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Source specific quantification and composition of municipal solid waste at Nomal Valley, District Gilgit, Pakistan

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Key words: Solid waste, Commercial waste, Institutional waste, organic waste, plastic waste.

Abstract

Solid waste menace is a serious concern all over the world. The current study focused upon the source specific quantification and composition of municipal solid waste at Nomal valley district Gilgit. Data was collected through preliminary field survey and sampling. Sample size constitutes 20% of the total sample frame. Purposive sampling technique was adopted for sampling from both commercial and institutional units. Separate polythene bags were used for collecting waste from these units for two weeks. Each week the collected waste was segregated into components on a plastic sheet of area 2.25 m^2. 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. For composition, 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. Further data was obtained through informal interviews. Data obtained was analyzed through descriptive statistical techniques. Total 1150 kg of commercial solid waste and 234 kg institutional waste was generated during the two observed weeks. Daily generation rate of commercial and institutional waste recorded was 82.28 Kg and 16.71kg respectively. It was observed that quantity of waste produced in commercial units is much more than those produced by institutional sectors, and plastic waste is most ubiquitous form of waste in both sectors particularly in commercial units that poses a challenge for solid waste management.

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Introduction

Transformation of human lifestyle from natural to artificial mode brought about notable changes. A wide array of wastes that are not dissolved in water nor escape into atmosphere are generated during and at the end of almost every activity undertaken by human. Dara defines Solid Waste as "Any unwanted or discarded material from residential, commercial, industrial, mining, and agricultural activities that cause environmental problems" (Dara SS., 1997).Waste generation is inescapable in any human settlement due to nature of human activities. Human activities which directly or indirectly produce waste could be agricultural, commercial, industrial and domestic activities (Ejaro and Jiya, 2013). MSW usually include durable goods, nondurable goods, container and packaging, yard waste, food leftovers, and miscellaneous inorganic wastes, this type of waste does not include waste from other sources like construction and demolition waste, municipal sludge, and industrial process waste (Bureau of Waste Prevention, Reuse and Recycling, 2000).

The waste is characterized according to the statutory and policy requirements and varies from region to region and country to country (Chandrappa and Das, 2012). Schools, hospitals, organizations, centers, universities and prisons are said to be institutions with waste produced from them being classified as institutional waste. This type of waste too includes food waste, paper, cardboard, plastics, textiles, leather, yard waste, room sweepings, wood glass, metals, ashes, leaves, crockery, and other comingled waste with some proportion of batteries, paints, waste oils, rubber etc. (Mwakumanya, 2010; Karak *et al.,* 2012; United Nations Environmental Program and International Environmental Technology Centre, 2014). Commercial units include stores, restaurants, markets, hotels, bakers, etc and waste generated from these sources are said to be Commercial waste respectively (California Integrated Waste Management Board, 2009). Type of waste generated in these units include: food waste, paper, cardboard, corrugated cartons, milk cartons, packaging, newspaper, plastics, textiles, leather, yard waste, house sweepings, wood glass, metals, ashes, leaves, glass, crockery, and other comingled waste with some proportion of batteries, paints, discarded lighters, fluorescent bulbs, waste oils, rubber etc. the residential wastes occasionally include dead animals (Pellowitz, 1995; Yang *et al.,* 2010).

Waste management is a major environmental and health challenge globally, and is more pronounced in developing countries (Ejaro and Jiya, 2013). According to International Resource Group, Ltd. (2009) if solid waste is not treated or disposed of properly, may lead to a wide array of problems including pollution of surface and ground water through leachate, soil contamination through direct waste contact, air pollution by burning of wastes, spreading of diseases by different vectors like birds, insects and rodents, or uncontrolled release of methane by anaerobic decomposition of waste (Singare, 2012). MSW may trickle out of toxic compounds and pathogenic organisms into the water, and also to ground water if covered inappropriately. Once polluted, it is difficult to remove the pollutants from ground water and may cost large sums of money (DEFRA, 2008; CMA, 2014).Solid waste can cause sedimentation, change bottom habitat and alter stream flow. Dumping, burning or burying waste in sensitive ecosystems may destroy or damage the natural resources and undermine the services they provide (Department for Environment, 2011).

Solid waste management chain requires intensive use of Environmental Sound Technology (EST) for its activities which could be as simple as containers for primary collection to as complicated as incinerators for disposal of hazardous waste (UNEP, 2009).The quantification of waste adds in forecasting future trends, determine environmental consequences, accurate records of quantities of solid waste generated have a crucial significance in selection of particular equipment for collection, and decision to decide disposal method for the waste to be collected (Yousuf and Rahman, 2007; Amber *et al.,* 2012).

According to Guangyu, (n.d.) as it is important to quantify the solid waste generated in a community by waste category, for residential wastes the amount of waste generated kg/person/day is used. But, in commercial sector the this method is inappropriate thus other ways are recognized to measure waste, these include quantities generated to the number of customers, the money value of sales, or number of employees. The use of weight is better than the volume to quantify waste; because second approach could be misleading i.e. a cubic meter of loose wastes had different quantity from a cubic meter of high density waste (US EPA, 2005).

