

## Waste Amount Survey and Physio-Chemical Analysis of Municipal Solid Waste Generated in Gujranwala-Pakistan

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### Abstract

Due to rapid population growth, increased industrial development and enhanced living standard, the per capita waste generation rates has been increased in the urban areas. The composition of the solid waste varies from region to region depending upon the income level, climatic conditions, social behavior and industrial production; influencing the per capita waste generation. The current study attempts to document the waste generation rates, composition and physio-chemical characteristics of the municipal solid waste produced in the Gujranwala City. The study was carried out for 8 days from 9-16 February 2015. For all physio-chemical analysis and testing standard ASTM methods have been used. The results of the study reveals that, all waste types contains 67 % to 99.1 % organic waste except street sweeping which have the lowest organic content (30%). Whereas, non-biodegradable fraction varies between 0.5 % to 4.5 % for all types of wastes. The accumulative apparent specific gravity was found 234 kg/m<sup>3</sup>. The chemical parameters (moisture, ash and combustible fraction) were found within optimum range.

**Keywords:** Waste amount; Waste composition; Chemical analysis; Coning an quartering; Waste density

### Introduction

Increasing population, industrialization, urbanization, economic growth and improved standard of living has resulted increased solid waste generation [1]. Management of these huge quantities of municipal solid waste has become a serious concern for government departments, environmental protection agencies, regulatory bodies and general public at the large. If the waste is not properly managed, the time is not far when our planet will be filled up with the waste.

The definitions of "solid waste" term vary greatly in literature. Solid waste is defined as, "Any discarded, rejected, abandoned, unwanted or surplus matter, whether or not intended for sale or for transformation or purification by a separate operation [2,3]. It can also be defined as anything non- liquid and non-gaseous in terms of by-product that is produced because of any human activity and can produce any detrimental impact on environment [4].

There are different types of solid waste originating from different sources, with varying quantities, characteristics and different methods of handling. Some type of waste are toxic, carcinogens, and malicious and require special care for its management and disposal. That is why there is a need to classify wastes according to their source of origin and quantity of production. Various Investigators from the field of environmental sciences and engineering had classified the solid waste into the various categories based on source of generation such as residential waste, industrial waste, commercial, nuclear waste, medical waste, electronic waste, commercial, institutional, demolition waste and agriculture waste [5].

The solid waste generation rate is greatly impacted by the socio-economics, education standard and infrastructure of the city [6]. The per capita waste generation in the developing Asian countries have been consistently increasing over the years [7].

Waste generation patterns in the low income countries varies within the range of 0.3 to 0.9 kg/cap/day; whereas, in high income countries this reaches up to 1.4 to 2 kg/cap/day [8].

The composition of the solid waste is almost same all over the

world with varying fractions due to change in income level, climatic conditions and cultural norms [9]. The waste produced in least developed and under developing countries contains higher fractions of organic materials as compared to industrialized countries where more of processed and tined food is used [10]. The characterization studies carried out in the developing countries reveals that, MSW contains 30-40 % organic, 30-40 % ash and fine earth, 3-6% paper and less than 1% of plastic, metal, glass and wood.

Assessment of chemical composition of solid wastes is important in evaluating alternative processing and recovery facilities. For example carbon/nitrogen ratio of solid wastes shows whether it is suitable for composting or not. Besides that, determination of carbon, hydrogen, oxygen, nitrogen and sulfur helps in estimating the potential of the wastes to produce biogas. Furthermore, energy contents of solid waste can also be evaluated from this information. The calorific value of the MSW ranges between 800-1000 kcal/kg and C: N value ranges between 20 -30 [11]. Apparent Specific Gravity (ASG) of the MSW varies between 150-200 kg/m<sup>3</sup> (when measures loosely). The moisture content of the waste with higher organic contents is found within the range of 40-50% [12].

Knowledge of the sources and types of solid waste, along with data on the composition and rates of generation, is basic requirement for the design and operation of the functional elements associated with the management of solid waste [13] beside this WACS is important in order to assess its impacts on the environment and communities [14].

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Current study has been carried out in the Gujranwala City for the winter season. It is located at 32.1° North, 74.9° east and is 226 meters above sea-level. Gujranwala shares its boundary with Wazirabad in North, NowsheraVikran and Kamoke in South. Gujranwala city comprised of seven (7) towns and ranked fifth amongst the big cities of Pakistan with a population of 1,132,509 in 1998 and 141, 5711 in 2007. During the inter censal years (1981-1998), the population growth rate of the City has been 3.79% in total area of 914 sq.km. After, the boundary alignment the city areas have been increased to about 238.1 sq. km. During the period of 1951-1961, growth rate of Gujranwala was as higher as 5.01% and increased further to 7.59% in 1972-81. It is also noticeable that the population of Gujranwala has increased nine times during the past 47 years with an average growth rate of 3.79% [15]. The study area has been shown in the Figure 1.

