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A Study of Source Specific Quantification, Composition and Disposal Methods of Municipal Solid Waste at Konodas Gilgit City, Pakistan

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Abstract

Urban centres are nexus of environmental pollutions; solid waste generation being one of them. This study was carried out to assess the amount of solid waste generated and its composition coupled with observation of disposal methods in Konodas section of Gilgit city, situated at 35.9221 longitudes, 74.3087latitude, and at an average altitude of 1,500 m above sea level. The study area was divided into two sections *viz.* commercial and residential and sampling constituted 25% of each section population units. Random sampling for residential while purposive sampling for commercial sections were employed to ensure proper representations at source and sampling was carried out three days a week. Total of 1259.026 Kg solid waste was produced from the area during study period, out of which 930.99 was residential while 328.027 Kg was commercial waste. Out of nine sections in to which waste was divided on the basis of composition: food and organic waste in both sectors was most dominant while corrugated boxes and dust made a large proportion of the commercial waste during the study. There was no proper mechanism at the time of the study for municipal waste collection and disposal, empty plots and streets are used for waste disposal by residents while business owners in the market burn waste to get rid of it. Need of the time is to initiate a formal Solid waste management program for the city for collection and environmental friendly disposal, as current practises merely change the spatial distribution of solid waste or transform it from land pollution to air pollution.

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Introduction

Urban areas are home to various forms of environmental pollutions, andsolid waste is most ubiquitous. The estimated quantity of Municipal waste generated worldwide is 1.7 –1.9 billion metric tons (UNEP, 2010). According to Chalmin and Gaillochet (2009) in many cases, municipal wastes are not well managed in developing countries, as cities and municipalities cannot cope with the accelerated pace of waste production. Waste collection rates are often lower than 70 per cent in low-income countries.

Rapid upward changes in urbanization, population growth and lifestyle in developing countries contribute to an increasing per capita municipal waste generation (Xiao *et al.*, 2007). Keeping pace with these developments require proportionate growth in schemes to protecting the environment, to improving public health and accomplishing effective and efficient municipal solid waste (MSW) management (Tchobanoglous *et al.,* 1993). This should be a priority particularly for cities in developing countries (Bartelings and Sterner, 1999; Jin *et al.*, 2006).

Basic information about the sources and types of solid wastes is required in the assessment of composition and generation rates of MSW (Sankoh *et al.*, 2012). Sources differ in quantity and type of waste produced from them. The waste is characterized according to the statutory and policy requirements and varies from region to region and country to country (Chandrappa *et al.,* 2012).

According to Sharholy *et al* (2008) improper management of solid waste in most cities of developing countries leads to problems that impair human and animal health and lead to economic, environmental and social detriment.

In developing countries, 20-50 percent of their curing budget of municipalities is often spent on solid waste management, although often only 50 per cent of the urban population is covered by these services (Zurbrucc *et al.*, 2003). In low-income countries, collection alone drains 80-90 per cent of total waste management budgets. Open dumps and open burning continue to be the primary method of MSW disposal in most developing countries (Chandak, 2010).

Like other countries of the world, In Pakistan life style has changed. Waste generation has increased extremely in Pakistan due to consumption oriented population (Worldwide Fund Pakistan, 2001). The solid waste in Pakistan mostly consists of food waste, plastic, animal waste, rubber, metals, glass, building material and material taken out of drains. Solid waste is produced by households, commercial centers, business organizations and industries (Pak-EPA, 2003).

According to Mustafa *et al* (2007) the situation of solid waste in Pakistan is neglected and is a leading factor in environmental degradation. The annual estimated cost of environmental and resource degradation is about six percent of the GDP.

Solid waste quantities and composition are a functions of utilization pattern, religious beliefs climatic conditions, season, cultural practices, living standards, income levels, lifestyle, household size, age, consumer purchasing habits, packaging of items bought, prices of community awareness, education level, institutional framework, consumption goods, rules and regulations and government policies(Singare, 2012).

Gilgit is the largest city of Gilgit-Baltistan region and faces more severe solid waste related problems than other cities. Very little flat land is available, making Solid Waste Management a challenge for the Municipal Corporation (IUCNP, 2003).