Solid Waste attributes vary notably for different regions, cultures, industry, population, etc. and provide important information for solid waste management (Ro*et al.,* 1997; Lamborn, 2009).Composition of solid waste does not remain constant and changes with time (Yousuf, and Rahman, 2007).The waste generated in rural areas is higher proportion of biodegradable waste while, urban areas produce larger amount of non biodegradable waste characterized by culture and practices by society (Chandrappa, and Das, 2012). Based on their chemistry, physical attributes, and biological characters or combination, waste could be divided into various components (Phuntsho, *et al.,* 2007; Bandara, *et al.,* 2007; Xiao, *et al.,* 2007; TRSWMA, 2011; Aguiler-Virgen *et al.,* 2012). Thus the main objectives of the current study were to characterize and quantify the solid waste generated, and compare the data obtained with those from an urban area to know the differences.

Materials and method

Primary data was collected through preliminary field survey in the village. The field investigation involved a perambulation through the village to assess the following:

1. Number of shops, hotels, restaurants and other commercial units.
2. Number of schools and other institutions.

This process gave general overview of the study area and helped to formulate the research design suitable for the location to determine the quantity and quality of the solid waste.

Sampling

After the preliminary survey and observations the study area was divided into two sub zones, namely: commercial and institutional for determination of quantity and composition of solid waste. In the Village 120 shops, 1 hotel, three restaurants, and 1 bank are carrying out commercial activities; and institutions include 8 schools, 4 private and 4 government. These representing the sample frame for the study. Purposive sampling technique was adopted for sampling from commercial units representing all types of commercial activities, and also from institutional to represent both private run and Government owned schools. 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 used. While, three large size sugar bags to each commercial and institutional units were used 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 m^2. 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. 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.

Results and discussion

Overall solid waste in study area was divided into following categories.

Commercial waste

Commercial waste in the study area 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.

Table 1. Quantities of various wastes produced by Commercial Units in Two weeks, in Nomal Valley, District Gilgit.

Unit	Time	No Of Employee	Total Waste	Organic Wt	Metal Wt	Plastic Wt	Rubber Wt	Corrugated Wt	Paper Wt	Glass/Ceramic Wt	Dust/Ash Wt	Other
C1	week1	1	15.34	2.30	1.01	4.70	0	4.10	1.13	0	2.10	0
	week2	1	14.43	2.19	0.79	4.60	0	4.37	1.29	0	1.19	0
C2	week1	1	16.01	1.50	1.10	4.30	0	4.71	3.30	0	1.10	0
	week2	1	18.1	1.42	1.14	3.21	0	3.90	3.24	0	1.29	0
C3	week1	1	15.59	1.30	1.71	3.10	0.5	5.13	2.20	0.41	1.14	0.10
	week2	1	17.05	1.29	1.31	3.26	0.79	4.79	2.16	0.76	1.79	0.90
C4	week1	2	15.12	1.76	1.24	2.16	0.10	4.30	3.15	0	2.41	0
	week2	2	14.74	1.27	1.19	2.76	0.61	3.30	3.71	0	1.90	0
C5	week1	1	15.43	1.10	0.72	4.13	0	2.71	3.41	0.51	2.14	0.98
	week2	1	15.24	1.13	0.69	3.98	0	1.99	3.56	0.79	2.19	0.91
C6	week1	1	13.72	1.30	1.13	2.60	0	4.40	2.89	0	1.22	0.18
	week2	1	15.3	1.40	1.90	2.71	0	4.49	2.52	0	1.37	0.91
C7	week1	1	15.32	2.51	1.10	3.20	0.71	4.29	2.10	0	1.41	0
	week2	1	15.83	2.97	1.14	3.10	0.19	4.20	2.31	0	2.10	0
C8	week1	1	12.99	2.10	0.97	3.27	0.31	2.10	1.78	0	1.67	0.79
	week2	1	12.9	1.90	0.73	3.21	0.19	2.36	1.98	0	1.90	0.63
C9	week1	1	16.31	2.80	1.21	3.45	0	2.31	2.19	0.71	2.51	1.13
	week2	1	15.8	1.90	1.29	3.90	0.41	2.42	1.90	0.69	2.19	1.10
C10	week1	1	13.81	1.18	0.89	2.49	0.20	2.29	2.17	0	3.31	1.28
	week2	1	13.29	2.19	0.86	2.47	0.49	1.49	2.19	0	2.51	1.09
C11	week1	1	13.85	1.58	1.10	3.16	0	4.41	2.46	0	1.14	0
	week2	2	12.8	1.40	0.96	2.19	0	3.56	2.79	0	1.90	0
C12	week1	2	16.05	1.95	0.78	2.98	0	3.47	3.19	0	2.90	0.78
	week2	2	15.67	1.13	0.71	1.46	0	2.90	2.90	0	2.98	0.69
C13	week1	2	12.62	0.79	0.19	1.56	0	4.10	2.90	0	2.98	0.98
	week2	1	13.26	0.46	1.21	1.98	0	4.36	2.90	0	2.10	0.63
C14	week1	1	13.68	1.42	1.05	4.13	0.96	3.10	1.79	0	1.23	0
	week2	1	13.24	0.99	1.17	4.49	0.76	2.91	1.63	0	1.29	0
C15	week1	1	12.45	2.18	0.58	3.46	0	2.90	2.14	0	1.19	0
	week2	1	11.91	2.37	1.09	3.49	0	2.11	1.64	0	1.36	0
C16	week1	1	12.16	1.78	1.21	2.98	0	1.47	1.97	0	1.56	1.19
	week2	1	12.24	1.98	1.57	2.19	0	1.79	2.91	0	1.79	1.01
C17	week1	2	12.06	1.19	0.64	2.41	0	3.41	2.62	0	1.79	0
	week2	2	13.51	1.76	0.56	3.18	0	2.71	3.19	0	2.11	0
C18	week1	1	13.44	1.21	1.13	3.59	0	2.19	3.46	0.97	0.89	0
	week2	1	18.18	1.37	2.10	4.10	0	3.96	2.76	1.90	1.99	0
C19	week1	1	14.52	1.56	0.96	3.41	0	3.52	2.97	0	1.18	0.92
	week2	1	15.59	1.49	0.91	3.91	0	4.11	3.12	0	1.66	1.11
C20	week1	4	19.21	7.96	0	1.13	0	4.52	2.37	0	2.13	1.10
	week2	5	19.6	7.91	0	1.17	0	3.90	2.49	0	2.71	1.42
C21	week1	1	12.64	1.13	0.76	2.14	0	3.56	2.82	0	1.31	0.92
	week2	1	11.38	1.20	0.16	2.56	0	2.77	1.97	0	1.96	0.76

