the next highest categories which accounted for 70.5, 17.79 and 11.97kg,

respectively. The other types of waste were paper and paper cardboard weighing totally 11.77 kg; grass 9.70 kg; metal 2.17 kg and glass 2.15kg.

An important observation was that only organic waste (OTP, vegetables, leftover food) and ash were generated from cafeteria 4 and not any other types of waste; similarly plastic PET bottles were not recorded from cafeteria 4. It was further observed that the amount of organic waste was higher in cafeteria 4 when compared to others like cafeteria 1, 2 and 3. In contrast, Cafeteria 1, 2 and 3 generated different categories of waste. The diversity of waste types generated in these cafeterias could be attributed to the status of the customers who are mostly employees with salaries that enabled them to purchase bottled water, bottled soft drinks, packed food items etc.

#### *Estimation of waste in the other four cafeterias (C5-C8):*

The average daily waste generations of cafeterias 5, 6, 7 (private) and 8 (governmental) were calculated from the average daily waste generation of cafeteria 1, 2, 3 (private) and cafeteria 4 (governmental), respectively. The average generation of waste /day/person from the private cafeterias was 0.104kg. Similarly for governmental cafeteria it was 0.317kg, indicating that governmental cafeteria produced more quantity of waste per person per day than private cafeteria (Table 3). Based on these values and the number of customers, the total waste generated by the cafeterias of the campus was 2076.20 kg per day (0.211 kg per day per person). In

addition, the daily average number of plastic water bottles generated from private cafeterias was 505.34 during the period of the study.

The statistical analysis (ANOVA) revealed that governmental cafeteria had significantly higher waste generation ( $1809.17 \pm 147.24$  kg/day) than private cafeteria ( $152.86 \pm 36.33$ kg/day). Although there was reduction in waste quantity on Saturday and Friday, it was not statistically significant as per t-test. Correlation analysis showed that the number of customers in the cafeterias and quantity of waste generation were positively correlated (Co-efficient value=0.986).

**Survey:**

From the survey among cafeteria managers and workers it was understood that the food served in all private cafeterias included omelet, fried egg, bread with sauce, *injera* with different sauce, rice, spaghetti, macaroni, beef, fruit juice etc. It was mostly Ethiopian traditional food items. In the governmental cafeterias the types of food served were bread, rice, *Injera* with different sauce (*Shiro wot*, meat, and meat with potatoes) and *Injera firfir*. But in all private and governmental cafeterias meat dishes were not prepared on Wednesdays and Fridays since those are fasting days (on such days the Orthodox Christians who form majority do not eat meat products). Waste items like Plastic water bottles, Plastic packaging, OTP peels and vegetables, Egg shell, Paper and paper board, Glass, Metal (bottle caps), Grass and Ash were stored all together in a single container and the leftover food in another separate bin. The number of customers in cafeteria 1, cafeteria 2, cafeteria 3 and

cafeteria 4 were 475, 726, 97 and 3799. Similarly the number of customers in cafeteria 5, cafeteria 6, cafeteria, 7 and cafeteria 8 were 746,423, 95, and 1910, respectively during the period of study. The organic wastes/ leftover food generated from governmental cafeterias were transferred by vehicles for feeding certain cattle of the campus. But the leftover food generated from most private cafeterias were supplied to the street children, as reported by them. All the other types of wastes were moved as composite waste (mixed waste) to a common collection center located in the campus itself; the composite wastes were later transported to the dumping site (disposal facility) of Mekelle city, as reported by them.

The present study revealed that the total waste generated by all the cafeterias of Endayesus campus of Mekelle university was 2076.20 kg per day. Of the total generated waste, 98.4% was of organic type. This value is comparable with some of the previous studies. Mengesha and Dessalegn (2014) reported that 90 per cent of the total waste generated per day from Hawassa University was compostable (organic). Later Aragaw *et al.* (2016), based on their study in Bahir Dar Institute of Technology, also found that more than half of the total cafeteria solid wastes was organic. A recent study by Kassaye (2018) in Haramaya University recorded that 89.21 per cent are biodegradable and 10.79 per cent non-biodegradable wastes. The comparatively higher percentage of organic waste in Endayesus campus might be due to the major contribution from the governmental cafeterias. The study on generation and composition of solid waste in two cafeterias of UNIMAS may be recalled that food scraps were the highest component of the

**Table 3 : Observed and Estimated (Calculated) waste generation in the 8 cafeterias of Endayesus campus, Mekelle University**

| Day                       | Private cafeterias                |                                   |                                   | Governmental cafeteria                     | Private cafeterias                |                                   |                                   | Governmental cafeteria            |
|---------------------------|-----------------------------------|-----------------------------------|-----------------------------------|--|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
|                           | Cafeteria 1 Waste generation (kg) | Cafeteria 2 Waste generation (kg) | Cafeteria 3 Waste generation (kg) | Cafeteria 4 Waste generation (kg) Observed | Cafeteria 5 Waste generation (kg) | Cafeteria 6 Waste generation (kg) | Cafeteria 7 Waste generation (kg) | Cafeteria 8 Waste generation (kg) |
|                           | Observed                          | Observed                          | Observed                          | Calculated                                 | Calculated                        | Calculated                        | Calculated                        | Calculated                        |
| 1(Monday)                 | 25.31                             | 44.45                             | 14.64                             | 1145.20                                    | 48.46                             | 27.48                             | 6.17                              | 575.76                            |
| 2(Tuesday)                | 34.93                             | 42.47                             | 15.91                             | 1129.40                                    | 53.58                             | 30.38                             | 6.82                              | 567.82                            |
| 3(Wednesday)              | 42.55                             | 53.35                             | 22.15                             | 1233.50                                    | 67.79                             | 38.44                             | 8.63                              | 620.16                            |
| 4(Thursday)               | 41.60                             | 54.00                             | 22.65                             | 1347.50                                    | 67.91                             | 38.51                             | 8.65                              | 677.47                            |
| 5(Friday)                 | 27.07                             | 44.53                             | 18.80                             | 1092.50                                    | 51.91                             | 29.43                             | 6.61                              | 549.27                            |
| 6(Saturday)               | 19.31                             | 23.60                             | 14.23                             | 1275.30                                    | 32.82                             | 18.61                             | 4.18                              | 641.17                            |
| Average weight/day        | 31.80                             | 43.73                             | 18.06                             | 1203.90                                    | 53.75                             | 30.48                             | 6.84                              | 605.27                            |
| Average weight/day/person | 0.067                             | 0.060                             | 0.186                             | 0.317                                      | 0.072                             | 0.072                             | 0.072                             | 0.317                             |