### Objectives of the WACS

The general objective of the waste amount and characterization survey (WACS) was to obtain data of waste amount and composition of municipal solid waste generated in the city of Gujranwala. The results/analysis of WACS shall be used as basic data to formulate the waste collection, 3R (reuse, recycle and recover), intermediate treatment and waste disposal plans addressing inefficiencies of the existing solid waste management system.

The specific objectives of the WACS are:

- To estimate per capita waste generation rate (Kg/cap/day).
- To determine the waste components and measuring their fractions (percentage by weight).
- To determine the variation of solid waste generation in social classes of the households (low, middle and high income).
- To estimate the fractions of recyclables, compostable and combustibles.

- To carry out chemical analysis to determine C: N ration, Moisture content, Ash and combustible components.

### Material and Methods

#### Sampling design

The waste amount and composition survey area includes all city areas as well as peri-urban areas of Gujranwala. Waste sources surveyed include households (high, medium, low income areas & rural), markets, shops & stores, hotels & restaurants, schools and institutes, offices and other commercial establishments.

Stratified sampling procedure was adopted for household waste survey. Households were divided into three strata (high, middle and low income) based on the income level. However, the data regarding these three income levels per Union Council (UC) was not available. Therefore, the criterion used for this classification was set by infrastructure including road condition and width, and house size and landscape access to electricity, water and gas network. The views of the field staff of Gujranwala Waste Management Company (GWMC) deployed in jurisdiction areas and the observations made after visiting the representative areas were taken into account for this task. Samples from ten discharge sources, i.e., residential sources (high, middle and low income groups, and rural areas as the peri-urban area) and nonresidential sources (restaurants, other commercial entities, markets, institutions, streets, and park) were collected and analyzed.

This survey has selected a total of 97 sampling points from each type of waste generation source to obtain the waste amount discharge ratio by generation source for 8 consecutive days. Hence, a total of 776 samples were collected and analyzed.

The purpose and the period of survey was communicated to the households, shop owners and inhabitants of the areas chosen prior to the survey for measurement of wastes. After receiving consent from related individuals, the data concerning the number of inhabitants, number of employees, floor area/total area and UC number of the household along with the GPS coordinates was recorded.

#### Waste amount analysis

Generation of solid waste can be determined by either using input method or output methods [16]. On national level, Input method can be used to estimate the waste production through collecting data from the production industries. The accuracy of this method depends upon the data collection and the refuse rate. For example, if the national glass production is 10,000,000 tons annually, and we can safely assume that all this will end up (sooner or later) in waste that would be dumped to the sanitary land filled, recycled or recovered. In this method, data are obtained from specialized agencies or institutions that regularly collect and publish data. This system provides regular updates about the current and future waste production estimates. However, this method is expensive because of the data collection.

For local level, reliable, accurate and most acceptable is output method (load count analysis method) of analysis and to perform sampling studies. This method requires less effort and finance as compared to input method. Sample size and method of characterizing the refuse are the most important variable for this method, which should be carefully chosen before initiating the composition analysis of any waste stream.

The later method has been used for the current study. Before the execution of sampling, the required number of plastic bags was