C22	week1	2	12.91	2.14	1.19	3.50	0	2.90	1.98	0	1.20	0
	week2	2	12,26	1.19	1.91	3.19	0	2.61	1.99	0	1.37	0
C23	week1	1	14	1.66	0.76	3.42	0.71	2.42	2.69	0.14	2.20	0
	week2	1	15.53	2.10	0.64	4.12	0.69	1.99	2.67	0.91	2.41	0
C24	week1	1	13.44	1.59	0	4.51	0.42	2.31	2.22	0	1.90	0.49
	week2	1	15.22	2.11	0	4.76	0.49	2.42	2.19	0	1.96	0.57
C25	week1	5	21.44	7.56	0.13	5.38	0	4.41	1.56	0	2.40	0
	week2	5	20.2	6.90	0.17	4.71	0	3.92	2.59	0	1.91	0
C26	week1	1	11.51	1.96	0	3.10	0	2.31	1.96	0	1.42	0.76
	week2	2	9.92	1.12	0	2.71	0	2.44	1.71	0	1.38	0.56
C27	week1	2	13.85	2.10	0	4.19	0.72	2.49	2.21	0	2.14	0
	week2	2	12.23	1.96	0	3.90	0.19	2.60	2.39	0	1.19	0
C28	week1	2	13.54	1.96	0.52	3.90	0	2.56	1.49	0	1.92	1.19
	week2	2	10.04	1.13	0.71	2.17	0	2.42	1.13	0	1.19	1.29
C29	week1	1	10.81	2.41	0	2.47	0	3.43	1.37	0	1.13	0
	week2	1	10.62	1.96	0	2.73	0	2.91	1.09	0	1.93	0
C30	week1	1	12.99	1.90	0.59	1.41	0	3.52	2.67	0	2.90	0
	week2	1	11.49	1.96	0.96	1.13	0	3.19	2.14	0	2.11	0
C31	week1	1	14.33	2.31	1.41	4.21	0.79	2.36	1.47	0.59	1.19	0
	week2	1	13.15	1.93	1.21	3.71	0.76	2.49	1.33	0.61	1.11	0
C32	week1	1	10.97	1.54	0	3.42	0	2.21	1.90	0	1.33	0.57
	week2	1	11.54	1.79	0	2.49	0	3.24	1.75	0	1.51	0.76
C33	week1	4	21.99	7.90	0	4.13	0	3.41	2.42	0	2.56	0.96
	week2	4	21.25	7.56	0	3.79	0	3.76	2.97	0	2.41	0.76
C34	week1	1	14.96	2.71	1.19	3.19	0.72	2.52	3.42	0	1.21	0
	week2	1	12.13	2.14	0.76	2.41	0.49	1.91	3.10	0	1.32	0
C35	week1	1	17.32	3.41	0.63	3.53	0.61	3.41	2.56	0.69	1.19	1.29
	week2	1	17.68	3.20	0.51	3.09	0.59	3.29	2.91	0.86	1.39	1.84
C36	week1	1	10.95	1.49	1.12	2.19	0	2.57	1.29	0	2.29	0
	week2	1	12.14	1.38	1.19	2.49	0	2.36	1.96	0	2.76	0
C37	week1	1	11.61	1.23	1.09	2.11	0	3.46	2.31	0	1.41	0
	week2	1	12.02	1.12	1.91	2.46	0	3.19	2.11	0	1.23	0
C38	week1	4	19.28	7.99	0	3.90	0	2.56	2.42	0	2.41	0
	week2	4	17.07	7.12	0	3.70	0	2.41	2.13	0	1.71	0
C39	week1	2	16.62	1.41	1.29	3.69	0.59	4.42	3.31	0	1.51	0
	week2	2	14.53	1.29	1.31	3.10	0.71	3.25	3.41	0	1.46	0
C40	week1	4	19.57	6.56	0	4.49	0	3.71	2.37	0	2.44	0
	week2	4	20.41	7.10	0	4.19	0	3.52	2.49	0	3.11	0
Total waste			1152	196	62	253	15	250	192	11	146	33

