

Baseline Study for Solid Waste Management - Karachi



Executive Summary

The current solid waste management practice is to dispose all categories of collected waste generated from the mega city of Karachi to land fill sites. The existing practice is not sustainable and putting immense pressure on environmental ecosystems. There is a large potential in reusing the organic fraction of solid waste for various beneficial purposes including production of renewable energy and bio fertilizer. This study has been conducted to determine the quantity and composition of solid waste generated from households which form the largest proportion in the solid waste. Moreover fruit and vegetable market also generate waste which can be used for production of renewable energy and biofertiliser, therefore this facet has also been covered in this study. The main objectives of this study were to determine household waste storage methods, social and cultural habits towards waste hygiene and cleanliness and also the roles of household members in managing waste, segregation of waste. The objectives also included existing waste cycle in the city and analysis of the waste produced at household, commercial sectors and city vegetable and fruit market and conducting a market chain analysis.

To accomplish the objectives of the study two parts were designed. In first part, questionnaire survey from household, commercial, market chain (sweeper level and junkyard shop level) was conducted. The second part comprised of collection and analysis of solid waste from household, commercial and vegetable and fruit market levels. The study showed that the average household solid waste generation for the city of Karachi is estimated to be 0.44 kg/c/d ranging from 0.19 to 0.84 kg/c/d. Waste analysis of commercial group and fruit and vegetable market showed that the average waste generation per commercial and fruit and vegetable group/market was 1.795 kg/shop/d and 11.77 kg/shop/d respectively. The waste composition analysis of household and vegetable and fruit market showed that the organic fraction (food waste) has the highest proportion ranging from 36.1 to 93% (weight/weight). It has been observed that a moderate proportion of people segregates their recyclable waste and in recycling females play an important role. In recyclables, contribution of metal was the highest followed by plastic and paper. The primary industries involved in reprocessing of recovered recyclables are

plastic, package, furniture, paper and metal. It is recommended that for better and more efficient service decentralized system should be adopted as in a mega city like Karachi centralized waste collection, transportation and disposal system is difficult to manage, maintain and monitor.

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1. Introduction

One of the consequences of the global urbanization is increasing volumes of solid waste. A considerable amount of money goes into managing huge volumes of solid waste. Solid Waste Management can be defined as the discipline associated with the municipal solid waste (MSW) in a way which is governed by the best principles of public health, economics, engineering, aesthetics and other environmental considerations; control of generation, storage, collection, transfer, processing and disposal of Municipal Solid Waste. Due to lack of financial and technical resources, the municipalities in developing countries fail to manage solid wastes in a safe and sustainable way. This raises the important issue of how to deliver quality service in the face of financial and skill constraints of the public sector. Approximately 9,000 tones of solid waste is generated daily in Karachi. Rapid establishment of new housing sectors and industrial states, construction activity and a variety of institutions contribute to waste generation. The amount of solid wastes is expected to substantially increase with the rapid growth of population and economic activity. It is estimated that by year 2020, the solid waste generation may approach 16,000 to 18,000 tons each day. The current poor solid waste mismanagement practices demand need of developing a mechanism for efficient solid waste management. Lack of planning, inappropriate technology and poor management are obviously the main areas of concern, this requires serious efforts from government authorities and other agencies for effective solid waste management.

The objectives of the study include the following:

- Determine household waste storage methods, social and cultural habits towards waste hygiene and cleanliness. Roles of household members in managing waste, segregation of waste at household level.
- Waste collection mechanism and its transportation from the household, defining services level provided by municipal authorities.
- Analysis of the waste produced at household, commercial sectors and city vegetable and fruit market.
- Market chain analysis for recyclables

2. Methodology

A methodology was developed to conduct the solid waste management baseline study for Karachi. The study comprised of two vital components, the first component comprised of a questionnaire survey. Four different questionnaires including household, commercial, market chain (sweeper level and junkyard shop level) were prepared. The second component comprised of collection and analysis of solid waste from household, commercial and vegetable and fruit market levels. This exercise was carried out to determine the waste generation and waste composition. The detail of these components is as follows:

2.2.1 Household Level Survey

As a first step, an experienced team developed a questionnaire for household survey (Annexure-A). The survey was conducted for three different classes: low income, medium income and high income areas of Karachi. Sixty households were selected for each class. Different areas were selected to achieve representative samples, the details of areas representing all three classes are illustrated in Table 1. The areas were selected based on the house size, income and locality.