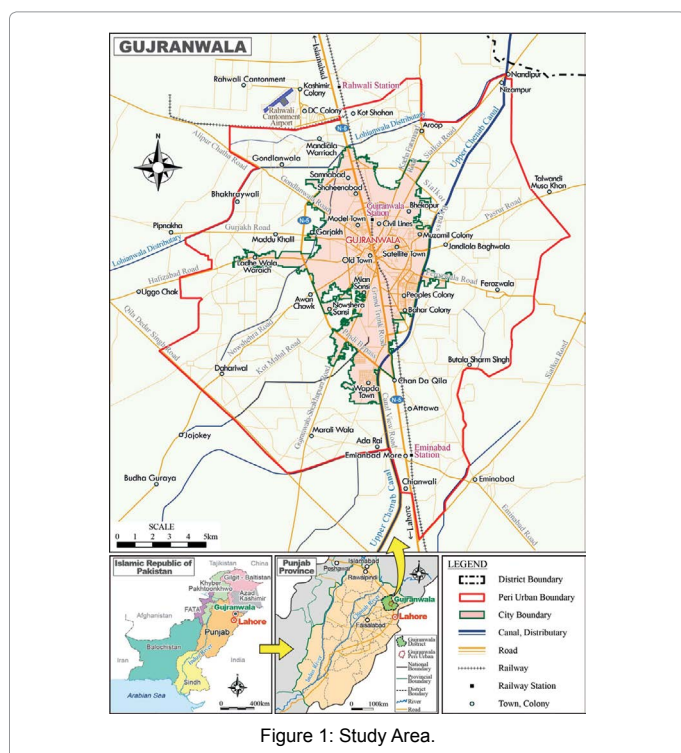


Figure 1: Study Area.

distributed to all selected sampling points except the points for market waste. Samples discharged from markets were collected by a collection vehicle specially assigned to the Project.

Each plastic bag of collected waste from the sampling points is bound with code numbers according to the generation source, so that no intermingling of samples will occur. Then, the amount of waste is measured by weight and recorded on the recording sheet at the collection points. The field investigations were conducted consecutively for 8 days however results for the first day were not included in the analysis to avoid the previous day's accumulated waste at the source. The average household size of high, middle low and rural areas is 7.76 people.

### Waste composition analysis

The procedure involves unloading and analyzing a quantity of wastes in a controlled area of a disposal site, that is isolated from winds. A representative sample resulting from a typical week-day collection route in residential area e.g. a sample size of 100-200 kg is sufficient for analysis. American Society for Testing Materials (ASTM) has named this method as ASTM-D5231-92 standard method for composition analysis of the municipal solid waste [16].

The samples of large waste generation sources are then subjected to the reduction method that entails repetition of the process below until the intended sampling weight of approximately 200 kg is obtained (If the total weight of the sample was found less than 200, it was subjected to direct segregation).

Mixing of wastes; bulky items in waste are cut into pieces in Table 1.1

Division of waste into four piles of approximately the same volume once the mixture is homogeneous.

Removal of two portions at diagonally opposite ends and the mixture of the remaining amount.

The above procedures are illustrated in Figure 2.

$$X_i = \frac{\text{Weight of each weight composition (kg)}}{\text{Total Amount of each waste composition (kg)}} \times 100 \quad (2.1)$$

After preparing of the representative sample, the waste is loaded into a plastic bucket. The plastic bucket containing the waste is dropped three times from a height of 30 cm to the ground, and then the volume is measured by a measuring tape and the total weight by a scale. The

Apparent Specific Gravity (ASG) is calculated through the following formula:

$$ASG = \frac{\text{Weight of the waste in Bucket (Kg)}}{\text{Volume of the waste (m}^3\text{)}} \quad (2.2)$$

After measuring the ASG, the sample was manually sorted into following 15 items:

1. Kitchen waste
2. Paper (recyclable/clean paper)
3. Paper (other paper)
4. Textile
5. Grass and wood
6. Plastic (recyclable plastic)
7. Plastic (non-recyclable plastic)
8. Leather and rubber
9. Metal (recyclable metal)
10. Metal (non-recyclable metal)
11. Bottle and glass (recyclable bottles and glasses)
12. Bottle and glass (non-recyclable bottles and glasses)
13. Ceramic, stone and soil etc.
14. Domestic hazardous wastes
15. Miscellaneous

### Chemical analysis

In consideration of the possibility of intermediate treatment, the large waste discharge amount from domestic waste and market waste is subject to the Three Component Analysis, Carbon and Nitrogen Analysis, and Moisture Contents Analysis. Three Component Analysis, Carbon and Nitrogen Analysis, and Moisture Contents Analysis are carried out for the waste discharge sources/types specified in Table 1.2.

Data and information from the Three (3) Component Analysis, Carbon and Nitrogen Analysis, and Moisture Contents Analysis of wastes might be used as the basic data for considering the introduction of intermediate treatment processes.

Type		Waste Amount Survey				
		Area	Samples per Area	Number of Samples	Survey Days	Total Samples
				A × B		C × D
A	B	C	D	E		
Household	High Income	2	5	10	8	80
	Middle Income	6	5	30	8	240
	Low Income	4	5	20	8	160
	Rural Area	2	5	10	8	80
Commercial	Restaurants	1	5	5	8	40
	Others	1	5	5	8	40
Markets (Food, Vegetable, etc.)		5	2	10	8	80
Institution		5	1	5	8	40
Street Sweeping		1	1	1	8	8
Park		1	1	1	8	8
Total			---	97	---	776

Table 1.1: Waste Generation Sources and Number of Samples for Waste Amount Survey.