Quantification of commercial solid waste

Data related to this sector was obtained through sampling the commercial units for two weeks. Out of 120 commercial units in the study area 40 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 and their individual weights were calculated and averages were found.

Organic waste

The finding reveals that the total 195.21 Kg organic waste generate in two weeks from the commercial units ranged between 0-7.56 Kg and it include "Food/Organic waste".

Amount of this waste was high from restaurants and Hotels followed by bakers and general stores. Most of the waste originated in this category was utilized as animal food, but some of them dump in ravine. An average 5kg organic waste production comes from commercial units. The high waste production in commercial site is organic waste in our study.

Table 2. Total commercial solid waste generated in two weeks.

S:No	Waste	Total (Kg)
1	Organic	195
2	Metal	61
3	Plastic	253
4	Rubber	15
5	Corrugated Carton	250
6	Paper	192
7	Glass/Ceramic	10
8	Dust	146
9	Others	33
Total waste		1150 Kg

Metal waste

The investigation shows that the total metal waste in two weeks 62.16 Kg and its quantity ranged between 0- 2.10 Kg and it include waste "Metal". *Banaspati Ghee* tins and other products tins were the most common source of this waste, which are recycled by the vendors dealing in scrape. An average 2kg metallic waste production comes from commercial units.

Plastic Waste

This waste was produced in larger amounts from the commercial sector is "Plastic waste". The total 255.86 Kg plastic waste generate in two weeks, its quantity ranged between 1.13-5.38 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. An average 7kg plastic waste production comes from commercial units in two weeks.

Table 3. Quantities and composition of various wastes produced by Institutions in two weeks.

Unit	Time	No Of Employee	Total Waster	Organic Wt	Metal Wt	Plastic Wt	Rubber Wt	Textile Wt	Paper Wt	Glass/Ceramic	Dust/Ash Wt	Other
I-1	week1	6	13.73	1.26	2.21	1.79	1.71	0	4.26	0.29	2.21	0
	week2	6	13.78	1.20	2.11	1.10	1.21	0	3.79	1.23	3.14	0
I-2	week1	12	15.85	0	0.79	4.41	1.21	0	4.26	1.21	3.41	0.56
	week2	12	14.43	1.10	1.13	3.52	1.09	0	3.49	1.12	2.19	0.79
I-3	week1	10	20.62	2.31	1.32	4.26	1.90	0	5.31	1.96	3.56	0
	Week2	10	18.48	2.59	1.56	3.79	2.10	0	4.97	1.30	2.17	0
I-4	week1	6	19.34	1.27	2.41	2.36	2.12	3.27	1.39	4.36	1.21	0.95
	Week2	6	22.72	1.10	2.79	2.41	2.56	3.79	2.20	4.21	2.90	0.76
1-5	week1	7	26.55	1.13	3.49	2.56	3.21	3.56	2.22	4.98	3.21	2.19
	Week2	7	25.89	1.19	2.59	2.90	3.76	3.98	2.10	3.90	3.57	1.90
I-6	week1	5	27.27	1.23	3.46	2.79	2.90	4.49	2.36	5.90	2.91	1.23
	Week2	5	25.48	1.11	3.24	2.19	3.10	4.91	2.47	4.41	2.76	1.29
Total waste			244.14	15.49	27.1	34.08	26.87	24	38.82	34.87	33.24	9.67
Average solid waste				1.49125	2.6075	2.9075	2.70625	3	2.8775	3.8775	2.78625	1.04

Rubber Waste

Rubber waste was hardly found in this survey as the plastic has replaced being cheap material for items previously made from rubber. The total 15kg rubber waste generation in two weeks and ranged between 0-0.10 Kg per commercial unit per week. Rubber components of bulky goods such as refrigerators etc made up this waste. An average 1kg rubber waste production comes from commercial units in two weeks.

