



Source specific composition and quantification of solid waste in Ghulmet valley, district Hunza-Nagar, Pakistan

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Abstract

Solid waste is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities in a given area. This waste must be disposed properly to avoid associated problems. Quantity and Composition determination of solid waste is one of the basic steps towards initiating a sound solid waste management program. Ghulmet valley with a rapidly increasing population, an attraction for outside visitors in the form of local, national and international tourists has an ideal example of quasi-urban locality in Gilgit-Baltistan going through various environmental issues, solid waste being one of them. The current study aimed at evaluating source specific Quantification and Composition of solid waste in the area. For this purpose the area was divided into two sectors namely Commercial and Residential. Sampling covered 20% of each sector population frame and sampled for two weeks on weekly basis, using random sampling technique, where wastes produced over a week were segregated into 9 groups and weighted individually to obtain composition and quantity values. Solid waste Management plan should be initiated at government and at the community to deals with the waste issue, which can reduce the negative effects on environment and health of people. Sessions must be conducted for communities to aware them from negative impacts of solid waste.

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Introduction

Solid waste menace is a serious concern all over the world and its effective disposal and management are hot topics of discussion today. Since the magnitude of matter related to solid waste varies with location and time, area specific studies need to be carried out to derive management plans adequate to the region. Human activities in society produce large quantities of wastes posing a problem for their disposal (Omran, *et al.*, 2008). Almost all such human activities generate some amount of waste. Rapid increase in volume and types of solid and hazardous waste as a result of continuous economic growth, urbanization and industrialization, is an up-and-coming problem for national and local governments to ensure effective and sustainable management of waste (Slack, *et al.*, 2004).

According to the Environmental Protection Agency of Pakistan (EPA) of 2005, solid wastes comprise all such non-flowing materials generated by households, institutions, commercial establishments and industries, and discharged from their premises for collection; all litter and clandestine piles of such wastes; street sweepings, drain cleanings, construction/demolition waste, dead animals and all such waste materials (EPA, 2005).

Source specific solid waste quantification and characterization is very much required to assess the quality and quantity of solid waste generated. Now-a-days, the waste is quantified on the basis of total waste generation in the city. It has not been categorized so far in different categories to know quantity of every component of the waste (Gomez, *et al.*, 2008). The aim of this study was to quantify, characterize and analyze the solid waste generated in the rural area of Ghulmet valley, Gilgit, Pakistan and to use this data for better management of solid waste produce in the study area.

Pakistan like other developing countries faces serious environmental problems. Rapid population growth and impressive GDP growth have put numerous

pressure on the country natural resources base and have significantly increased level of pollution in which one of them is solid waste (WWF, 2009). Solid waste collection by government owned and operated services in Pakistan currently average only 50 percent quantities generated. Unfortunately, none of the urban and rural area in Pakistan has a proper solid waste management system right from collection of solid waste up to its proper disposal. Much of the uncollected waste pose serious risk to public health through clogging of drains formation of stagnant ponds, and providing breeding ground for mosquitoes and flies with consequent risks of malaria and cholera (EPA, 2005).

In Gilgit – Baltistan due to the unavailability of any proper solid waste management, sanitation and sewerage system, all municipalities generating heaps of the solid waste in front of the municipal claims of cleanliness. As a result the region is facing spread of epidemics, aesthetic pollution, water contamination, air pollution and soil pollution due to solid waste generation and accumulation (GB –EPA, 2013). Presently domestic solid waste in northern areas of Pakistan has not been carried out in a sufficient and proper manner in collection, transportation and disposal or dumping. Therefore the environmental and sanitary conditions have become more serious year by year and people are suffering from living in such conditions.

Domestic solid waste in Gilgit-Baltistan is serious concern for relevant departments and agro pastoral communities in general while municipalities and conservation organization in particular (GB –EPA, 2013).

The present investigation aimed to determine the source specific composition and quantification of solid waste in the mountainous region of Ghulmet valley, Pakistan. The main objectives of the research were, to quantify the amount of waste generated, to evaluate the composition of waste generated and to

provide suggestions and recommendations for waste management.