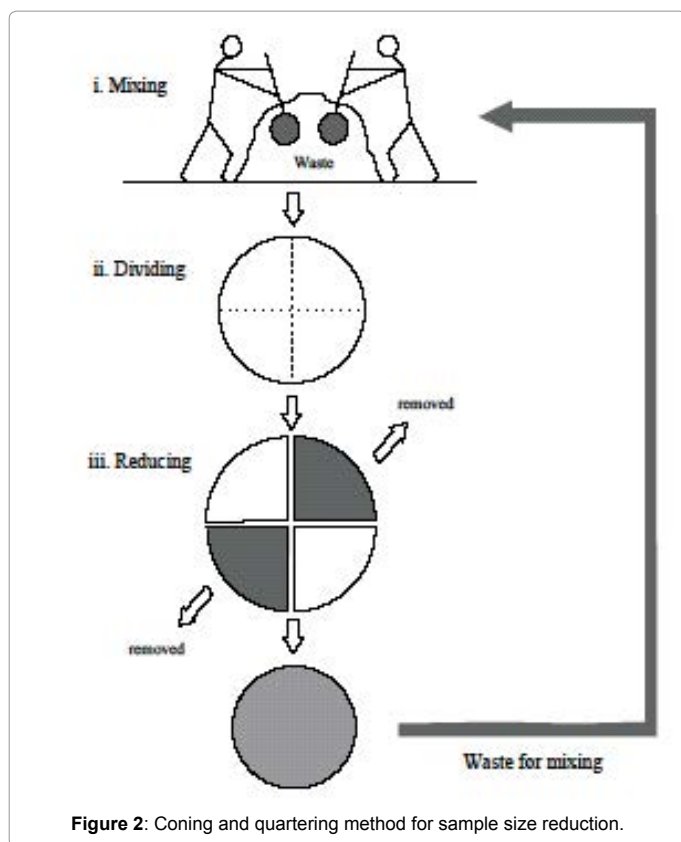


Figure 2: Coning and quartering method for sample size reduction.

- Analysis of the three components (waste types 1 to 15)
- Analysis of Carbon and Nitrogen concentration in wastes (waste type 1, 2, 3 and 5)
- Measurement of moisture content of combustible waste (waste type 1, 2, 3, 4, 5 and 8)

The waste of each composition was put into a container for measuring the moisture content of each composition at laboratory. At least, 1 (one) kg of each waste sample was secured. The sample was sealed for avoiding the moisture change.

The sample was put in oven or incubator to control the temperature in the range of 90 to 100 °C for 4 to 5 days [17]. The moisture content of each waste composition, we, can be calculated as follows.

$$W_i = \frac{\text{Weight before drying (Kg)} - \text{Weight after drying (kg)}}{\text{Weight before drying (Kg)}} \times 100 \quad (2.3)$$

The nitrogen was analyzed in laboratory using Total Kjeldahl Nitrogen Method (official method of AOAC international, 16th Edition, Method No. 955.04 using mercuric oxide or metallic mercury HgO or Hg) as a catalyst [18].

For the chemical analysis, chemical property analysis of the three contents, namely; moisture, ash and combustible was carried out. The analyses were made based on the following recommended procedure [19,20].

- 5 to 6 g of the waste sample was measured by a 100 ml skull crucible furnace of known volume and weight.
- Heat above sample at the temperature of 800 degree Celsius at an

electric furnace for 3 (three) hours

- The sample was then cooled and dried at the temperature of 105 ± 5 degree Celsius.
- The dried sample was cooled at the desiccators for 20 to 30 minutes, and the weight was measured.

The combustible (V %) and ash component (a %) were calculated as follows.

$$V(\%) = \frac{\text{Sample Weight (g)} - \text{Weight after heating at 800 C(g)}}{\text{Sample Weight (g)}} \times 100 \quad (2.4)$$

And,

$$A(\%) = \frac{\text{Weight after heating at 800 C(g)}}{\text{Sample Weight (g)}} \times 100 \quad (2.5)$$

The laboratory analysis was conducted by the nationally accredited Pakistan Council for Scientific and Industrial Research (PCSIR), Lahore.

## Results and Discussion

### Waste generation

The waste generation amount per capita per day of each generation source is as shown in Table 2.1. The average waste generation amount per capita per day of the four groups in residential areas ranges from 0.36 kilograms per capita per day (kg/c/d) to 0.46 kg/c/d, as shown in Figure 3.1.