Corrugated carton waste

The finding shows that total 250kg corrugated carton waste generate in two weeks and it ranging between 1.91-5.13 Kg. corrugated cartons made one of the large proportions of commercial waste stream due to their bulky volume and weighty mass. An average 6kg corrugated carton waste production comes from commercial units in two weeks. The Corrugated cartons are reused for storing or carrying good while worn-out ones are either dumped or burnt.

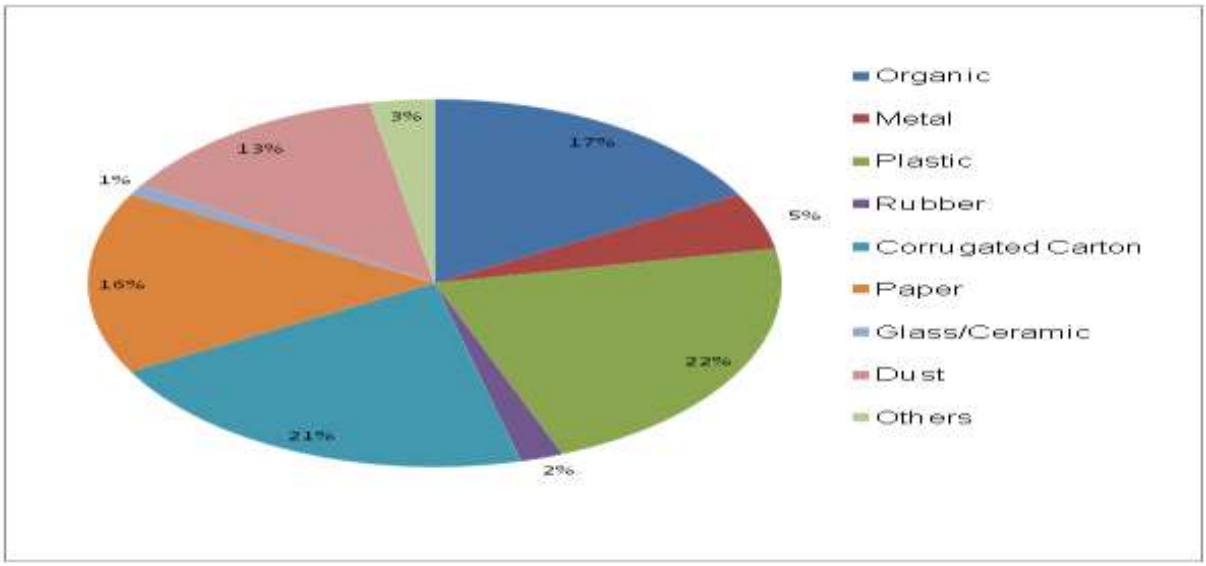

Fig. 1. Average Composition of Commercial Solid Waste.

Paper waste

An average 5kg paper waste production comes from commercial units in two weeks. The finding reveals that 192kg total paper waste generate in two weeks and ranging between 1.09 and 3.71 Kg paper waste from commercial activities. Commercial units producing this waste either burn it in pits or dumped it into ravine or away from their business.

Glass/Ceramic

The total waste in two weeks is 9.57 and ranging between 0 to 0.14 Kg of glass/ceramic waste is produced weekly. Amount of glass or ceramic produced from Commercial units comprised of empty liquor bottles including sauces, soft drink bottles etc. An average 0.26kg glass/ceramic waste production comes from commercial units in two weeks.

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. The total 146kg dust waste generate in two weeks and ranging between 0.89 to 3.31 Kg. This waste is thrown out from the commercial unit or dumped off the location. An average 4kg dust/ash waste production comes from commercial units in two weeks.

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 waste. The total 34kg some sort of mix waste

generates in two weeks and their quantity ranged between 0 to 2.76 Kg. An average 1kg other waste production comes from commercial units in two weeks.

Total commercial solid waste in two weeks

The table 2 shows the total quantity of commercial solid waste generates from the commercial sectors, which include total Organic waste 195 kg, Metal waste is 61kg, Plastic waste 253kg, Rubber waste 15kg, corrugated carton waste 250kg, Paper waste 192kg, Glass/ceramic 10kg, Dust waste 146kg, while the other waste is 33kg.