The objectives of the study were to evaluate the quantity of municipal solid waste generated in the Konodas section of the Gilgit city at the source and composition at this point of generation, to observe the

current collection and disposal mechanism and to suggest recommendations for management of this waste.

Material and methods

Area of study

The study was conducted in Konodas Gilgit, situated at 35.9221 longitudes, 74.3087latitude, and at an average altitude of 1,500 m (5,000 ft). Konodas is part of Gilgit city municipality situated across the main bazaar on Northern bank of river Gilgit. The colony is densely populated belonging to various ethnic groups and sects, and houses are constructed in a grid pattern constituting 320 residential units, along with 80 commercial entities including general store, mobile shop, fruit shop etc, as well as this is main area of government offices including Accountant General of Pakistan Revenue (AGPR), Chief court, High Court, Civil Courts, Anti Tourists Court and settlement office. The study was conducted from September 2014 to September 2015 and was focused on solid waste generated from commercial and household sectors in the study area.

Data collection

The primary data was collected through initial field survey followed by division of the study area into sectors and then sampling. After initial survey the area was divided into two categories viz. residential and commercial to determine the quantity and composition of solid waste. Residential units included houses where families lived, while commercial units included shops like, bakery, general stores, stationery shop, ladies shops, mobile shops, fruit shops, tea shops, restaurants, banks.

Sampling

In light of the preliminary survey 80 households out of 320 and 20 shops out of 80 were selected for sampling purpose, comprising 25% of each area.

Sampling procedure

The simple Random sampling method was employed for sampling from households while for commercial sector purposive sampling was used to ensure representation from all type of commercial activities carried out in the area. From each unit waste was collected through distribution of Plastic bags, two for each commercial and household unit: one for organic waste and other for inorganic waste collection. To identify the disposal method of waste of the study area, personal communication and observation was used.

Households and commercial unit were given numbers for purpose of data recording and analysis, plastic bags were corded by marker according to the numbers assigned to households and commercial unit and data sheets were also prepared for recording of data. Households and commercial unit were asked to store all waste produced in the next 3days in a week.

After three days from bag distribution, collected waste was analyzed; waste was segregated on a plastic sheet. After segregation of waste the individual components were weighed on the weighing machine to determine respective quantity and recorded in the data sheet and individual class of wastes were summed up to determine the total quantity for the sampled time. In order to obtain a higher accuracythe method was repeated for another week.

Solid waste characterization

To find the composition of waste, waste was characterized in different categories i.e. food/organic, plastic, paper, metal rubber, textile,glass/ceramic, corrugated Boxes, Dust/Ashand other wastes was determined and expressed in kilogram and the percentage of each constituent was calculated (Ali15).

Equipments used

There is some equipment to use for the measurement of solid waste.Weighing scale – to weigh solid waste, Plastic sheet – to spread waste over it for categorization, Plastic bags for each sampling unit - for week 1 and week 2 (6 days), Gloves- for field volunteers to handle waste and Face masks – o protect worker from respiratory infection.

Data analysis

Data collected was analyzed using Microsoft Excel 2010 software for calculation of mean, percentage, and other statistical variables.

Results and discussion

Categories of municipal solid waste found in the study area

Food/Organic waste

Food/Organic wastes originate from the processing, cooking, handling or consumption of food.

Table 1. Solid Waste categories.

Waste Type	Composition
Food/organic waste	food leftovers, vegetables, fruits, fruit skins, bones, bread and used *chai patti* etc.
Metal	tins, steel and iron utensils, wires, razor-blades cooking oil cans, soft-drink cans etc.
Plastic	packaging, plastic bags, pipe, utensils and items of daily use, bottles, etc.
Rubber	tires, tube, slippers and accessory parts of refrigerators and other electronics, etc.
Corrugated Boxes	In various sizes and with varying weight of packaging container i.e. milk pack carton, candy boxes etc.
Textile	rugs, torn clothes, cotton, socks, fur, etc.
Paper	books, note-books, magazines, newspaper, packaging paper etc.
Ash/Dust	Fine material from wood burning, home sweeping.
Glass/Ceramic	broken window glass, showpieces, cups, jugs, plates and other kitchen utensils made from these materials, beverages, vinegar, sauce, and medicine bottles.
Others	those waste materials which could not be distinctively classified in any of the above mentioned groups like disposal nappies/dippers or those items which are rarely produced or produced in very minute quantities, these include wood splinters, human hair, household hazardous substances, razors, batteries, paint, household chemicals, grass blades, electric and electronic waste.