Materials and methods

Study area

The Gilgit-Baltistan of Pakistan is located at 35°-37°N and 72°-75°E encompasses about 72,696 sq km area and provide home to a human population of nearly 1.8 million people (GB-EPA, 2013). Ghulmet Valley is starting valley of Nagar Gilgit northern areas Pakistan is situated in front of Nagar River (fig. 1). The study area is also famous for local, national and international tourist in all seasons. The study was

conducted during March 2013 March 2014. The study was focused on household & commercial solid waste generation and composition in Ghulmet valley. The Primary data were collected through preliminary field survey and sampling in the valley. After the preliminary survey and observations the study area was divided into two sub zones, namely: residential and commercial for determination of quantity and composition of solid waste. **Residential units** included houses where families lived, **Commercial Units** included shops like, bakery, general stores, stationery shop, ladies shops; hotels and restaurants in the study area.

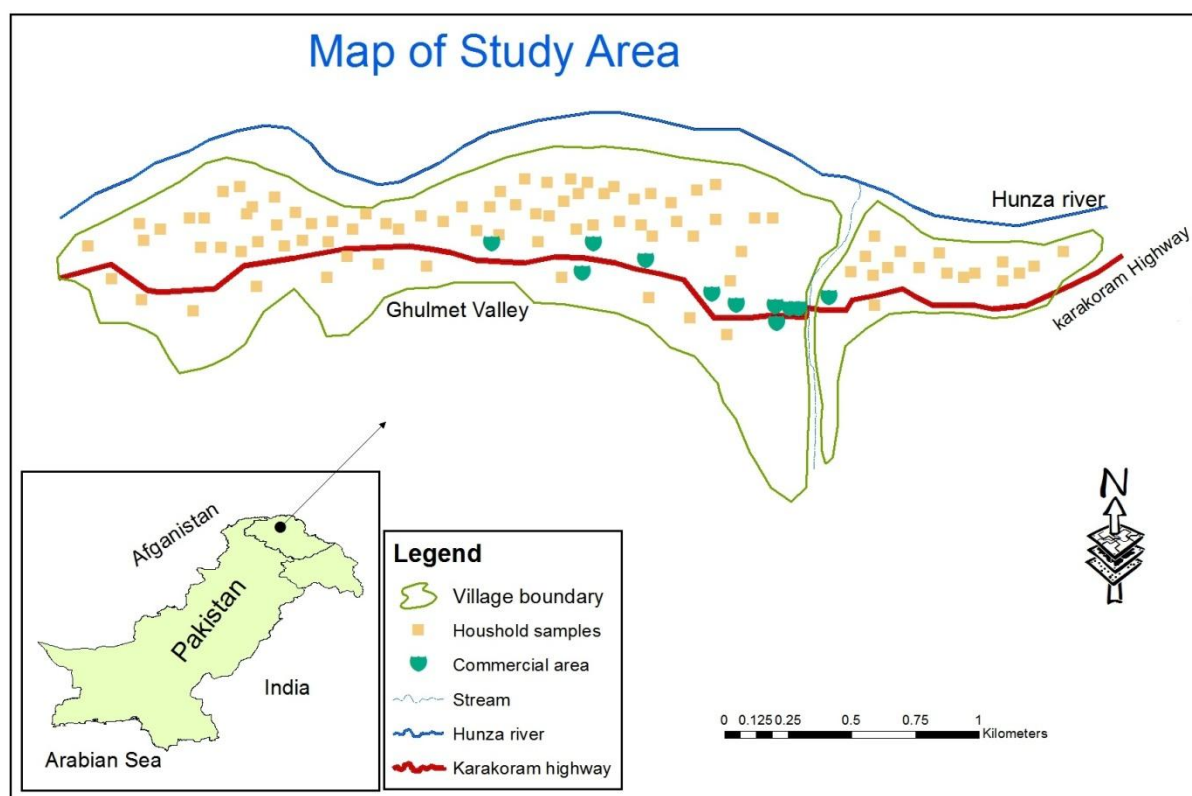


Fig. 1. Map showing the sampling sites and their locations.

Sample Frame and Sample Size Determination

Sample size constituted 20% of the total sample frame. Which were tagged accordingly as mentioned in the table 1:

Table 1. Sample frame and Sample Size Determination.