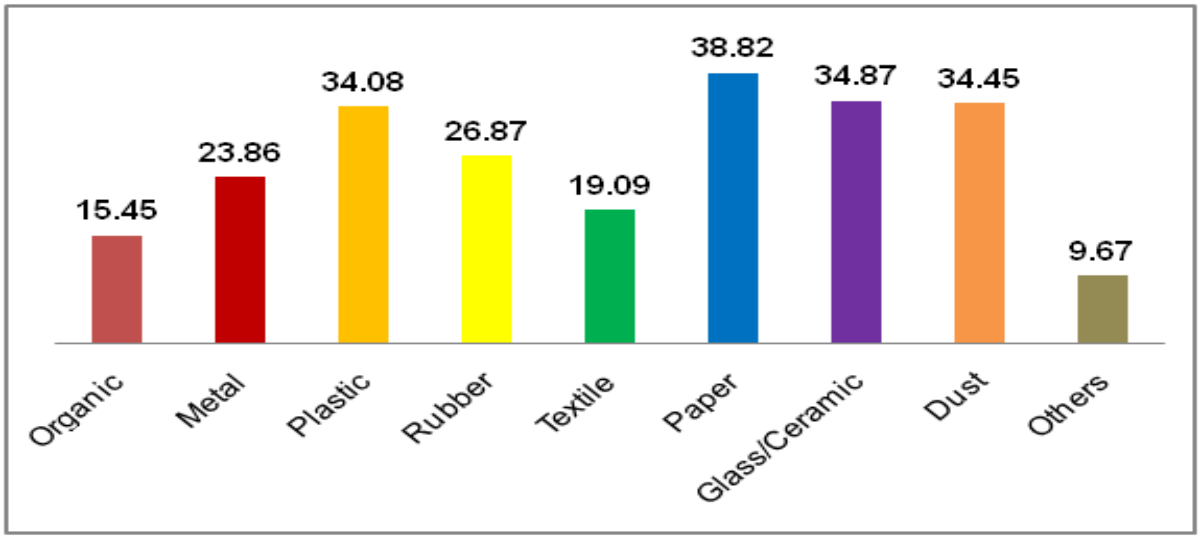

Fig. 2. Total Institutional Solid Waste generation in Two Weeks (Kg).

Institutional solid waste

Institutional Solid Waste in the study area implies to the solid waste produced from the premises of organization having an influence on the social life of the study area.

Quantification of institutional solid waste

Data from Institutions was obtained through collection of waste generated within time period of two weeks. Waste generated was segregated into the components detail shown in Table 2 and weighted to obtain figures mentioned in Table, and schools, banks, hospitals, were selected out of total in the study area to assess the solid waste generated.

Organic waste

Total Organic waste in two weeks is 15.49 from institutional units ranged between 0-2.59 Kg and which shown in Table 4 under the title of "Organic/Food". This type of waste generate from the kitchens of different institutions. This waste is usually used as a food for animal which usually taken by the workers of the institution. An average 2kg organic waste generates by these institutional units in two weeks.

Metal waste

Table 4 shows the total metal waste in two weeks which is 27.10 and quantity of Metal waste from the institutions ranging between 0.79 to 3.49 Kg. This waste included broken parts of Chairs made from Metallic material. No proper method for management of such kind of solid waste which generate by these institutions. An average 2.5kg metal waste generates by these institutional units in two weeks.

Plastic waste

The total plastic waste in two weeks is 34.08 and quantity of plastic waste ranged between 1.10 to 4.41 Kg on weekly basis and the data in Table 4 shows the title of "plastic waste". Mostly food packaging from canteen accounted for this waste, followed by

shopping bags of various sizes from office. Schools get rid of this type of waste by burning it in yard. An average 3kg plastic waste generates by these institutional units in two weeks.

Rubber waste

The total rubber waste in two weeks is 34.08 shown in Table 4 and one of the least productions of such wastes in a rural setting while quantity was measured between 1.21 to 3.76 Kg. Most of this was produced from broken chair components made from rubber. An average 2.5 kg rubber waste generates by these institutional units in two weeks.

Textile waste

The total textile waste in two weeks is 24 kg which is shown in Table 4.The quantity measured was between 0-4.91 kg and textile waste produced from the institutions composed of rugs used for cleaning. This type of waste is disposed by burning with rest of the useless waste. An average 3kg textile waste generates by these institutional units in two weeks.

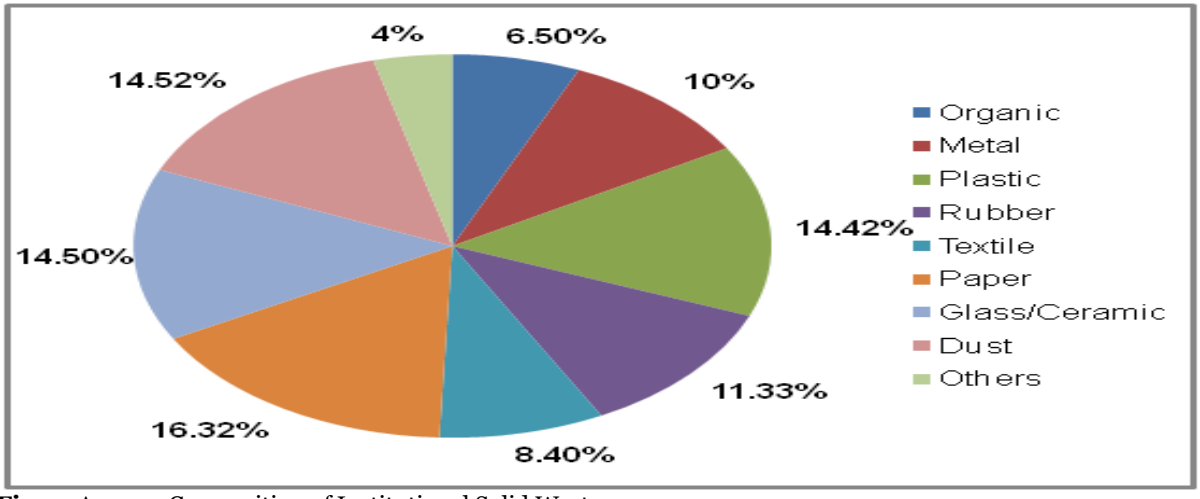

Fig. 3. Average Composition of Institutional Solid Waste.

