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***Research Article***

# DETERMINANTS OF MUNICIPAL SOLID WASTE IN URBAN ZONE OF BAGLUNG MUNICIPALITY, NEPAL

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## ABSTRACT
The studies on the solid waste generation and characterization with their relationships with different determinants are limited in Nepal which helps in the implementation of the solid waste management approach. This study is focused on the quantification of the municipal solid waste (MSW) generation rate and its characterization in the Baglung Municipality, Nepal. Factors affecting MSW generation with perceptions towards the MSW management were also evaluated through household survey. The study was carried out in the month of January 2021 in four wards of urban zone in the municipality. The average waste generation rate in 188 households (HHs), 20 institutions, and 20 commercial sites were 0.43 kg/c/d, 0.83 kg/institute/day and 2.75 kg/commercial site/day, respectively. The largest component, which accounted for about 74% household waste, 75% institutional waste and 52% commercial waste composed of organic waste. The analysis of variance (ANOVA) indicates a significant variation in between MSW generation rate with respect to household size and type of days. Regarding affordability of MSW management, most of the households can be able to afford service fee ranged from US$ 0.5 to 1.0 (55.38%). Most of the households dispose of solid waste in the municipal vehicle. From this study, the residents of the municipality are suggested to prepare compost manure at the source for the minimization of waste volume to be transported and disposed of. Higher production of recyclable MSW depicts there is a possibility of revenue generation and importance of MSW management in community mobilization in the municipality.

**Keywords:** Determinants, generation rate, municipal solid waste, waste characterization

## INTRODUCTION
The generation rate of municipal solid waste (MSW) is increasing with the increase in the population (Moghaddam *et al.*, 2014). The environmental problem that arises due to solid waste is considered as a crucial and emerging one (Baderna *et al.*, 2011). Waste generation is an important element of human life and attributed to the material or object used and finally discarded as waste (Adogame, 2009). The percentage of components of waste varies in various factors, which directly depend on socio-economic components and land use type such as built-up areas and the lifestyle of the consumers (Abumere, 1983). The rate of generation and the characteristics of MSW varies spatially and temporally with the differentiation in the consumer viewpoint, rate of population growth, types of seasons and the latest available technologies in use of materials or objects (Amori *et al.*, 2013).

The characterization of municipal household waste comprises the evaluation of MSW determinants which is considered as the foremost step to be determined for the planning and implementation of management facility of MSW (Asnani & Zurbrugg, 2007). In the present time, more failure in the MSW management, especially in disposal techniques with no segregation in the collection phase, leads to the inappropriate characterization of wastes with an insufficient understanding of their use (Afon, 2003). The fundamental concept of solid waste management (SWM) in a city requires framework that need to be allotted locally (Ogunbiyi, 2001). Though the generation rate of MSW was estimated separately in case of Berlin (Germany), it is closely related to the features of waste, which have a direct dependence on the source types (Darmastuti, 2010).

Globally, MSW is taken as a rising issue, especially in cities of developing countries. Moreover, the rate of urban growth is rising rapidly in the time period between 2002 to 2012 and population growth rate and waste generation rate was increased by 3.5% and 87.5%, respectively which accounts for more growth mainly in the developing countries (Hoornweg & Bhada-Tata, 2012). The study conducted by Dhokhikah and Trihadiningrum, (2012) has also reported the variation in the characteristics of the MSW with respect to people's income in the settlement areas. The fraction of biodegradable waste composition in low-income countries was higher than in the high-income ones but in aggregate, the share of decomposable waste is higher in developed countries (Hoornweg & Bhada-Tata, 2012). For instance, the fraction of biodegradable waste in East Asia and Pacific (EAP) countries is 62% than the Organization for Economic Co-operation and Development (OECD) countries with only 27%

(Hoornweg & Bhada-Tata, 2012). The studies conducted in the different countries has indicated higher organic content MSW in Casstell'on de la plana/Spain- 57% (Bovea *et al.*, 2010), in Portugal- 35.5% (Magrinho *et al.*, 2006) and in Bangkok/Thailand- 43% (Chiemchaisri *et al.*, 2007).

Various factors such as the consumer habits, the living standard of residents, the lifestyle and the types of activities in the commercial markets determine MSW generation. The seasons may also and temporally determine MSW generation (Zhu *et al.*, 2008). This type of correlation of variables with the generation rate of MSW has the application in of waste management approaches such as collection and disposal (Al-Khatib *et al.*, 2009). The quantification and characteristics of MSW generation denote the present state of MSW and are always indispensable to determine before the decision making in the MSW recovery and its effective management (Adeniran *et al.*, 2017).