The waste amount survey was also conducted for commercial areas which included restaurants and shops, fruit and vegetable markets, institutions, street sweeping and public parks. As there is no information available for number of personnel generating the specific amount of waste, average weight for the 7 days has been used for plotting the graphs as shown in the Figure 3.2.

For market wastes transported by collection trucks, the collection truck loaded with waste is measured by a weighbridge before going to the disposal site for the waste composition survey. It was found that, average waste generated per day in the fruit and vegetable market in 360 kg.

Specific gravity for each category was calculated using equation 2.2. Daily data for eight days was recorded and data for the 7 days (i.e. day 2 till day 8) were analyzed for results. Average for 7 days is shown in the Figure 3.3.

As shown in the following Figure 3.3, commercial waste especially those from restaurants have the highest apparent specific gravity of about 455 kg/m<sup>3</sup> while the other commercial wastes from shops have the lowest. The apparent specific gravity of household is at around 238 Kg/m<sup>3</sup>, whereas, the accumulated average for all types of waste is calculated as 234 kg/m<sup>3</sup>.

### Physical composition

The results of the physical composition of the survey has been summarized in the Table 2.2 and presented in Figure 3.4.

- The characteristics of the two survey results are summarized as follows:
- The highest percentage of waste composition is kitchen waste from households (43-68%), restaurants (77-90%) and markets (49-78%) followed by paper (3-15%) and plastics (7-12%).
- High percentage of grass and wood from institutions (43-48%),

Type		Chemical Composition Survey			
		Discharge Source	Three Component Analysis	Carbon and Nitrogen Analysis	Moisture Contents
		F	Samples	Samples	Samples
Households	High Income	1	3 × 3 days = 9	3 × 3 days = 9	3 × 3 days = 9
	Middle Income	1	3 × 3 = 9	3 × 3 = 9	3 × 3 = 9
	Low Income	1	3 × 3 = 9	3 × 3 = 9	3 × 3 = 9
Markets (Food, Vegetable, etc.)		1	3 × 3 = 9	1 × 3 = 9	3 × 3 = 9
Total		4	36	36	36

Table 1.2: Number of Samples for Chemical Composition Survey.

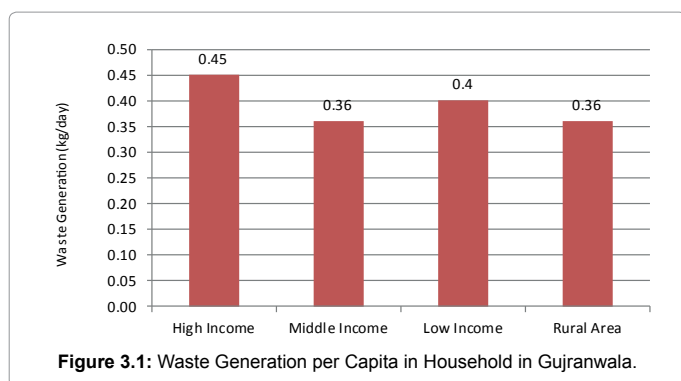


Figure 3.1: Waste Generation per Capita in Household in Gujranwala.

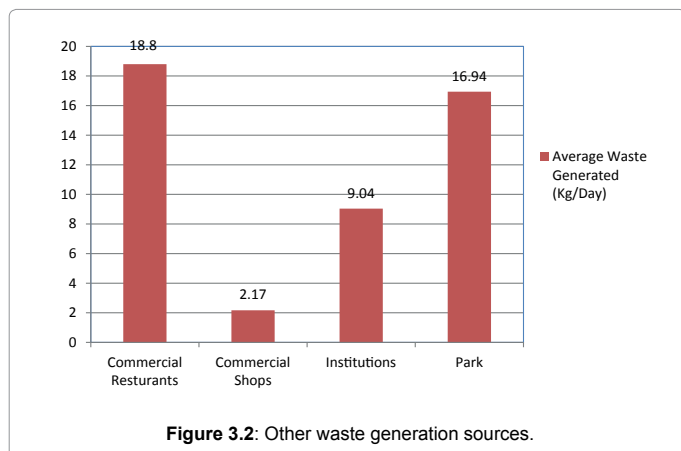


Figure 3.2: Other waste generation sources.