Table 1 Details of representative areas for various classes

S.No.	Class	Representative areas
1	Low Income	Scheme-33, Gabol Goth and Safoora Goth
2	Middle Income	Gulshan-e-Iqbal, Abul Hassan Isphani Road and Garden West
3	High Income	Defense Housing Authority , Gulshan-e-Iqbal

2.2.2 Household Level Waste Generation and Composition

Sixty samples from each class were collected to evaluate the waste generation and composition at household level for eight consecutive days. Each day the samples were collected from selected areas and transported for analysis. The samples were stocked at designated places. All sixty samples were weighted and the per capita daily waste generation was calculated by ratio of total weight to household size.

For analysis of solid waste composition, twenty five random samples were selected from each class each day. In order to determine the waste composition, the samples were segregated in nine different categories including fruit and vegetable, bones, paper, textile, plastic, grass/wood, leather/rubber, metals, glass, fines/miscellaneous.

2.2.3 City Vegetable and Fruit Market Level Waste Generation and Composition

In order to evaluate the waste generation at city vegetable and fruit market, fifty samples were collected from different shops located in main vegetable and fruit market, main super highway. To achieve authentic results, the sampling was carried out for eight consecutive days. For analysis of solid waste composition, twenty five random samples were selected each day.

2.2.4 Commercial Level Survey

A questionnaire for commercial level survey (Annexure-B) was developed and survey was conducted for ten different shops.

2.2.5 Commercial Level Waste Generation

In order to evaluate the waste generation at commercial level, ten samples were collected from banks, offices, restaurants, general store, mart, and travel agent. In order to determine the waste composition, the samples were segregated in various categories.

2.2.6 Market Chain Analysis

In order to determine the mechanism of scavenging by waste pickers at the dumping site and selling to different dealers, a market chain analysis was carried using participatory appraisal approach in which interviews were conducted and relevant information was collected (Annexure-C1 & C2).

2.2.7 Municipal Services

The level of services provided by the town municipalities for solid waste management, interviews were conducted from the key personals of concerned departments with prior appointments. A copy of request for information from the concern personals is attached

as (Annexure-D). List of questions were prepared to gain information on current waste collection, transportation, transfer, disposal and recycling systems.

2.2.8 Data Compilation

All collected data from questionnaire and field work was compiled and electronically saved for subsequent analysis. The questionnaire survey will assist in finding the current solid waste management practices at household and municipal level for Karachi. The analysis of solid waste samples collected from household, markets and commercial area will give an overall characteristics and waste generation rate.

3. Findings

3.1 Existing Solid Waste Management System

According to Master Plan 2020, approximately 9,000 tons of solid waste is generated each day (2005) and population was 15.12 Million. However, no authentic current data is available related to waste generation, due to this reason the data for 2012 has been extrapolated using the currently available authentic data. The estimated solid waste generation is 12,280 tons which is 0.595 kg/c/d for a current population of 20.61 Million with an annual growth rate of 3.5%.