In the context of Nepal, a low-income country with inhabitants of 26.5 million people and an average growth rate of 1.35% (CBS, 2014), the increase in the MSW is related to the population growth in the cities (SWMRMC, 2008). Moreover, increased MSW is also associated with the increase in the gross domestic product (GDP) which has increased from US$ 9.04 to 21.14 billion (2006-2016) (Aleluia & Ferrão, 2016). Limited studies have been carried out in the municipalities and rural municipalities of Nepal, regarding the SWM system.

This study examines households' socioeconomic factors that are impacting the generation of waste which play an important role in the reflection of waste quantity and characteristics. Additionally, this research also focused on the theoretical source for MSW management for the urban and suburban areas.

**Study area**

This study was carried out in the Baglung Municipality (Fig. 1) in Baglung District, Nepal. It has an area of 98.9 km². It is divided into 14 wards, and has a population of 57,823 (CBS, 2011). It has a population density of 585 persons/km² with the average household size of 3.9. The study was conducted in four wards (1, 2, 3 and 4) in the municipality with 1082, 2111, 2610 and 832 households, respectively.

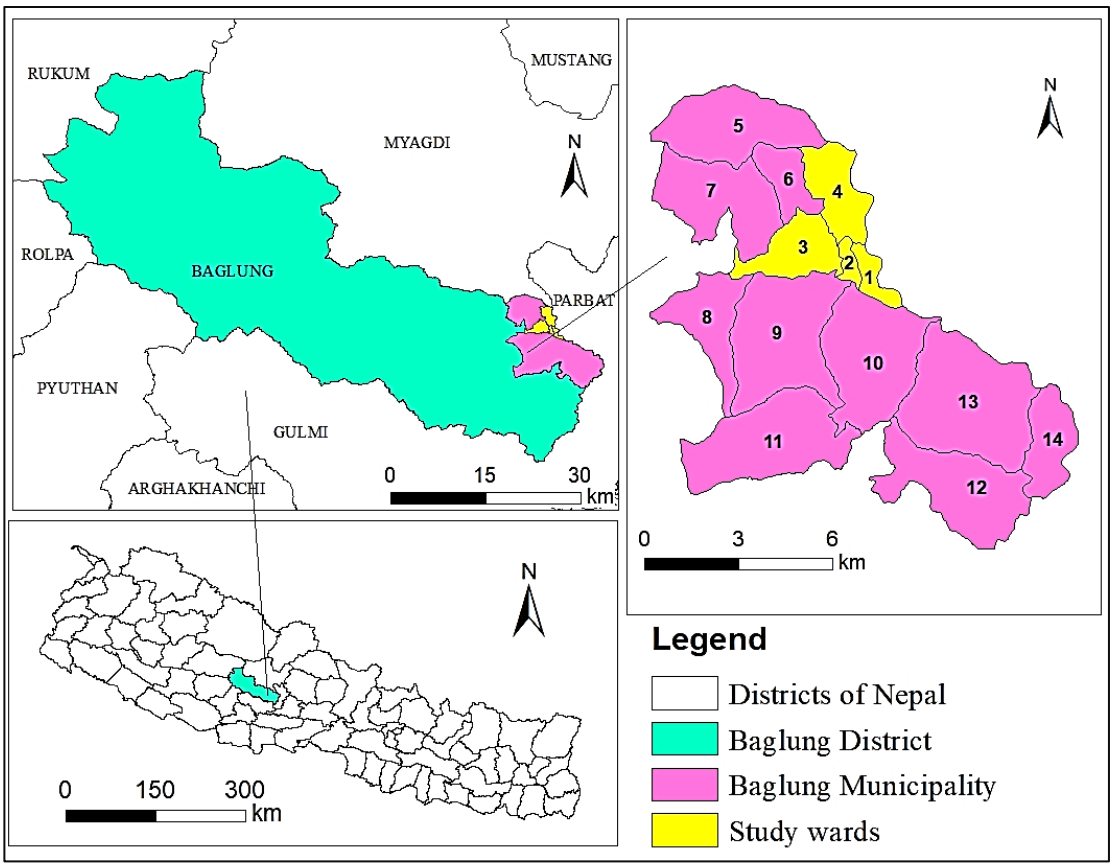


**Figure 1. Map of the study area (Baglung Municipality). Numbers indicate fourteen wards of Baglung Municipality, and the yellow highlighted wards are the focal study areas.**