Paper waste

The total paper waste in two weeks is 38.82 kg. Paper waste produced in institutions weighted between 1.39 to 5.31 Kg. It was one of the most produced wastes in institutions and listed in Table 2 under the title of "paper waste". The reason for its mass production at institutional level is careless use of books, notebooks and other stationary. Some of the paper was also from the canteen area selling food items with paper packaging. An average 2.5kg plastic waste generates by these institutional units in two weeks.

Glass/Ceramic

The total glass/ceramic waste in two weeks is 34.87 kg and quantity of waste in this category ranged between 0.29 to 5.90 Kg. This included under the category of "Glass/Ceramic waste". An average 3.8kg glass/ceramic waste generates by these institutional units in two weeks.

Dust

The total dust waste in two weeks is 33.24 kg Dust is produced as a result of sweeping the ground for cleaning purpose, since institutions sampled here had many classrooms and verandas along with corridors. Waste in this category was produced in high volume. Its quantity ranged between 1.21 to 3.57 Kg per week. The institutional units disposed this waste by throwing into playground or threw it outside the school premises. An average 2 kg dust waste generates by these institutional units in two weeks.

Others

The total other waste in two weeks is 9.67 kg. Miscellaneous items which did not fall into any of the above category or which were produced in low

quantities were collectively weighted up and given the title "other wastes" as detailed in Table 2.

Their quantity ranged between 0 to 2.19 Kg per week. This waste was burned with other types by the school's staff dedicated to this work. An average 1kg other waste generates by these institutional units in two weeks.

Total institutions solid waste in two weeks

The study finding shows that the total quantity of the institutional waste generates from institutional sectors, which include total Organic waste 15.45 kg, Metal waste is 23.86 kg, Plastic waste 34.08 kg, Rubber waste 26.87 kg, Textile waste 19.09 kg, Paper waste 38.82 kg, Glass/ceramic 34.87 kg, Dust waste 34.45 kg, while the other waste is 9.67 kg respectively.

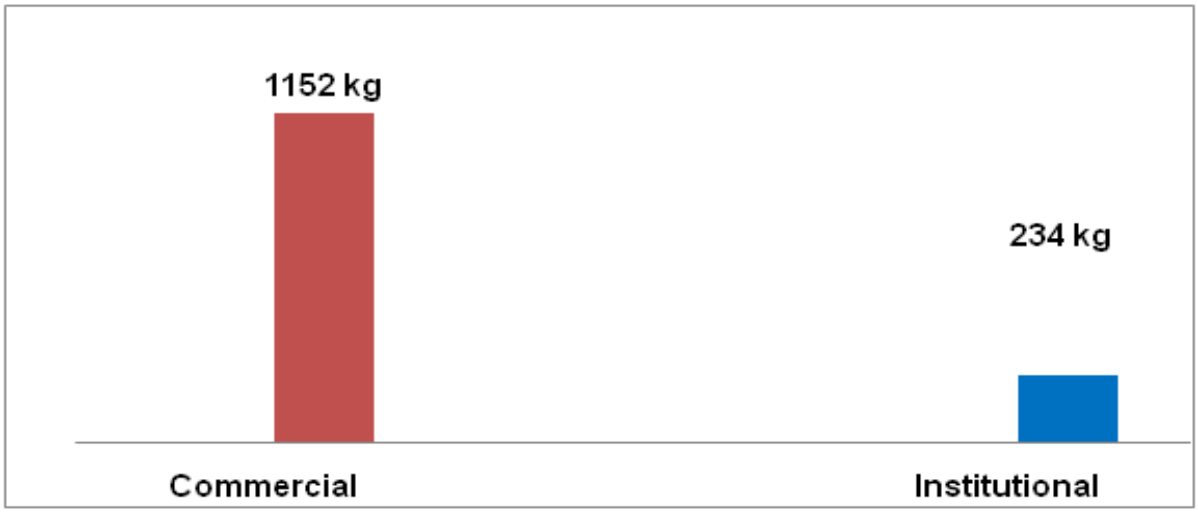

Fig. 4. Total waste generated from commercial and institutional sectors in two weeks in (kg).

Fig. 5. Daily Generation Rate of Waste from Commercial and Institutional Sectors in (Kg).