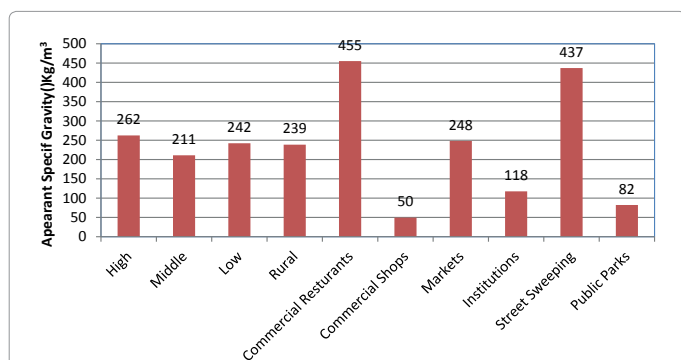


Figure 3.3: Average Apparent Specific Gravity (Kg/m³) for the Sampled Data.

street sweeping (3-17%) and parks (66-76%) can be observed because they might include garden waste.

- Except the waste from street sweeping, the ratio of organic waste is quite high at 68 to 99%.
- The ratio of recyclable material such as paper, plastic, metal and glass from households varies from 4- 10%, and its average is around 5.6% considering the rate of population for each income group.

### Chemical analysis

The average of moisture content analysis performed for 36 samples turned out to be 74.68% with high income areas accounting for 79.98%, middle income regions for 77.73%, low income 73.84% and market areas with 67.18%. The moisture content of waste with high organic waste content is observed in the market areas and high income regions which was unexpected in case of high income region. The moisture contents results in the high income region were unexpected as the general trend reveals the organic products to be at a decelerating consumption rate in high income regions and is considered to carry higher percentages in the middle income regions comparatively in Figure 3.5.

The average value calculated for C: N for all samples was found 234.60 with high income strata having 241.77, middle income 273.91, low income 157.08 and 265.61 for market waste. The C: N of the sampled waste being highest in the middle income group followed by markets, and high income areas and low income strata depicted the lowest C: N in their respective waste samples as shown in the Figure 3.6.

The three components exhibit almost the same tendency, i.e., the ratio of moisture, ash and combustible. The average of moisture content analysis performed in the three component analysis for 36 samples turned out to be 75.12% with high income areas accounting for 78.3%, middle income regions for 76.25%, low income 77.89% and market areas with 68.33%.

The average of combustible content analysis performed in the three component analysis for 36 samples turned out to be 13.14% with high income areas accounting for 15.46%, middle income regions for 11.63%, low income 12.21% and market areas with 13.26%.

Similarly the average ash content for these samples were 11.74% with high income areas accounting for 6.51%, middle income regions for 12.12%, low income 9.91% and market areas with 18.41%. The combustible content with high organic content was high in high income area and that of least in the low income area.

Wastes from the high income groups in residential areas showed the highest value of moisture content while the market wastes have the highest percentages of ash content as shown in the Figure 3.7 below.

Type	Unit	Waste Generation (kg/day)	
		Survey 9-16 February 2015	
Household	High Income(HI)	person	0.46
	Middle Income(MI)	person	0.36
	Low Income(LI)	person	0.40
	Rural Area(RA)	person	0.36
Commercial	Restaurants(R)	establishment	18.80
	Others(O)	establishment	2.17
Markets (Food, Vegetable, etc.)[M]	market		360.00
Institution(I)	establishment		9.04
Street Sweeping(SS)	meter		0.19
Park(P)	park		16.94

Table 2.1: Waste Generation Rate of Each Generation Source.