## MATERIALS AND METHODS

### Household survey

The samples of the MSW from the estimated 118 households were collected from selected four wards. Urban areas of the wards were chosen for the study. Easy road access and densely populated area were other characteristics of the selected wards. Purposive sampling was deployed for the sampling. The household survey was organized from 10th to 22nd of January 2021. Samplings were carried out in seven consecutive days to study the MSW generation rate and its composition. The sampling technique for the determination of the sample size was used according to Yamane (1967) at a 95% confidence level.

$$n = \frac{N}{\{1+N\,(e)2\}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where:

n: Sample size
N: Population size
e: Level of precision

The estimated total number of samples were 539.01 and the final samples taken into the study were 118, which is 10% of estimated total number of samples.

### Institutional waste and commercial waste

Twenty samples of institutional and commercial waste of each were also analyzed which include institutions like schools, government and non-governmental institutions and commercial places such as: shops, hotels, and restaurants. Different categories of the MSW generated in Baglung Municipality was separately assessed on the basis of the descriptions below, and their composition was determined according to the quantity contained in the bulk. The analysis of institutional and commercial waste was accomplished with aid of the household survey.

The description of waste components under each category as described by Mbeng *et al.* (2012) which is given as:

1. Organic: kitchen waste including vegetable and fruit peeling, wasted food
2. Plastic/Polythene: polythene bags water bottles, toys, beverage bottles
3. Paper/cardboard: newspaper, study books, copy, cardboard
4. Glass and Ceramics: beverage bottles, medicinal bottles
5. Others: old clothes, slippers, shoes, belt

### Sampling procedure

The household wastes were segregated as biodegradable and non-biodegradable and were collected in the separate containers. The sample collected in the first day was not considered since the waste was not confirmed as of last 24 hours. The waste was further segregated into sub-category and weighed by using digital spring balance. Protection equipment's such as gloves and mask were used during the sampling. A semi-structured questionnaire was prepared for the collection of information about socio-economic aspect, perspective, behavior, and affordability regarding the MSW and its management. The survey was conducted with the purposive selection of the house and was shifted to the next one if the selected household was not interested in the sampling. A door-to-door interview was carried out with head of the house or the adult member of the house.

### Data analysis

Microsoft Excel-2010 and Statistical Package for the Social Science (SPSS)- version 20.0 were used to analyze the data. The obtained datasets were subjected to the normality test which showed approximately normal distribution. So, the analysis was done through descriptive statistics and analysis of variance (ANOVA) test (Tabachnick & Fidell, 2007).

## RESULTS AND DISCUSSION

### Socio-economic characteristics of surveyed households

Overall socio-economic characteristics of respondents and respective households are presented in Table 1. Overall socio-economic characteristics of respondents and respective households are presented in Table 1. Out of the 118 households interviewed in the studied wards of Baglung Municipality, 67.8% respondents were male. Most of the respondents have a bachelor's degree and above level of education (36.8%) and only 3.2% of the respondents were literate. Moreover, respondents who are illiterate, with primary, secondary and higher secondary level of education were 26.4%, 4.0%, 4.0 % and 25.6%, respectively. The average household size was found to be 4.61 persons with 4≤5 member's family constitute highest (64.41%) and above 5 members constitute lowest (14.41%). With regard to monthly income, 21.19% of the respondents earned less than 125 US$ and 40.68% earned between 125 and 250 US$. Likewise, 33.05% of the respondents' income level was in between 250 and 420 US$ and only 5.08% have more than 420 US$.

### MSW generation rate

MSW samples from 118 households, consisting of 544 population were taken into the study. Overall, 1512.11 kg MSW was accumulated and segregated in the studied wards. The per capita MSW by a household is determined as 0.43 ± 0.22 kg/c/d with 4.63 average household size. The minimum and maximum MSW generated are 0.757 and 0.239 kg/c/d, respectively which reflect the significant variation in the MSW generation. The result signified the obtained data are highly skewed (skewness >1). The obtained value of

kurtosis >3 which showed distribution as leptokurtic in nature. Table 2 represents the comparison of MSW generation rate in the Baglung Municipality and other cities in the world. For instance, Gorkha (Maskey & Singh, 2017), Risikesh (Rawat & Daverey, 2018), Suzhou (Zhang *et al.*, 2018) and Cape Haitian City (Philippe & Culot, 2009) have lower rate of waste generation whereas Takoradi (Miezah *et al.*, 2015) and Mexicali City (Gomez *et al.*, 2008) have higher household waste generation in comparison with this study. The household's generation rate of MSW is very high in Mexicali City (0.676 kg/c/d), which is a relatively developed city. Though Baglung Municipality is expanding, the generation rate is greater than other developed cities. This could be due to the difference in the study time, sample observed and variation in the season. On the other hand, the inclusion of all types of biodegradable waste generated from the households could be a reason for the elevated generation rate. The SWM baseline survey conducted in 58 municipalities of Nepal by ADB (2013) has reported the average household per capita generation of MSW was 0.17 kg/c/d which seems to be lower than the present study.