Table 2. Amount of different waste categories in total sample size analyzed at the Residential unit.

Waste types	Total (kg)
Food/Organic	468.274
Plastic	11.063
Textile	10.977
Rubber	10.136
Paper	11.678
Metal	7.924
Dust/Ash	285.693
Glass/Ceramic	5.392
Others	119.862
Total Waste Generated	930.999

Plastics waste

Plastic waste comprises a large proportion of Municipal solid waste. Plastics are found in all major Municipal Solid waste streams due to the packaging and carrying of goods i.e. shopping pages.

Textile waste

"Textiles" means items made of thread, yarn, fabric, or cloth.

Corrugated Boxes waste

Corrugated Boxes included various sizes of cartons includes milk, juice, and frozen food boxes.

Rubber waste

This type of waste includes tires, tube, slippers and accessory parts of refrigerators and other electronics, etc.

Paper waste

Paper waste is also one of most rising part of municipal solid waste. This waste includes magazines, newspaperand packaging paper.

Glass /Ceramic waste

Glass is found on Municipal solid waste mostly in the form of containers. In the container category, glass is found in soft drink bottles, etc.

Metal Waste

Metal waste is also part of municipal solid. Included material of this waste are tins, steel and iron utensils, wires, razor-blades cooking oil cans, soft-drink cans etc.

Dust/Ash Waste

Dust/Ash waste is also sub category of municipal solid waste. Included material of this waste is Home sweeping and fine material from wood burning.

Table 3. Average composition (in weight- %) of the total sample size analyzed at the residential unit.

S.No	Solid waste type	(Min-Max) Percentage	Average parentage
I.	Food/Organic	0.01- 1.34%	50.29%
I.	Plastic	0- 3.52%	1.18%
I.	Textile	0- 22.19%	1.17%
/.	Rubber	0- 24.96	1.08%
/.	Paper	0-5.39%	1.25%
I.	Metal	0- 17.60%	0.085%
I.	Dust/Ash	0.01- 2.21%	30.68%
I.	Glass/Ceramic	0- 10.41%	0.57%
‹.	Others	0- 2.87%	12.87%

Table 4. Amount of different waste categories in total sample size analyzed at the Commercial unit.

Waste	Total (kg)
Organic	62.803
Plastic	12.858
Rubber	7.781
Corrugated Cotton	103.905
Glass/Ceramic waste	3.328
Paper	5.007
Metal	23.301
Dust	99.03
Other	10.014
Total Waste Generated	328.027

Others

Those materials that cannot be mentioned in any of the categories listed above e.g. disposable diapers or rarely produced or produced in very minute quantities.

The detail of these MSW categories is given in the table 1.

Residential solid waste

Residential wastes were collected (single and multi-family homes. Residential waste generated from households was divided into different categories as given in Table 1(Ali *et al.*, 2015).

Total quantities of residential solid waste

The total quantity of waste generated in the residential unit was 930.999 kg, throughout the sampling periods; while the generating range of per house was 0.148-14.24 kg, and the average rate of waste generation was 5.82 kg per household during the sampling period.

The quantity of Food/Organic waste generated during the sampling periods was 468.274 kg, Dust/Ash 285.693 kg, and others waste were 119.8623 kg. The detail of total generated waste is given the (Table 2).(Ali *et al*, (2015) studied the generation of Municipal solid waste in Gilgit city, area adjacent to our study area, and found that 11 tonnes per day of residential waste is generated in the city by all the households. As our study solely focused on the households i.e. 80 during the study, due to which no relationship can be established between the two studies in this regard owing to difference in method and spatial scales of the study.

Table 5. Average physical Composition (in weight- %) of Commercial Solid waste.