Waste Composition		Household				Commercial		M	I	SS	P
		HI	MI	LI	RA	R	O				
Kitchen Waste		68.0	55.6	63.9	60.9	89.8	4.0	78.1	2.8	16.0	20.3
Paper	Paper(recyclable/ clean)	2.6	2.6	2.7	2.8	0.2	14.4	0.7	3.0	0.9	1.1
	Paper (others)	12.4	15.2	10.4	3.7	2.6	33.3	4.1	5.1	4.8	1.6
	<i>Subtotal-Paper</i>	<i>15.0</i>	<i>17.8</i>	<i>13.1</i>	<i>6.5</i>	<i>2.8</i>	<i>47.7</i>	<i>4.8</i>	<i>8.1</i>	<i>5.7</i>	<i>2.7</i>
Textile		2.3	5.9	3.4	3.0	2.2	7.2	1.3	0.7	1.6	0.5
Grass and wood		1.5	1.6	1.8	5.0	0.2	0.2	4.2	47.8	3.3	66.1
Plastics	Plastic (recyclable)	1.2	1.0	0.6	1.6	0.0	5.4	0.1	0.8	0.3	0.5
	Plastic (non- recyclable)	5.8	7.8	6.7	5.3	4.1	23.8	3.2	6.7	3.2	5.2
	<i>Subtotal-Plastic</i>	<i>7.0</i>	<i>8.8</i>	<i>7.3</i>	<i>6.9</i>	<i>4.1</i>	<i>29.2</i>	<i>3.3</i>	<i>7.5</i>	<i>3.5</i>	<i>5.7</i>
Leather and rubber		1.0	1.0	0.3	1.2	0.2	1.8	0.4	0.1	0.1	0.7
<b>Organic Waste - Subtotal</b>		<b>94.8</b>	<b>90.7</b>	<b>89.8</b>	<b>83.5</b>	<b>99.3</b>	<b>90.1</b>	<b>92.1</b>	<b>67.0</b>	<b>30.2</b>	<b>96.0</b>
Metal	Metal (recyclable)	0.4	0.2	0.1	0.6	0.0	0.7	0.0	0.2	0.0	0.0
	Metal (non-recyclable)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	<i>Subtotal-Metal</i>	<i>0.4</i>	<i>0.2</i>	<i>0.1</i>	<i>0.6</i>	<i>0.0</i>	<i>0.7</i>	<i>0.0</i>	<i>0.2</i>	<i>0.0</i>	<i>0.0</i>
Bottle & glass	Bottle and glass (recyclable)	0.9	1.3	0.9	0.6	0.3	3.4	0.0	0.0	0.1	0.3
	Bottle and glass (non- recyclable)	0.2	0.2	0.0	0.7	0.3	0.0	0.0	0.7	0.0	0.0
	<i>Subtotal-Bottle and glass</i>	<i>1.1</i>	<i>1.5</i>	<i>0.9</i>	<i>1.3</i>	<i>0.6</i>	<i>3.4</i>	<i>0.0</i>	<i>0.7</i>	<i>0.1</i>	<i>0.3</i>
Ceramic, stone and soil etc.		0.5	1.8	1.0	2.9	0.0	0.4	0.9	5.3	2.4	0.2
<b>Inorganic Waste - Subtotal</b>		<b>2.0</b>	<b>3.5</b>	<b>2.0</b>	<b>4.8</b>	<b>0.6</b>	<b>4.5</b>	<b>0.9</b>	<b>6.2</b>	<b>2.5</b>	<b>0.5</b>
Domestic Hazardous Waste		0.6	0.9	0.3	0.3	0.1	0.3	0.0	0.1	0.3	0.0
Sieve Remaining		1.7	4.0	4.0	4.6	0.0	3.7	3.5	6.0	18.5	1.3
Miscellaneous		0.9	0.9	3.9	6.8	0.0	1.4	3.5	20.7	48.5	2.2
<b>Total</b>		<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

Table 2.2: Waste composition of each source.

## Conclusion and Recommendations

Results of the waste amount and characterization study reveal that:

- Waste generation rate in kg per capita per day for high income groups turns out to be 0.46. The generation rate for middle and low income is 0.41 and 0.4 respectively. Generation rate for rural households is 0.33.
- The waste generated from the residential (low income, high income, middle income & rural), commercial restaurants and parks is mainly comprised of organic waste with highest

percentage of kitchen waste from households (43- 68%) restaurants (77-90%) and markets (49-78%) followed by paper (3-15%) or plastics (7-12%). Similarly waste generation rate for commercial shops was found 10.98 kg/day, 2.07kg/day for shops, 4.66kg/day for institutions, 1.8 kg/day for street sweeping, 9.4kg/day for parks and highest 360 kg/day for fruit and vegetable market

- Commercial waste especially those from restaurants have the highest apparent specific gravity of about 455 kg/m<sup>3</sup> while the other commercial waste from shops has the lowest. The

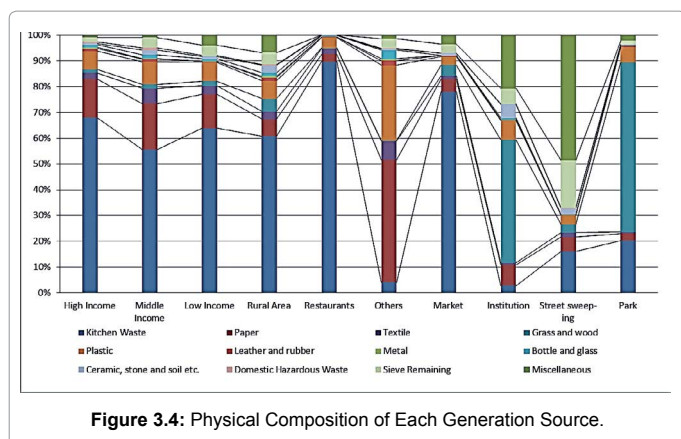


Figure 3.4: Physical Composition of Each Generation Source.