**Table 1. Socio-economic characteristics of responding household.**

| | Frequency | percentage (%) |
|---|---|---|
| **Gender of respondent** | | |
| Male | 80 | 67.80 |
| Female | 38 | 32.20 |
| **Age of respondent** | | |
| 18-30 | 12 | 10.17 |
| 31-50 | 39 | 33.05 |
| 51-75 | 54 | 45.76 |
| Above 75 | 13 | 11.02 |
| **Family size (individuals)** | | |
| ≤ 3 | 25 | 21.19 |
| 4≤ 5 | 76 | 64.41 |
| > 5 | 17 | 14.41 |
| **Education level of respondent** | | |
| Illiterate | 5 | 4.00 |
| Can only Read/write | 4 | 3.20 |
| Primary | 5 | 4.00 |
| Secondary | 32 | 25.60 |
| Higher Secondary | 33 | 26.40 |
| Bachelor and above | 39 | 31.20 |
| **Monthly income (in US$) of respondent** | | |
| <125 | 25 | 21.19 |
| 125-250 | 48 | 40.68 |
| 250-420 | 39 | 33.05 |
| >420 | 6 | 5.08 |

Note: 1 US$= NPR 119.52 (NRB, 2021)

The average MSW generated is estimated as 0.83 kg/institute/day. The study reveals organic wastes as the largest proportion in MSW followed by paper/cardboard and plastic/polythene in the institution. Shops, hotels, and restaurants were included for the determination of waste generation rate from commercial sites and the rate vary according to their type and visited customers. MSW generation in commercial places were mostly organic (52.43%,), glass/ceramics (26.09%) and plastic (13.68%). The average MSW generation from commercial site is assessed as 2.75 kg/commercial site/day.

**Table 2. Waste generation rate in different cities in the world.**

| City (Country) | Household waste generation (kg/c/d) | References |
|---|---|---|
| Baglung (Nepal) | 0.43 | This study |
| Bhaktapur (Nepal) | 0.11 | (KC & Karmacharya, 2012) |
| KMC (Nepal) | 0.497 | (Dangi *et al.*, 2011) |
| Gorkha (Nepal) | 0.24 | (Maskey & Singh, 2017) |
| Rishikesh (India) | 0.26 | (Rawat & Daverey, 2018) |
| Beijing (China) | 0.23 | (Gu *et al.*, 2015) |
| Suzhou (China) | 0.28 | (Zhang *et al.*, 2018) |
| Takoradi (Ghana) | 0.47 | (Miezah *et al.*, 2015) |
| Cape Haitiaan City (Haiti) | 0.21 | (Philippe & Culot, 2009) |
| Mexicali (Mexico) | 0.676 | (Gomez *et al.*, 2008) |