generated wastes (Zarak and Adam, 2009). Another study conducted in cafeterias of Universiti Tun Hussein Onn, Malaysia for two months also found that food waste generated in G3's cafeteria was the highest with 1823.5 kg among the other cafeteria (Alias *et al.*, 2017).

As can be noted from Table 2, in cafeteria 4 (Governmental) the major types of waste generated were leftover food (91.6 %) and OTP peels (7.8%). The components of leftover food were *Injera* (local traditional food item), bread (*Dabo*) and rice. The enhanced amount of such wastes can be due to various reasons such as: the amount of food delivered to each student was more than the demand particularly by female students, and/or sometimes the paste (*Wot*), a side dish used along with *Injera*, was not tasty, and/or the *Wot* was not in enough quantity to consume the *Injera* in full. Whatsoever, the waste generation from cafeterias particularly governmental one was alarmingly high. Although it was heartening to note from the survey that the leftover food from the private cafeterias was supplied to the street children and that from government cafeteria was used as food for cattle, there appeared a need for reducing the food waste. The average daily food waste in government cafeteria was about 1203.90 kg per day (Table 1). Measures to reduce such a huge production of food waste (left over food) are needed, as also better utilization of it. One suggestion is to reduce the quantity of food served to students, particularly girls; and another is to increase the quality of food both of which might help in reducing food waste. In addition, a waste recycling method such as composting can be considered for processing the second largest organic component, OTP and vegetables.

Private Cafeterias are catering to the needs of the staff (academic and supporting), students and visitors of the university. The customers of these cafeterias consumed different types of food items, in addition to the bottled water, tea/coffee and soft drinks. As a result, besides food waste empty plastic bottles were produced in large numbers. The total of 1516 waste bottles (PET) and the daily average number of 505.34 plastic water bottles generated from private cafeterias during the study period was indicative of this. These bottles were found just discarded along with other wastes. It could be a better practice if these are diverted for recycling. Another option is that these waste plastic bottles can be utilized for house construction (Staff reporter, 2018).

Waste generation particularly organic was less on Saturday than the other days of the week in all private cafeterias. But a slightly lower amount of waste was recorded on Friday in Governmental cafeteria. This can be related with the holiday (Saturday) of the campus and the poor customer strength on that day in private cafeterias. This result is similar to the study conducted in the Spanish university Universitat Jaume by Gallardo *et al.* (2016) who reported that the day of the week, especially Saturdays affected the solid waste generation, by a decrease in generation rate. On the other hand, the decrease in governmental cafeteria on Friday could be related to the food type served on that day, as stated earlier. But the reductions in quantity of waste noticed on both Saturday and Friday were not statistically significant.

As seen in Table 3, the average daily waste generation of both the private and governmental cafeterias was 0.104 kg and 0.314 kg/day/person, respectively. It indicated that cafeterias with higher number of customers generated larger amount of solid waste and the quantity of waste generated was positively correlated with the number of customers, the correlation coefficient being 0.986. It further showed that governmental cafeterias produced higher amount of solid waste compared to the private cafeterias.

Another calculated result was that an average of 2076.20 kg of solid waste was generated from all cafeterias per day and 0.211 kg per day per person. This value is higher compared to the study of Gallardo *et al.* (2016) in a Spanish university which found 89.50g/ person / working day, and lower to the study result of Mengesha and Dessalegn (2014) in Hawassa university main campus where the generation rate was 0.64 kg/ person/ day. However, in order to get a total data on waste generation of the whole Mekelle university campus, further studies on waste generation from other sources such as the various offices, dormitories of students and business centers of the campus are required.

From the survey results it was also clear that no waste segregation was done at source level, particularly in the private cafeterias. UNEP (2009) insisted that the most important step for processing of waste is segregation of waste at the source itself such that each type of waste can be recycled later appropriately. The study of Smyth *et al.* (2010) revealed that waste segregation was a common practice at the Prince George campus of the

University of Northern British Columbia. It is thus concluded from the study that the solid wastes generated from the cafeterias of the Endayesus campus of Mekelle University are not scientifically managed to recover the valuable resources.

### Recommendation:

Based on the inferences of study made in Endayesus campus, measures for better waste management such as segregation, reduction and recycling, particularly of organic waste and plastic are to be initiated. The first step required is waste segregation at source itself. Each cafeteria shall store the wastes after segregating them as organic (mainly, food waste) and inorganic. Mekelle University shall consider setting up of waste recycling units particularly for food waste. The food waste can be subject to composting process to obtain compost that can be used for manuring plants in the campus itself. Alternately biogas digesters shall be installed for each cafeteria to yield biogas for cooking, and the solid waste obtained after digestion in biogas plants can be used as organic fertilizer. Plastic bottles generated from cafeterias, another major menace, are to be collected and transported for recycling or used for construction of walls of buildings by filling them with soil.

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