S.No	Solid waste type	(Min-Max) Percentage	Average Composition
1.	Food/Organic	0-12.97%	19.14%
2.	Plastic	0.28- 13.92%	3.91%
3.	Rubber	0-30.07%	2.37%
4.	Corrugated Boxes	0-6.74%	31.67%
5.	Glass/Ceramic	0-17.77%	1.01%
6.	Paper	0-13.4%	1.52%
7.	Metal	0-13.34%	7.10%
8.	Dust	1.05-5.21%	30.10%
9.	Other	0.08-9.49%	3.05%

Table 6. Comparison of different solid waste categories of the residential and commercial units.

Waste type	*Values of different types of waste (kg) in study area during the sampling*					
	RESIDENTIAL		COMMERCIAL		TOTAL	
	weight (kg)	%age	weight (kg)	%age	weight (kg)	%age
Food	468.274	50.29%	62.803	19.14%	531.077	42.18%
Plastic	11.063	1.18%	12.858	3.91%	23.921	1.89%
Paper	11.678	1.25%	5.007	1.52%	16.685	1.32%
Rubber	10.136	1.08%	7.781	2.37%	17.917	1.43%
Metal	7.924	0.85%	23.301	7.10%	31.225	2.49%
#Corrugated boxes	00	00	103.905	31.67%	103.905	8.25%
Glass/Ceramic	5.392	0.57%	3.328	1.01%	8.72	0.69%
*Textile	10.977	1.17%	00	00	10.977	0.88%
Dust	285.693	30.68%	99.03	30.10%	384.723	30.56%
Others	119.862	12.87%	10.014	3.05%	129.876	10.31%
TOTAL	930.999	100%	328.027	100%	1259.026	100%

represent waste category found only in commercial unit

* represent waste category found only in residential unit.

Composition of residential solid waste

The waste composition study was to identify the amount of various forms of waste generated in the study area. the ratios of the composition are given below in descending order: the percentage of organic waste was ranged between 1.01-1.34%,while and averaging percentage was 50.29%, Dust/Ash waste ranged between 0-3.52% and averaging percentage was 30.68%, Others waste ranged 0-2.87% and averaged 12.87%. (Table -) provides details regarding

the composition of household solid waste sampled over the study periods. Ali *et al.* (2015) studied the composition of household solid waste in Ghulmet valley and found on average 35.8% food waste, 49% dust and others category waste 7%. The variation in percentages may be due to difference in feeding pattern for food waste. While in case of dust and ash, the Ghulmet valley showed higher percentage this may be due to unpaved streets and open houses with higher probability of air transported dust into the house.

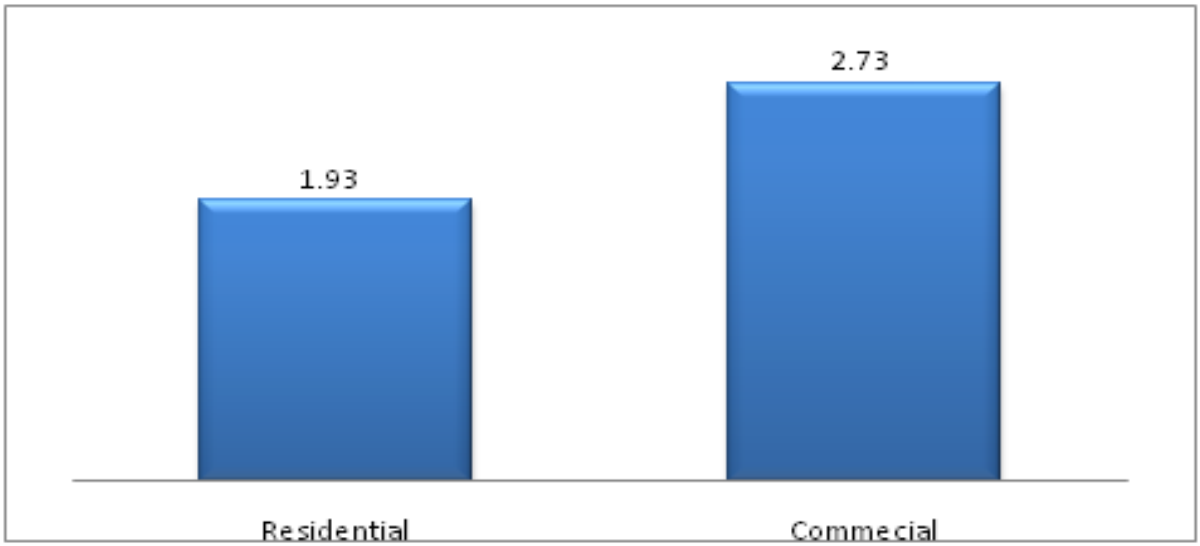

Fig. 1. Daily Generation Rates of each sampled unit in study area (kg).