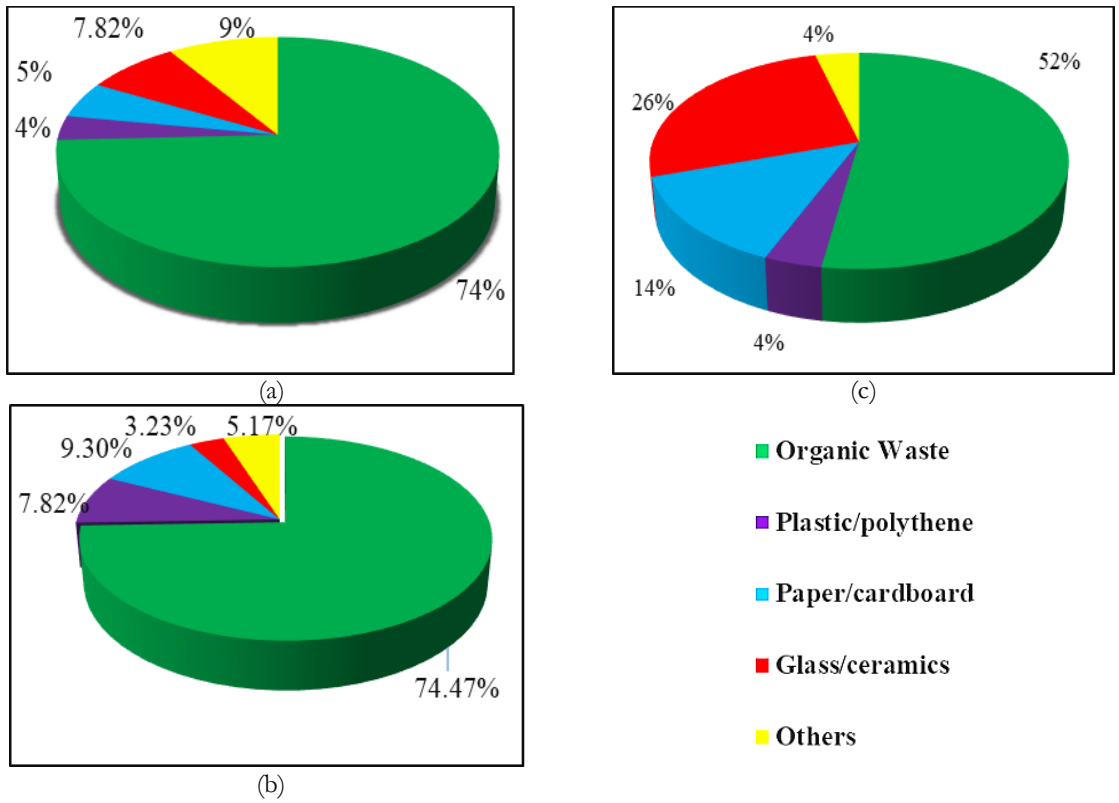


**Figure 2. Composition of the household waste a), institutional waste b), and commercial waste c) of Baglung Municipality.**

**MSW characterization**

The largest component, which accounted for 74% of households waste, 74.47% of institutional waste, and 52% of commercial waste, were organic waste (Fig. 2). Similarly, the portion of glass and ceramics generated from the household and commercial waste were quite high, which was 7.82% and 26%, respectively, and paper/cardboard were high (9.30%) in institutions. The constituent of plastic/polythene in both households and institutions was 4% each whereas there was 7.82% plastic/polythene in institutional waste. Other wastes including old clothes, slippers etc. were 9%, 5.2%, and 4% in HHs, institutions and commercial waste, respectively.

The composition of the MSW varies depending on the different factors such as geographical locations, climate condition, consumers' habits, lifestyle, level of nation and socio-economic condition (Iftekhar, 2005; Hoornweg & Bhada-Tata, 2012). The composition of MSW in the study notably varied in comparison with other studies in various cities of the world (Table 3). In addition, the municipality has a higher composition of organic waste than other cities of different countries. The glass/ceramics contents in the MSW were found

to be higher than in other cities. The quantity of plastic/polythene was recorded as higher than Asian cities like Allahabad (India) and Chittagong (Bangladesh) and lower as compared to others listed in Table 3.

**Factor affecting waste generation rate**

**household size**

The number of persons in the family with less than or equal to three count 25, four to five persons count 76 and above five persons count 17. The average MSW generation for the household size with less than or equal to three family member was 0.59 kg/c/d. Ironically, households with four to five family member and more than five members account for 0.39 and 0.34 kg/c/d, respectively. The frequencies of the family size of 1, 2, 3, 4, 5, 6, 7, 8 and 10 in the studied sample were 1, 7, 17, 35, 27, 19, 9, 2 and 1 households, respectively. Table 4 presents the significant variation ($p<0.05$) in the MSW generation with respect to the household size.