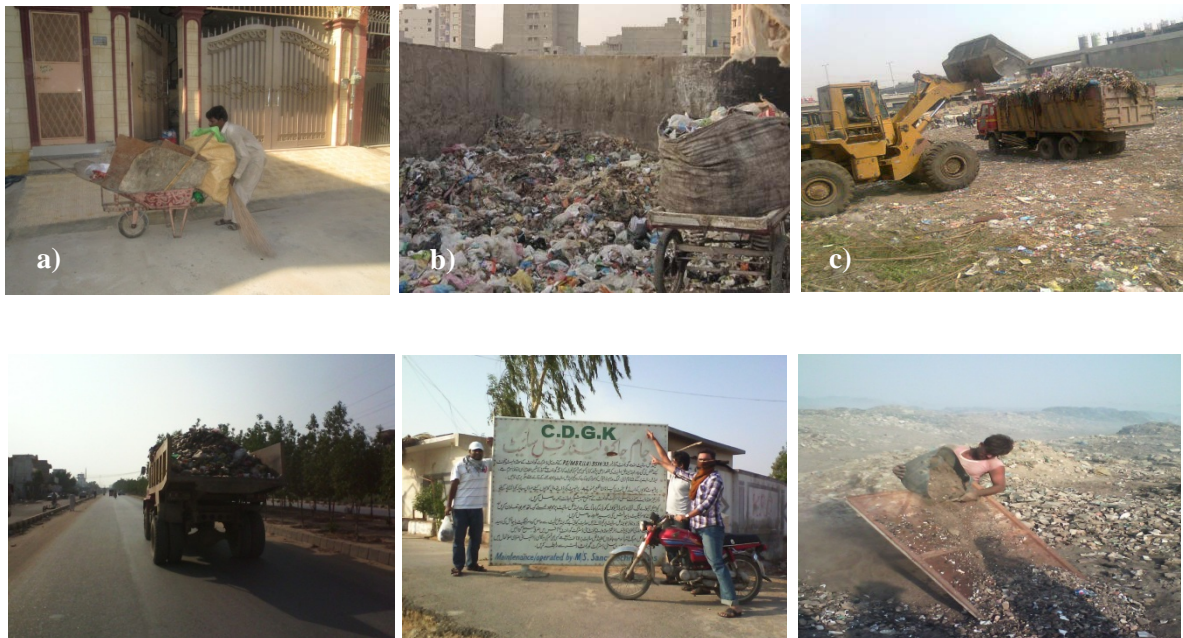


Fig.1 Solid waste management (a) collection (b) kundi (c) intermittent transfer station (d) transportation to landfill site (e) Jam Chakro disposal site (f) Gond Pass disposal site

According to CDGK (City District Government Karachi), solid waste of the 80% of the city is managed by recruited staff of CDGK and remaining 20% of the solid waste is managed by Defense Housing Authority and Cantonment Boards. According to Master Plan 2020, the CDGK collects 84% of the total generated waste and transport to designated operated landfill sites of Gondpass and Jam Chakro. These two sites were designed as proper landfill sites but are now being operated as dumping sites. The allocated area for each was 500 acres, but due to encroachment by land mafia, less than half i.e. 200 acres is available for solid waste management. CDGK, collects solid waste from 4085 designated Kundi, using 567 vehicles the waste is transported to the above landfill sites. According to Karachi Master Plan 2020, approximately 50% of the total waste generated is collected by the city municipal services department using lifter, dumper, loader and tractor trollies. The remaining waste is disposed on streets, drains and open spaces. 11,843 staff is employed for waste collection while 11,974 staff is employed in waste management in total.

It is estimated that the cost of solid waste collection and transportation from various parts of city is approximately Rs.294/ton. Currently resource recovery and 3R approach is not practiced formally. However, most of the resource recovery is carried out by the informal sector. In particular, teendabe wala and junkyard shops are the major role players in the recycling process.

3.2 Solid Waste Management at Household Level

3.2.1 Collection

Teams for collection of waste from selected areas comprised of sweepers and helpers (Annexure-E). It was noticed that most of the collection took place in morning from 8:00 to 12:00. In low income the collection time was earlier compare to other two classes.



Fig.2 Sample collection from (a) low income, (b) middle income and (c) high income areas

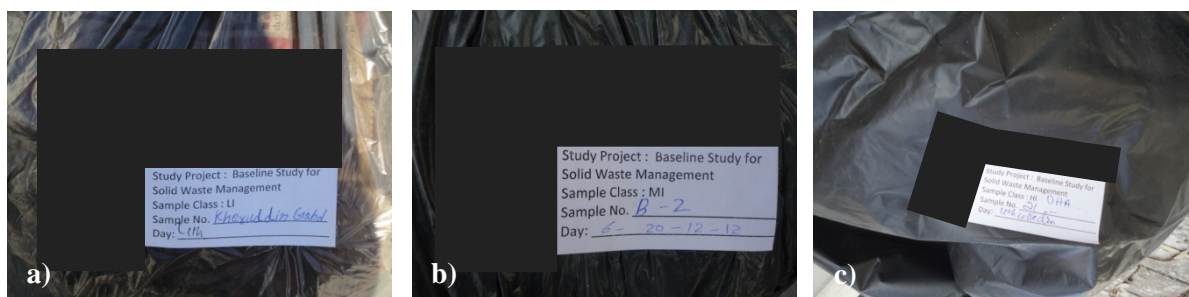


Fig.3 Sample tagging (a) low income, (b) middle income and (c) high income

Waste collection was comparatively difficult from high income areas. Waste collection from three classes is shown in Fig. 2. Garbage collection bags with labels (Fig. 3) were supplied to independent households, who agreed to participate in this study. This exercise facilitated in the analysis of solid waste. A private vehicle was hired for transportation and analysis of the households samples (Fig. 4).