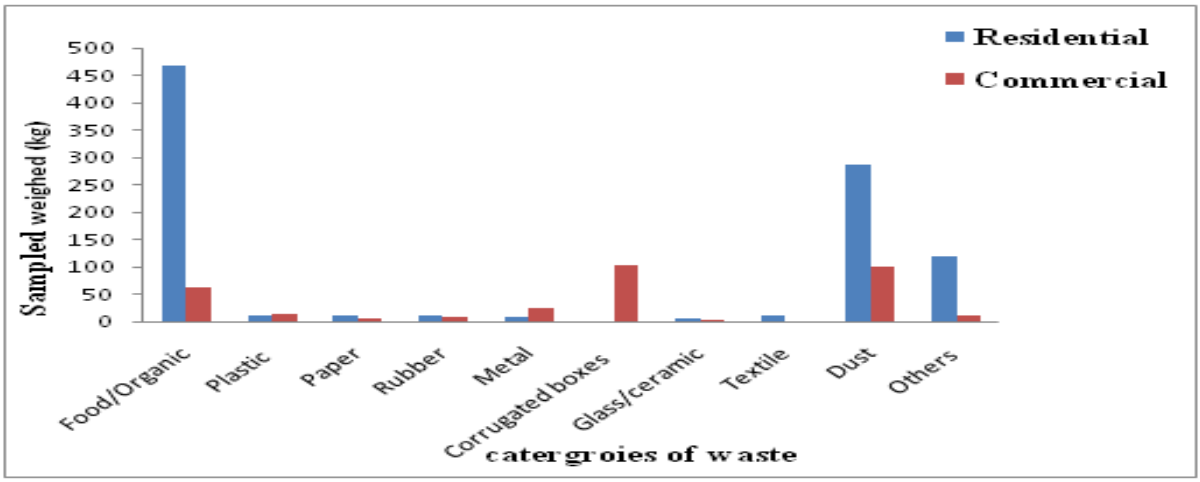

Fig. 2. Comparison of both units sampled solid waste in the study area.

Per unit per day generation rate

In the residential unit the total weighed waste was 930.999 kg, during the sampling periods. per day generation rate of Residential unit was divided the total amount of waste generated by the sample size 80 answer was again divided by the total days of two sampling periods (6) and the result is 1.93 kg per day. Ali *et al.* (2015) who studied Municipa solid waste in Gilgit city found a per day generation rate of 1.38 Kg per day per household. The differnence may be due to inclusion of sweep dust in our study.

Daily per Person Generation rate

The total generated solid waste in the residential unit was 930.999 kg, from a sampled size 80 households. The total family size was 542 and the total days of

sampling periods were 6. So the per day generation rate was worked out to be 0.286 kg/person/dayFig. 1. The average family size of each household was 6.7 persons.This figure of 0.286 Kg/person /day figure is closer to the figure obtained by Ali *et al.* (2015) for Gilgit city that is 0.16 Kg per person per day if sweep dust quantity is deduced from our study.

Commercial waste

Commercial waste is referred to the waste generated from the activities aimed at getting monetary benefit by a single person or a group of persons involved directly or indirectly in those activities.

Waste generated from commercial sources such as hotels, tea shop, fruit shop mobile shop and General & department stores varies in term of composition. However, main components are the same which are biodegradable components such as food/organic waste, recyclable waste such as paper, plastic corrugated cotton and metal.