**Table 3. Waste composition (%) in different cities of the world compared with this study.**

| City/country | Organic Waste | Plastic/ polythene | Paper/ cardboard | Glass/ ceramics | Others | Reference |
|---|---|---|---|---|---|---|
| Baglung/Nepal | 74.29 | 3.44 | 5.15 | 7.82 | 9.30 | This study |
| Kathmandu/Nepal | 71.0 | 12.0 | 7.5 | 1.3 | 8.4 | (Dangi *et al.,* 2011) |
| Allahabad/India | 45.3 | 2.86 | 4.69 | 0.73 | 46.42 | (Sharholy *et al.,* 2007) |
| Chittagong/Bangladesh | 62.0 | 2.0 | 3.0 | 5.0 | 12.0 | (Sujauddin *et al.,* 2008) |
| Phnom Penh/Cambodia | 63.3 | 15.5 | 6.4 | 1.2 | 13.6 | (Seng *et al.,* 2011) |
| Bangkok/Thailand | 43.0 | 10.9 | 12.1 | 6.6 | 27.4 | (Chiemchaisri *et al.,* 2007) |
| Bahrain/Bahrain Kingdom | 59.6 | 13.4 | 9.9 | 5.5 | 12.6 | (Al Sabbagh *et al.,* 2012) |
| Baghdad/Iraq | 70.0 | 5.3 | 5.0 | 2.2 | 17.5 | (Mustafa *et al.,* 2018) |
| Lagos/Nigeria | 68.0 | 7.0 | 10.0 | 4.0 | 11.0 | (Kofoworola, 2007) |
| Ghana | 61.0 | 14.0 | 5.0 | 3.0 | 17.0 | (Miezah *et al.,* 2015) |
| Portugal | 35.5 | 11.5 | 25.9 | 5.4 | 21.7 | (Magrinho *et al.,* 2006) |
| Casstell'on de la plana/Spain | 57.0 | 10.0 | 15.0 | 7.0 | 11.0 | (Bovea *et al.,* 2010) |
| Chihuahua/Mexico | 48.0 | 11.9 | 16.1 | 5.9 | 18.4 | (Gomez *et al.,* 2008) |

**Table 4. Households waste generation rate on the basis of family size.**

| Groups (Family size) | Count | % | Sum | Average (kg/c/d) | Variance |
|---|---|---|---|---|---|
| ≤ 3 | 25 | 21.19 | 14.9 | 0.59 | 0.093 |
| 4≤ 5 | 76 | 64.41 | 25.9 | 0.39 | 0.027 |
| > 5 | 17 | 14.41 | 5.8 | 0.34 | 0.018 |

**ANOVA Table**

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Between Groups | 0.89 | 2 | 0.44 | 11.24605709 | 3.46061E-05 | 3.075144 |
| Within Groups | 4.56 | 115 | 0.039 | | | |
| Total | 5.45 | 117 | | | | |

The outcome of the study shows the MSW generation rate is higher in the household size of less than or equal to 3 people, whereas the rate of MSW generation rate was significantly lower with the increase in the household size. A similar result was observed in the study conducted in Rishikesh (India) by Rawat and Daverey (2018) in which the quantity of MSW was reported 0.37 ± 0.07 kg/c/d in HHs size of 2 and 0.19 ± 0.03 kg/c/d for 8 household sizes. This reveals the lifestyle of South Asian households with the combined

kitchen in a family. Gu *et al.* (2015), Ojeda-Benítez *et al.* (2008) and Thanh *et al.* (2010) also indicated identical association of rate of MSW generated with household size.

**Weekdays and weekends**

For this study, variation in MSW generation has been seen with respect to type of days (Sunday to Saturday) within the study period. The highest MSW recorded was on Sunday (15.11%), commercial waste on Friday (17.09%) and institutional waste on Sunday (19.06%). No samples were recorded from institutional sites on Saturday (weekend). There are six weekdays (Sunday to Friday) as working days in Nepal. The effects of each day of the week (Sunday to Saturday) are presented in Table 5.

Table 5 illustrates there is significant variation in MSW generation rate in weekdays and weekend ($p < 0.05$). The MSW generation from the households is higher on Tuesday (4.39 kg/h/d), and the least on Friday (1.63 kg/h/d). In Nepal, people usually purchase goods on weekends or holidays. It is presumed that the generation of MSW is higher on Saturday due to the shopping and other activities that increase the waste production. Interestingly, the accumulation of the waste is more on Tuesday. But it is noteworthy that there is the variation in the outcomes of household MSW generation from the study conducted by in the Zhu *et al.* (2008) in which there is maximum MSW accumulated in the weekends (Saturday- Sunday) with respect to weekdays (Monday-Friday).

**Table 5. Households waste generation rate on the basis of days.**

| Groups (Days) | Count | Total (kg) | % | Average (kg/h/d) | Variance |
|---|---|---|---|---|---|
| Sunday | 118 | 228.48 | 12.62 | 1.93 | 0.82 |
| Monday | 118 | 212.94 | 11.76 | 1.80 | 0.84 |
| Tuesday | 118 | 519.17 | 28.68 | 4.39 | 20.80 |
| Wednesday | 118 | 221.17 | 12.22 | 1.87 | 0.98 |
| Thursday | 118 | 208.89 | 11.54 | 1.77 | 0.93 |
| Friday | 118 | 192.7 | 10.64 | 1.63 | 0.79 |
| Saturday | 118 | 227.18 | 12.55 | 1.92 | 0.97 |