Unit	Sample frame	Sample size	Tag
Residential (R)	450	90	R1, R2, ... R90
Commercial (C)	51	10	C1, C2, ... C10

Sampling Procedure

Sampling in residential units was carried out through random sampling technique after dividing the village into various zones i.e. *Mohalla* wise. While to get a fair data purposive sampling technique was adopted for sampling from commercial units representing all types of commercial activities. After determining sample frame and division of area into the subzones, polythene bags to each household: one for storing organic waste and other two to store rest of the waste were provided. While, three large size sugar bags to each commercial units were provided for collection of the produced waste for two weeks. Each week the collected waste was segregated into components on a plastic sheet of area 2.25 m². After segregation of waste the individual component was weighed to determine its composition. Finally, all the components were added to determine the overall waste quantity for that week.

Data Analysis

To find the composition of the waste, waste was segregated into various components i.e. food/organic, metal, plastic, rubber, textile, paper, glass/ceramic, sweeping, corrugated cartons and miscellaneous, while quantity was measured in Kilogram. Data obtained was analyzed through descriptive statistical techniques to draw graphs and tables, and also to determine mean, total, maximum, minimum, and per day generation rates.

Results and discussion

Residential Solid Waste

Residential waste in this research work implies the waste in solid form from the buildings used as permanent or temporary dwelling by humans. In this section the quantities and composition of solid waste generated by Households in the study area have been described.

Quantification of Residential Solid Waste

Data was collected regarding the amount of solid waste generated in the study area by sampling ninety households on weekly basis for two weeks. Sampled

Residential units included single to multifamily, *Pukka* and concrete houses with varying room numbers. Collected samples from each week were segregated into the groups mentioned in Table-2 and their individual weights were calculated. Figs obtained give weekly based scenario of solid waste.

Food Waste

Organic waste from households ranged between 0.15 to 3.81 kg per week with a mean of 1.61 Kg, and included materials mentioned in Table.2 subtitle "Food/Organic". The amount of organic waste produced from a household is directly proportional to family size, income level, number of children. Moreover this waste does not enter into the solid waste stream of the area as it is used as animal food by every household.

Metal waste

Metal waste was not frequently encountered in the waste samples and thus it ranged between 0 to maximum 1 kg per week with an average of 0.079 Kg and included materials mentioned in Table.2 subtitle "Metal". Cooking Oil Cans usually accounted for the majority of Metal waste produced in a household. Like food waste, waste falling in this category too does not enter the solid waste stream of the study area, because it is stocked at home and sold to vendors dealing in scrape, thus recycling the material.

Plastic Waste

Plastic waste is one of the ubiquitous wastes produced in the study area due to its larger volume and one of the major parts of the actual solid waste stream. Its quantity ranged between 0 to 0.552 Kg with a mean of 0.062 Kg on weekly basis. This category included materials mentioned in Table.2 under subtitle "Plastic". Quantity of plastic waste in the waste stream usually shopping bags in larger proportion depended on season, in winter this type of material is burnt for heating and cooking purposes while in summer it is dumped into street or in ravine while few households bury it on personal land.

Rubber Waste

Rubber Waste in the rural solid waste is hardly encountered. In the study area it ranged between 0 to 0.72 Kg with 0.036 Kg average per week. It included the material mentioned in Table.2 under the subtitle “Rubber”. Like metal this type of waste is recycled and is not a part of waste stream in the study area. Worn-out Slippers and wellingtons, made from this material formed main part of Rubber waste.

Textile Waste

Quantity of textile waste produced in the study area ranged between 0 to 0.2 kg with an average of 0.005 Kg on weekly basis. This waste included the material mentioned in Table.2 under category “Textile”. Waste produced under this category becomes a part of waste stream.

Paper Waste

Paper waste is generated from ever household and in the study area its quantity ranged between 0 to 1.18 Kg with an average of 0.076 Kg. Varieties of this waste are mentioned in Table.2 in subtitle “Paper”. Waste falling in this category is burnt for heating and cooking in households.

Glass/Ceramic

0 to 2 Kg of glass/ceramic waste is produced weekly with an average of 0.057 Kg per week. The varieties of waste in this category are cited in Table.2 under title “Glass/Ceramic”. Amount of glass or ceramic produced in a household depends upon the type of kitchen ware, family with children, and in case of a sickness large amounts of medicine bottles are produced as waste. This type of waste has sharp edges and cause physical injury. This type of waste is either buried or dumped into ravine in the study area.