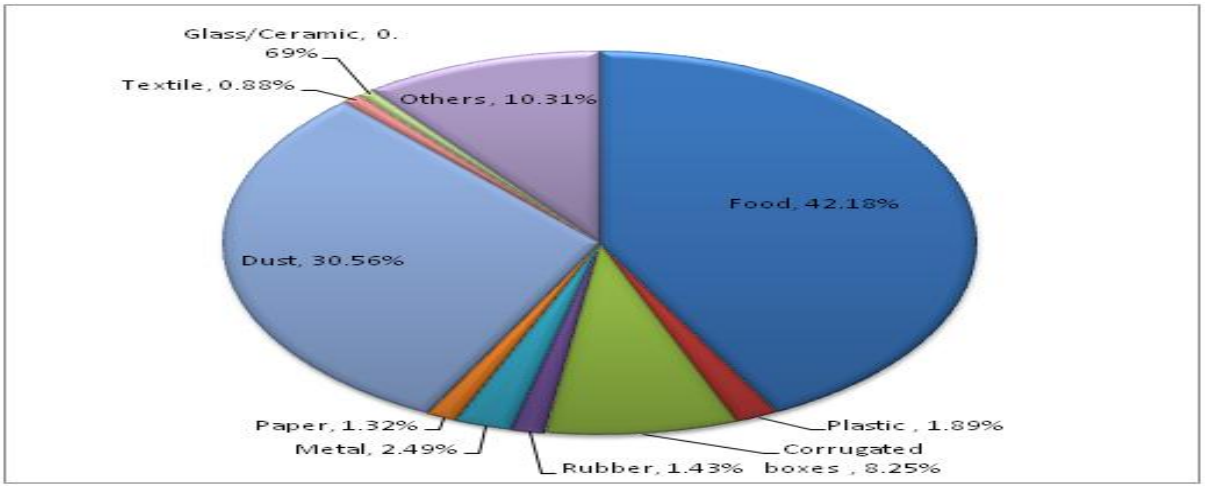

Fig. 3. Composition of total sampled solid waste during the study.

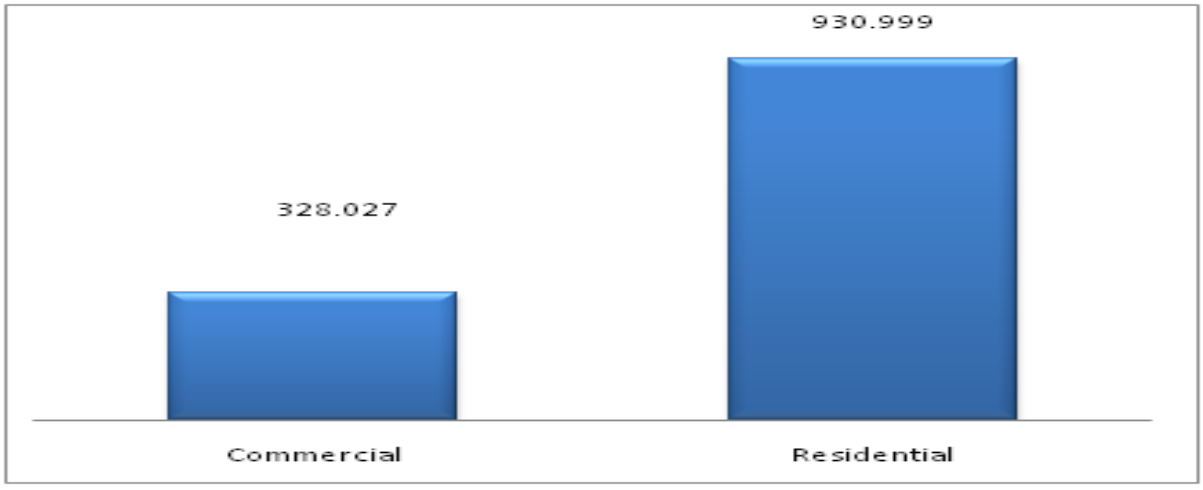

Fig. 4. Total generated waste in the study area (kg).

Total quantities of commercial solid waste

The total solid waste generated in the commercial unit was 328.027 kg, the generation ranged was 3.835-14.482 kg and its average rate was 8.21 kg per sampling period, the quantity of Corrugated Cotton was 103.905 kg, Dust 99.03 kg, and Organic was 62.803 kg.The detail of commercial solid waste is given in the (Table 4,).