Fig.4 Transportation of samples of (a) low income, (b) middle income and (c) high income areas for analysis

3.2.3 Waste Analysis

After collection of waste was completed, samples were analysed for waste generation and waste composition which is discussed below:

Table 2 Statistical data of waste generation in all three classes

S.No	Class	Waste Generation (kg)/c/d		
		Average	Low	High
1	Low income	0.19	0.087	0.59
2	Middle income	0.29	0.11	0.68
3	High income	0.84	0.14	2.33

Waste Generation

After waste collection and transportation the wet weight of all collected sixty samples of all three classes was recorded (Fig.5). Waste analysis showed that the average per capita waste generation varied with different classes. The average of low, middle and high incomes was 0.19, 0.29 and 0.84 kg/c/d (Table 2), respectively. The waste generated in low income area was observed in range of 0.087 to 0.59 kg/c/d (Table 2). Percentage of population belonging to LI, MI and HI groups are 60%, 30% and 10% respectively. Average domestic waste generation rate based on weighted average is 2351 tons for LI class, 1793 tons for MI class and 1731 tons for HI class. Bulk density of solid waste generated from low, middle and high-income class is 125, 140 and 180 kg/m³, respectively. The bulk density of high class is higher compared to the other two classes.



Fig.5 Weighing of wet solid waste samples collected from various areas

It was observed that waste generated per capita was highest for high income areas compare to middle and low income areas. Because of their living standard the per capita waste generation was higher, the average per capita waste generation for high income

group was 4.4 times higher compared to low income and 2.9 times higher compared to middle income group (Fig. 6). The obvious reason of high generation from high income class is that higher the standard of living greater the solid waste generation.

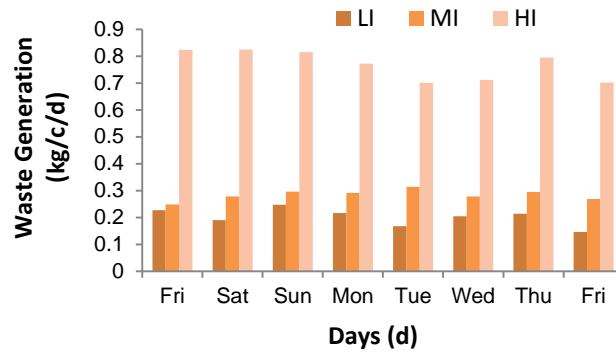


Fig.6 Daily waste generation in all three classes

Waste Segregation

After recording the weight of all collected sixty samples of all three classes, twenty five samples from each class were randomly selected and categorized for waste composition (Fig.7-8).



Fig.7 Selection of twenty five random samples from sixty collected samples



Fig.8 Segregation and re-weighing of solid waste samples collected from various areas

It is observed from Fig.9 that in low income class, the food wastes including vegetable and fruit waste is higher on Sunday (holiday) compared to Friday (working day). The reason for this is most likely that all family members of the house are present at home, however during working days, the family members are outside their house at workplaces. It can also be seen that the composition of recyclables on week days are higher compare to weekends. It is observed from Fig.10 that in middle income class, the food wastes including vegetable and fruit waste is higher on Tuesday (working day) compare to Friday (last working day). It can also be seen that the composition of recyclables on week days are higher compare to last working day.