Conclusion

During the research work it was found that quantity of waste produced in commercial units is much more than those produced by institutional sectors. The waste generated from commercial sector was mostly comprised plastic, corrugated cartons, and organic waste while waste produced from institutional sector was mostly paper, glass and plastic. Plastic waste is most ubiquitous form of waste in both sectors particularly in commercial units that poses a challenge for Solid Waste Management.

Recommendations

- Local and higher tiers of government 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.
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References

Aguilar-Virgen Q, Taboada-Gonzalez P, Ojeda-Benitez S. 2012. Seasonal Analysis of the Generation and Composition of Solid Waste: Potential use—a case study. Environ Monit Assess **185,** 4633–4645.

Amber I, Kulla DM, Gukop N. 2012. Municipal Waste in Nigeria Generation, Characteristics and Energy Potential of Solid. Asian Journal of Engineering, Sciences and Technology, **2**.

Bandara NJGJ, Hettiaratchi JPA, Wirasinghe SC, Pilapiiya S. 2007. Relation of waste generation and composition to socio-economic factors: a case study. Journal of Environmental Monitoring and Assessment **135,** 31-39.

Bureau of Waste Prevention, Reuse and Recycling 2000. Characterization of New York City Waste Stream.

California Integrated Waste Management Board. 2009. California 2008 Statewide Waste Characterization Study.

Chandrappa R, Das DB. 2012. Waste Quantities and Characteristics. Solid Waste Management. Environmental Science and Engineering, DOI: http://dx.doi.org/10.1007/978-3-642-28681-0_2.

Chicago Metropolitan Agency for Planning 2014. Impacts of municipal solid waste.

Dara SS. 1997. Environmental Chemistry and Pollution Control (chapter-4). New Delhi: S. Chand and Company ltd.

Defra.gov.uk 2008. Health summary.

Department for Environment, Food and Rural Affairs 2011. Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes.

Ejaro SP, Jiya SN. 2013. Source Specific Quantification, Characterization and Management of Solid Waste in Lapai, Niger State, Nigeria. Ethiopian Journal of Environmental Studies and Management, **6(5),** 2013.

Guangyu Y. (n.d.). Amount and Composition of Municipal Solid Wastes. Point Sources of Pollution: Local Effects and its Control **1.**

International Resource Group, Ltd. 2009. Solid Waste: Generation, Handling, Treatment and Disposal (chapter: 15).

Karak T, Bhagat RM, Bhattacharyya P. 2012. Municipal Solid Waste Generation, Composition, and Management: the World Scenario. Critical Reviews in Environmental Sciences and Technology **42(15),** 1509-1630,. http://dx.doi.org/10.1080/10643389.2011.569871

Lamborn J. 2009. Characterization of Municipal Solid Waste Composition into Model Inputs. Third International Workshop "Hydro-Physico-Mechanics of Landfills". Braunschweig, Germany:

Mwakumanya MA. 2010. Baseline Survey on Solid Waste Management in Kilifi Town.

Pellowitz D. 1995. Commercial Generation Study Palm Beach County, Florida. Solid Waste Authority of Palm Beach.

Phuntsho S, Herat S, Shon H, Vigneswaran S, Dulal I, Yangden D, Tenzin UM. 2007. Studying Municipal Solid Waste Generation and Composition in the urban areas of Bhutan.

Roet KS, Choi HM, Tsai FJ. 1997. Solid Waste Research. Journal of Environmental Science and Health. Part A: Environmental Science and Engineering and Toxicology **32(2),** 367-390.

Singare PU. 2012. Quantification Study of Non-Biodegradable Solid Waste Materials Accumulated in The Mangrove of Mahim Creek, Mumbai. Journal of Marine Science **2(1),** 1-5.
http://dx.doi.org/10.5923/j.ms.20120201.01

Three Rivers Solid Waste Management Authority. 2011. Solid Waste Management Plan.

United Nations Environmental Program and International Environmental Technology Centre (n.d.) 2014. Converting Waste Plastics into Fuel: Report on Waste Quantification and Characterization for Chiang Mai.

United States Environmental Protection Agency 2005. Municipal Solid Waste Characterization Methodology.

Xiao Y, Bai X, Ouyang Z, Zheng H, Xing F. 2007. The Composition, Trend and Impact of Urban Solid Waste in Beijing. Environ Monit Assess **135,** 21-30.
http://dx.doi.org/10.1007/s10661-007-9708-0

Yang X, Okashiro T, Kuniyasu HO. 2010. Impact of Food waste disposers on the generation rate and characteristics of Municipal Solid Waste. J Mater Cycles Waste Manag, **12,** 17-24.
http://dx.doi.org/10.1007/s10163-009-0268-y

Yousuf BT, Rahman M. 2007. Monitoring quantity and Characteristics of Municipal solid waste in Dhaka City. Journal of Environ Monit Assess **135,** 3-11.
http://dx.doi.org/10.1007/s10661-007-9710-6