**ANOVA Table**

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Between Groups | 678.73 | 6 | 113.12 | 30.27465 | 6.74E-33 | 2.109633 |
| Within Groups | 3060.23 | 819 | 3.73 | | | |
| Total | 3738.97 | 825 | | | | |

**Attitude towards MSW management**

Regarding affordability for waste collection service charge, the maximum respondents would be able to pay about US$ 0.5 to 1.0 (55.4%) and US$ 1.0 to 1.5 (12.3%) and less than US$ 0.5 (12.3%) per month, whilst 20.0% wouldn't be able to afford the charge and they recommended that waste generated in the municipality should be managed by the municipality office. With respect to the distance that they would travel for the MSW disposal site, about 55% of the respondents indicated that they would be able to travel 10–20 m distance. Most of the respondents expressed the optimistic behavior in SWM and 38.14% of respondents proclaimed they would be able to segregate the household MSW in different subcategories: paper/cardboard, glass/ceramics, metal, plastics/ polythene, and organic waste and 12.71% of respondents showed willingness if the funds were available (Fig. 3). In contrary, 33 % of respondents expressed lack of space (8.47%), lack of time (24.58%), afraid of diseases (3.39%), and responsibility of the municipality (12.71%) in MSW management.

The disposal behavior of the respondents (Fig. 4) was categorized on the basis of waste types. For organic waste, most of the respondents use the municipal vehicle for the disposal (33.0%) while 33.0% use to feed animals, 14.4% dispose of in the pit and remaining 19.5% make manure. Regarding non-biodegradable waste, 73.7% of the respondents use the municipal vehicles, 20.3% burn the waste and 5.9% dispose of in the pit. The common problems of SWM from the household is plastic waste (80.0%) and the lack of the proper disposal site (20.0%). Moreover, the common difficulties were lack of dustbins on the roadside, insufficient knowledge and technology, lack of awareness and lack of effective programs regarding SWM.