Composition of commercial solid waste

The average composition of the total analyzed amount of waste in commercial unit during the sampling Corrugated Boxes were the single largest waste, along the distribution range was 0-6.74%, while the averaged percentage was 31.67%, Dust waste was second largest waste category, representing approximately 30.10% and ranged was 1.05-5.21 % and the Organic waste was third position, while the range was 0-12.97% and its averaged percentage was19.14%, the detail composition of commercial solid waste is shown in (Table 5, fig. 4).

Ali *et al.* (2015) who studied commercial solid waste in Ghulmet valley found averages as follows: corrugated carton 16%; dust 30.10%; organic waste 19.14%. the difference may be because the commercial sector in Konodas area of Gilgit has large number of stores that sell goods manufactured and packed in cartons from industries in other cities of the country, while in case of Ghulmet valley commercial sector is dominated by restaurants and hotels serving tourists, that is why waste generated there has a higher composition of organic waste.

Per unit/per day generating rate

In the commercial unit total waste during the sampling periods was 328.027 kg; the sample size of the unit was 20 out of 80 shops. the per day generation rate of commercial unit is divided the total amount of waste generated by the sample size 20 answer was again divided by the total days of sampling periods (6) and the result is 2.73 kg per day Fig 1.

The generation rates of both sampling units are shown in Fig. 1.Ali *et al.* (2015) who studied Municipal solid waste in Gilgit city found per unit generation rate of 3.15 Kg per day in commercial sector. This difference may be attributed to large commercial market of the Gilgit city that facilitates people coming from all the areas of Gilgit-Baltistan, while in our study area commercial sector caters to local people and civil servants only.

Comparison of solid waste

Comparison of both units i.e. (residential and commercial) is given in the table.6,the table shows detail of percentage, and weight of each solid waste in both units. The most interesting thing in both units was the absence of textile waste category in commercial unit while the absences of corrugated boxes in residential unite detail both units is givenin Fig. 2.

Total solid Waste

The total solid waste was 1259.026 kg throughout the sampling from both the units (commercial and residential) in the study area; the total waste generated from the Residential unit was 930.999 Kg, and commercial waste was 328.027 kg, from the study area during the sampling periods. Furthermore generated waste was presented graphically below the.Fig. 4

Disposal methods

During field study it was also observed that there is no proper mechanism for collection and disposal of the municipal solid waste in the study area, due to lack of resources and unawareness. People throw the residential solid waste into the streets, lanes and open places. During the sampling it was observed that few residents of the study area threw their house garbage or municipal waste at the doors of surrounding neighbors and in empty plots. While in commercial unit shopkeeper burnt their municipal solid waste in front of their shops or threw in to dumps. Main dump site in the study area is situated on the left side of the university road near by AGPR offices. The Gilgit city municipal committee is responsible to collect the waste, but unfortunately they do not collect the waste on the regular basis from the study area. Municipal committee collects the waste from the study area twice or three times in a week which is not sufficient in wake of the quantity generated. Beside this, it was also noted that the lack of proper transportation and modern collection facilities for solid waste management which pose a risk to both human and

environment. The most important thing which is the basic cause of failure of the whole municipal system is the induction of disable peoples for collection and disposal purposes.

Conclusion

The current study recognized some findings during the study, which may hold true in other parts of Gilgit-Baltistan. During the quantification of municipal solid waste in both units' i-e commercial and residential units Organic waste was found in bulk quantity out of overall sampled solid waste as well as Glass/Ceramic waste was least encountered waste category found in both study units.

Additionally corrugated boxes waste were found only in commercial unit and the Textile waste was found only in residential unit, while the plastic waste is most ubiquitous form of waste in both study units that poses a challenge for Solid Waste Management.The area during study generated 1259.026 Kg of Solid waste out of which 930.99 was produced by residential units, while 328.027 Kg was generated by commercial sector. Residential units generated 0.148 to 14.24 Kg of solid waste averaging 5.82 Kg per household.

Food waste dominated this sector making 50.29% of the total generated from residential units. In commercial sector solid waste generation ranged between 3.835 to 14.482 Kg with average rate of 8.21 Kg per unit during the sampling period. In commercial sector corrugated cartons was most dominant form of waste averaging 31.67%, followed by dust and organic waste ranging 30.1% and 19.14 respectively.

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