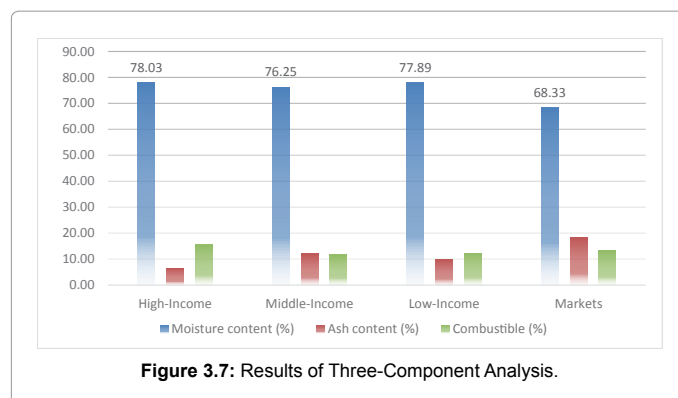


Figure 3.7: Results of Three-Component Analysis.

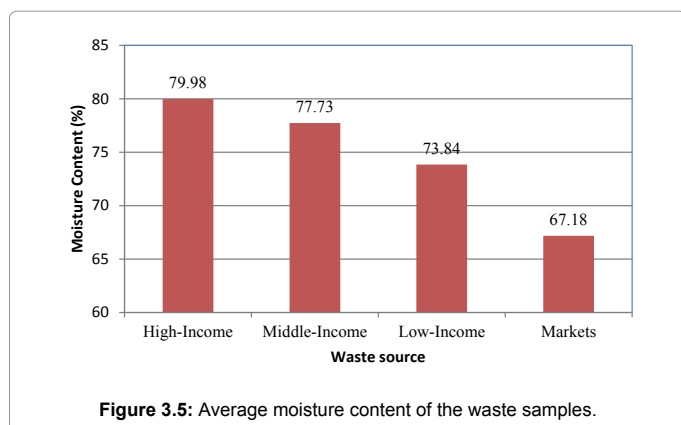


Figure 3.5: Average moisture content of the waste samples.

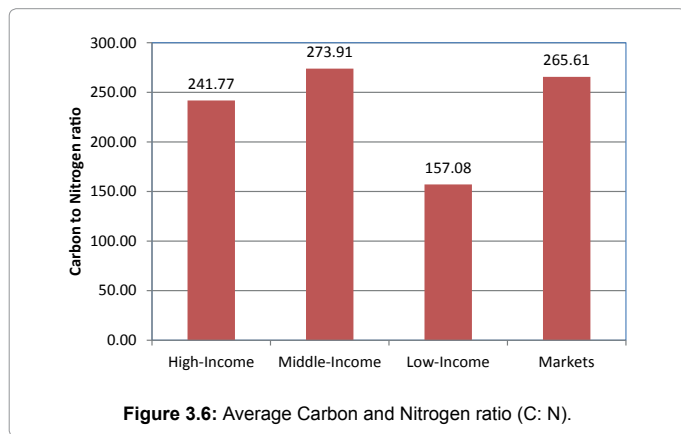


Figure 3.6: Average Carbon and Nitrogen ratio (C: N).

apparent specific gravity of household was found around 238 Kg/m<sup>3</sup>, whereas, the accumulated average for all types of waste is calculated as 234 kg/m<sup>3</sup>.

- Analysis of moisture content revealed more or less comparative results, it ranges from 79.98% for high income to 77.73% for middle income and 73.84% for low income areas. Moisture content in waste of fruits and vegetable markets was determined as 67.18%.
- The average value calculated for carbon to nitrogen ratio for all the analyzed samples was 234.60. Separately it was 241.77 for high income regions, 273.91 for middle income, 157.08 for low income group and 265.61 for market waste.

- For the three component analysis combustible content analysis showed that high income areas has 15.46% with for 13.14%, middle income regions account for 11.63%, low income 12.21% and market areas has 13.26% value for combustible content.
- Lastly the average ash content for all the samples were 11.74% with high income areas accounting for 6.51%, middle income regions for 12.12%, low income 9.91% and market areas with 18.41%.

WAC study reveals that waste generated from the Gujranwala City has highest potential for composting if onsite segregation is practiced because the 98% of the waste is composed of organic components.

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