Dust/Ash

Dust and ashes form a large amount of waste in rural settings. Dust is formed as a result of cleaning households. As most of the streets and driveways are non-metal with open and barren fields thus large quantity of dust finds its way into house. Amount of

dust produced from sweeping is directly related to House size and number of family members. Ashes are formed as a by-product of burning solids fuel, since wood is chief form of fuel, thus rural dwellings produce ash in large quantities. In the study area: dust/ashes weighted between 0.102 to 4.83 Kg, with an average of 2.11 Kg on weekly basis from a single unit. This type of waste is used as animal bedding or used as a soil material.

Others

Miscellaneous items which did not fall into any of the above group or which were produced in minute amount were collectively weighted up and given the title other wastes as detailed in Table.2 under subtitle “Others”. Their quantity ranged between 0 to 1.2 Kg averaging 0.32 per household per week.

Total Quantities of Household Waste

The total amount of waste produced from 90 households during two weeks weighted 788.678 Kg in which share of each type is mentioned in Table.4 and presented graphically in Fig. 2.

Table 2. Total Household Solid Waste in Two Weeks.

Waste	Total (Kg)
Food	289.82
Metal	14.234
Plastic	11.234
Rubber	6.495
Textile	0.895
Paper	13.934
Glass/Ceramic	10.235
Dust/Ash	379.676
Others	57.796

As table describes the amount of food waste produced in two weeks weighted 289.82 Kg, while metal weighted 14.243 Kg, plastic 11.234 Kg, Rubber 6.495 Kg, Textile weighted 0.895Kg, Paper scaled 13.934 Kg, Glass and Ceramic 10.235 Kg, Dust and Ash 379.676 Kg, and others weighted 57.796Kg.

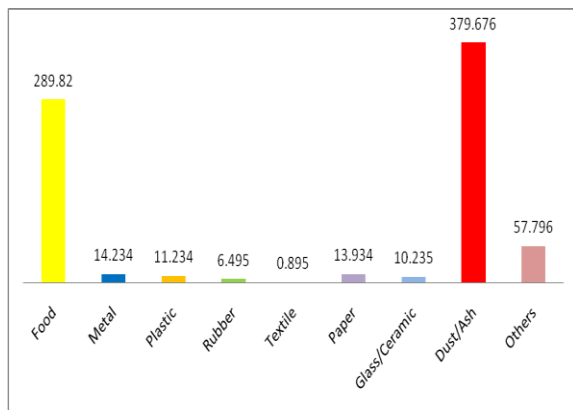


Fig. 2. Total Household Solid Waste Two Weeks.

Composition of Residential Waste

Relative proportion of each category to the total is said to be composition of that category.

Table 3. Composition of Residential Solid Waste.

S. No.	Waste Type	Percentage Composition	Average Composition
1.	Food	7.2-62.6%	35.8%
2.	Metal	0-31.9%	1.8%
3.	Plastic	0-14.6%	1.5%
4.	Rubber	0-25.1%	0.8%
5.	Textile	0-5.5%	0.1%
6.	Paper	0-19.9%	1.9%
7.	Glass/Ceramic	0-46.7%	1.4%
8.	Ash/Dust	7.5-84.2%	49%
9.	Others	0-34.8%	7.7%

Metal ranged between 0-32 % averaging 1.8%. Composition of plastic ranged between 0-15% averaging 1.5%. Rubber composition varied between 0-25 % averaging 0.8%. Textile composition varied between 0-6 % with a mean of 0.1% whereas, paper and glass had a composition of 0-20 and 0-47 with averages 1.9 and 1.4 respectively. Other had a composition of 0-35% averaging 7.7 % of the total. For food waste the composition ranged between 7-62 % with an average of 36%, while Ash/Dust averaged 49 % of the total waste with ranging between 7.5-84.2% in combination these two accounted for 85 % of the total waste composition.

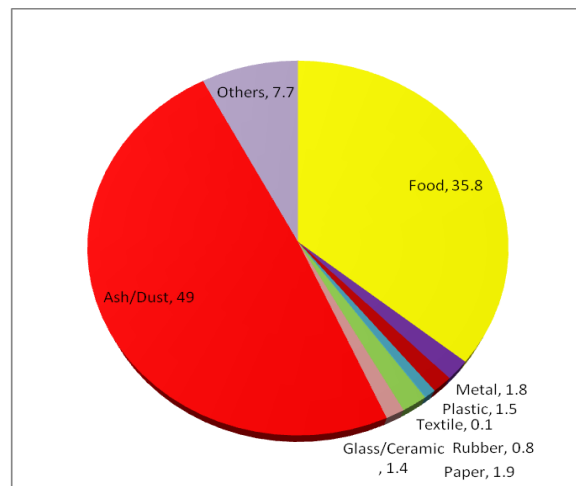


Fig. 3. Average Composition of Residential Solid Waste.