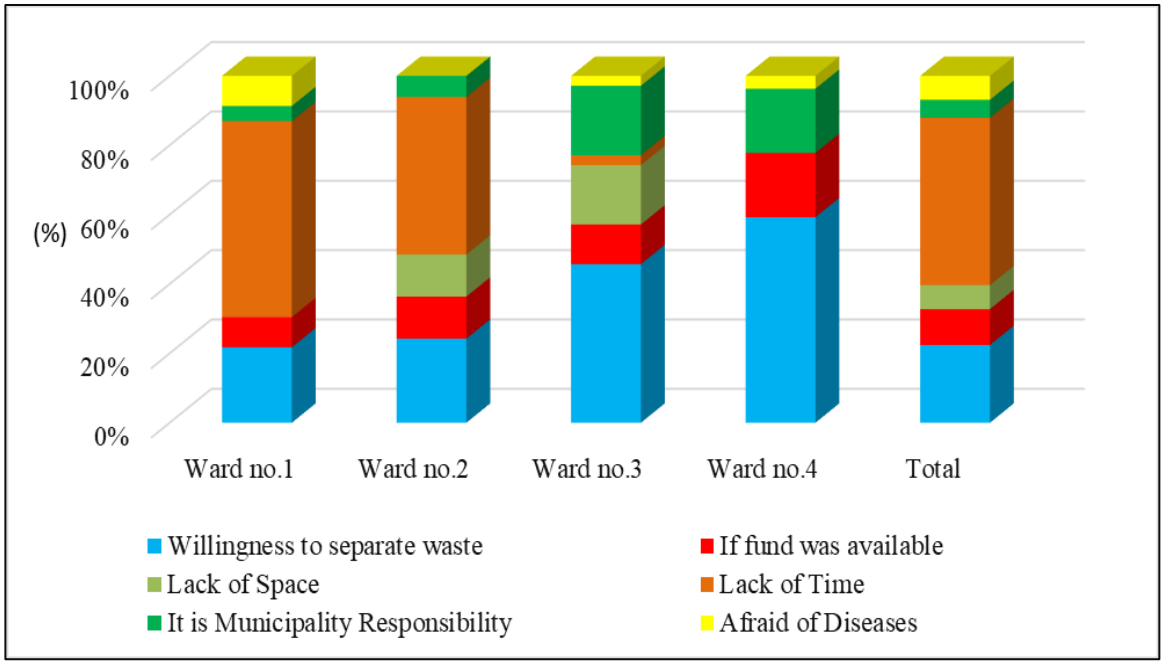


**Figure 3. Responses towards the waste management in Baglung Municipality.**

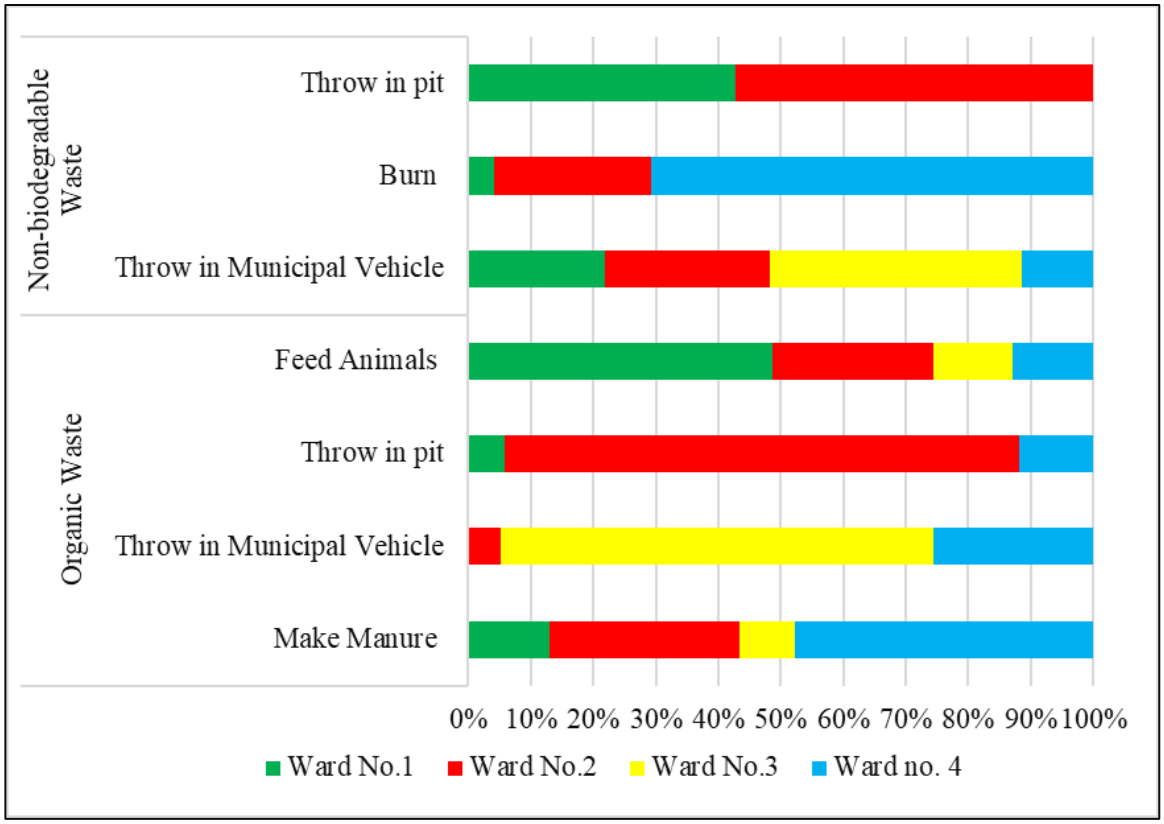


**Figure 4. Disposal behavior of respondents in Baglung Municipality.**

## CONCLUSIONS

The average MSW generation rates from the households, institutions and commercial sites in the Baglung Municipality were 0.43 kg/c/d, 0.83 kg/institute/day and 2.75 kg/commercial site/day, respectively. 74.0% of the household waste, 74.5% of institutional waste and 52.0% of commercial waste were composed of organic waste. Similarly, 7.8% glass/ceramics were generated from the household waste and 26.0 % from commercial wastes. There was 9.3% of paper/cardboard in the institutional waste. A significant variation in between MSW generation rate with respect to household size and type of days were observed. From this study, the residents of the municipality are suggested to carry out compost manure preparation at the source, which assist in reducing volume of MSW to be transported and disposed of. Higher production of paper/cardboard and glass/ceramics could be the opportunity for the municipality to generate revenue. The local government is recommended to initiate community mobilization in the municipality for the SWM.

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## AUTHOR CONTRIBUTIONS

TR conceived and designed the study, reviewed outputs, defined key conclusion, contributed to key inputs, and drafted the manuscript. MG actively participated in the field work and revised the manuscript. SMS supervised, reviewed, and edited the work in all phases.

## CONFLICT OF INTEREST

The authors declare no competing interests.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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