Commercial Waste

Commercial waste in this research work is referred to the waste originating from the activities aimed at achieving a monetary benefit for a single person or a small group of persons involved directly or indirectly in those activities or including the locations where such activities are being carried out. In this section the quantities and composition of solid waste generated by the commercial sector in the study area have been described.

Quantification of Commercial Solid Waste

Data related to this sector was obtained through sampling the commercial units for two weeks. Out of 51 commercial units in the study area 10 were selected for sampling representing every type of activity falling in this category like restaurants, hotel, bakers, General stores, meat shops, garment shops, etc. Collected samples from each week were segregated into the groups mentioned in Table.2 and their individual weights were calculated and averages were found. Fig.s obtained give weekly based scenario of solid waste.

Organic Waste

With an average of 2.133 Kg per week the Organic waste from commercial units ranged between 0-6.51 Kg and included the material mentioned in Table.2 under the title "Food/Organic". Amount of this waste

was high in restaurants and Hotels followed by bakers and general stores. Most of the waste originated in this category was utilized as animal food if the local owned the business, while with non local persons running the business the waste is dumped into ravine.

Metal waste

Averaging 0.19 Kg metal waste was one of the most sporadically occurring wastes and during sampling period its quantity ranged between 0-1.5 Kg and this category include waste mentioned in Table.2 under subtitle "Metal". *Banaspati Ghee* tins were the most common source of this waste, which are recycled by the vendors dealing in scrape.

Plastic Waste

This waste was produced in larger amounts from the commercial sector. Its composition included the waste mentioned in Table.2 under subtitle "Plastic". Averaging 4.07 Kg, its quantity ranged between 1.28-12 kg. Most of this material is dumped into ravine, or water channels along the roads and in streets or is burnt by few commercial units. Packaging of different materials and shopping bags constituted the major part of plastic waste.

Rubber Waste

Rubber waste was hardly found in this survey as the plastic has replaced being cheap material for items previously made from rubber. Its quantity averaged 0.11 Kg and ranged between 0-0.8 Kg per commercial unit per week. Rubber components of bulky goods such as refrigerators etc made up this waste

Corrugated Carton Waste

Quantity ranging between 0-8.21 Kg and averaging 3.23 corrugated cartons made one of the large proportions of commercial waste stream due to their bulky volume and weighty mass. Their composition is mentioned in Table.2 under category "Textile". Corrugated cartons are reused for storing or carrying good while worn-out ones are either dumped or burnt.

Paper Waste

Ranging between 1.7 and 10.5 Kg paper waste from commercial activities averaged 4.037 and included types mentioned in Table.2 under title "paper". Commercial units producing this waste either burn it in pits or dumped it into ravine or away from their business.

Glass/Ceramic

0 to 1.3 Kg of glass/ceramic waste is produced weekly with an average of 0.274 Kg per week. The varieties of waste in this category are cited in Table.2 under title "Glass/Ceramic". Amount of glass or ceramic produced from Commercial units comprised of empty liquor bottles including sauces, soft drink bottles etc.

Dust

Dust is formed as a result of cleaning commercial units. Due to non-concrete ground outside the shops large amount of dust originates on sweeping and is a function of ground surface area of the commercial unit. Dust weighted between 2.1 to 6.45 Kg, with an average of 4.17 Kg on weekly basis from a single unit. This waste is thrown out from the commercial unit or dumped off the location

Others

Miscellaneous items which did not fall into any of the above group or which were also produced amount were collectively weighted up and given the title other wastes as detailed in Table.2 under subtitle "Others". Their quantity ranged between 0.25 to 1.8 Kg averaging 0.82 per unit per week.

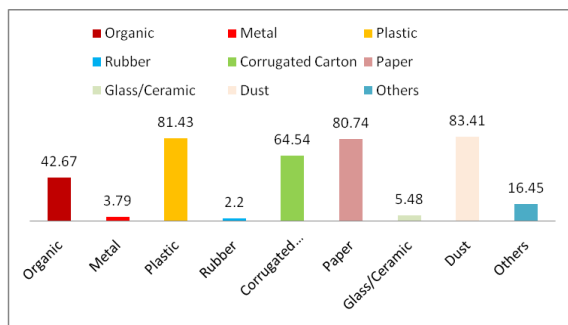
Total Quantities of Commercial Waste

The total amount of waste produced from sampled ten commercial units during two weeks weighted 399.7455 Kg in which share of each type is mentioned in Table.7 and presented graphically.

From the Table.7 Organic waste weighted 42.67 Kg, metal 3.79 Kg, Plastic 81.43 Kg, Rubber 2.2Kg, Corrugated Carton 64.54 Kg, paper 80.74 Kg, Glass and ceramic 5.48 Kg, Dust 83.41Kg.

Table 4. Total Commercial Solid Waste in Two Weeks.

Waste	Total (Kg)
Organic	42.67
Metal	3.79
Plastic	81.43
Rubber	2.2
Corrugated Carton	64.54
Paper	80.74
Glass/Ceramic	5.48
Dust	83.41
Others	16.45

**Fig. 4.** Total Commercial Solid Waste Two Weeks.

Composition of Commercial Waste

Relative proportion of each category to the total is called composition of that category. To find the composition of commercial solid Waste percentages were calculated by dividing each component to the total waste.

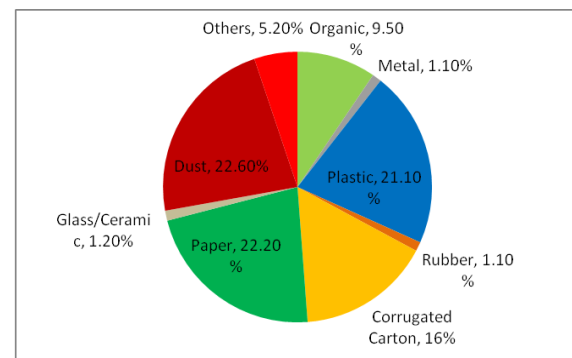
Table 5. Composition of Residential Solid Waste.

S. No.	Waste Type	Percentage Composition	Average Composition
1.	Organic	0-25.3%	9.5%
2.	Metal	0-6.3%	1.1%
3.	Plastic	6.6-37.2%	21.1%
4.	Rubber	0-10.6%	1.1%
5.	Corrugated Carton	0-41.3%	16%
6.	Paper	11.5-51.9%	22.2%
7.	Glass/Ceramic	0-5.3%	1.2%
8.	Dust	10.6-31.6%	22.6%
9.	Others	0.9-18%	5.2%

The composition of the commercial solid waste was not evenly distributed among the various components. Organic waste composition ranged between 0-25.3% averaging 9.5%, metal composition fell between 0-6.3% averaging 1.1%, Plastic ranged

between 6.6-37.2% averaging 21.1%, rubber made up 0-10.6% of the total commercial waste averaging 1.1%, corrugated cartons were 0-41.3% averaging 16% of total, paper percentage fell between 11.5-51.9% with average 22.2%, glass and ceramic accounted for 0-5.3% of total with 1.2% average dust was 10.6-31.6% averaging 22.6% and 0.9-18% with 5.2% average was made by category other wastes.

From the above figs it is obvious that plastic, dust, paper and corrugated cartons were the most frequently occurring wastes in commercial solid waste stream of the study area followed by organic waste. While metal, rubber, glass and ceramics wastes were created in fewer proportions.

**Fig. 5.** Average Composition of Commercial Solid Waste.

Recommendations

- Local and higher tiers of governments should educate citizens about sustainable environmental practices that deal with solid waste management.
- Community must be educated to reduce the amount of waste by teaching them resource conservation, reuse and recycling techniques.
- Community either disposes waste into ravine or into streets, which leads to land and water pollution with aesthetic degradation. Informing them to dispose waste properly or by burying properly could help curb this problem.

Conclusions

The research conducted into source specific quantification and composition of Solid Waste in the study area led to following conclusions. Quantity of waste produced in residential units is much less than those produced by commercial activities. Most of the waste produced by Households in the study area is either reused or recycled. Household with high income level and living, non-agrarian lifestyles tend to produce more waste of inorganic origin than the families associated with agriculture. Organic waste along with dust/ash accounts for the major proportion of Solid Waste in households. Plastic waste is most ubiquitous form of waste in all three major sectors particularly in commercial units and institutions that poses a challenge for Solid Waste Management.

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