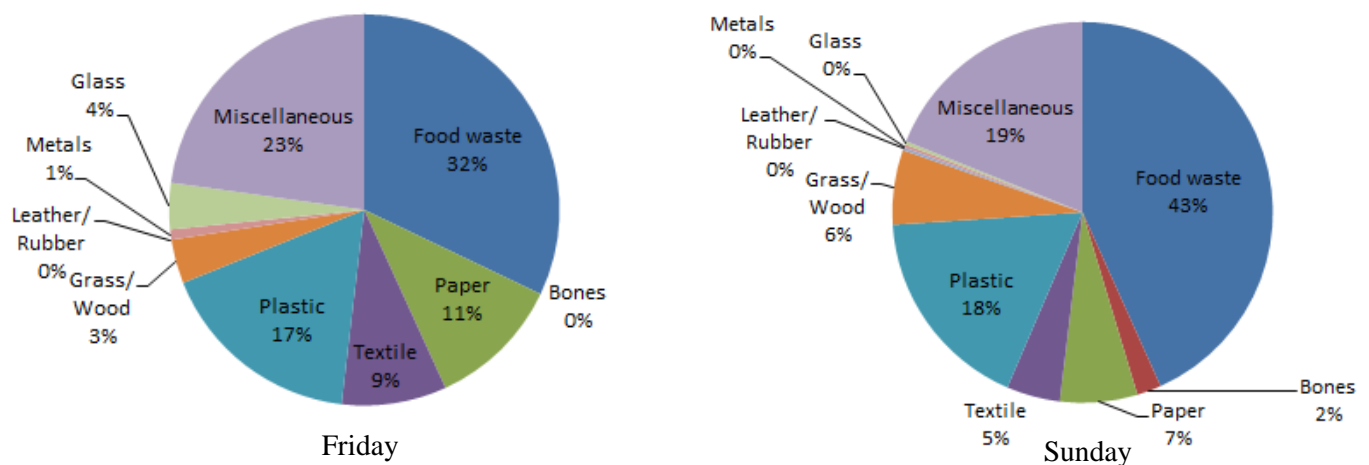


Fig. 9 Average waste composition category wise on lowest (Friday) and highest (Sunday) waste generation day for low income class

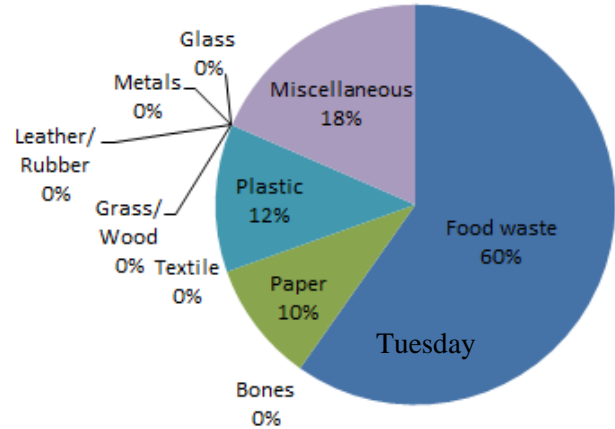
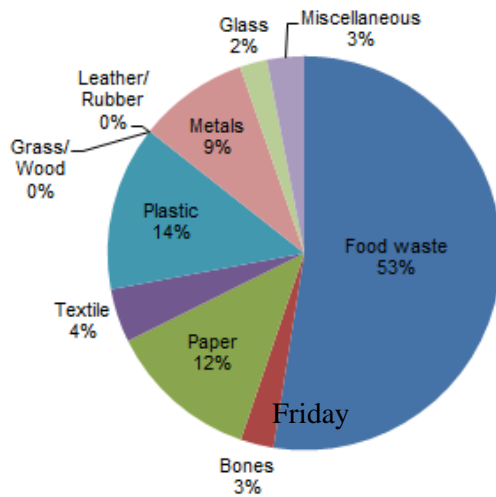


Fig.

10 Average waste composition category wise on lowest (Friday) and highest (Tuesday) waste generation day for middle income class

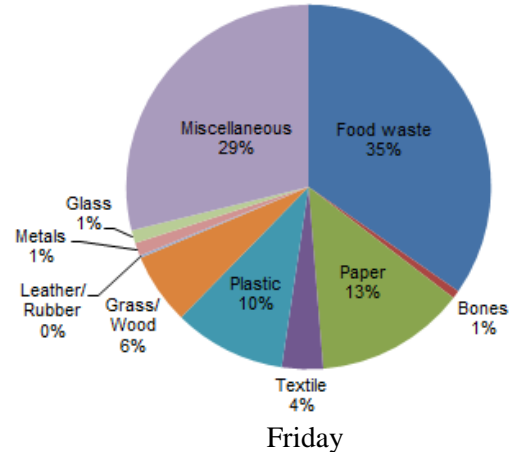
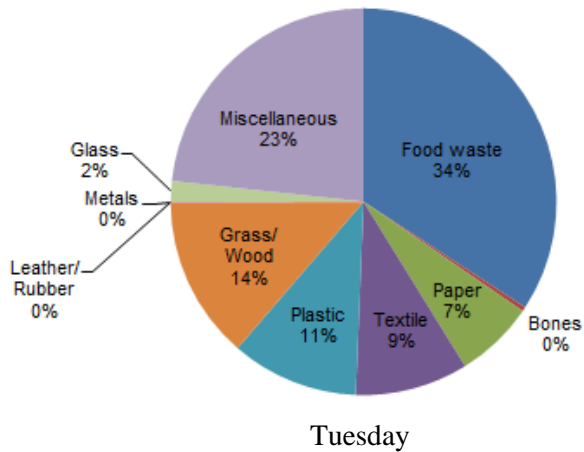


Fig. 11 Average waste composition category wise on lowest (Tuesday) and highest (Friday) waste generation day high income class

It is observed from Fig.11 that in high income class, composition of recyclable waste is higher on working day compared to the last working day. The composition of food waste remained same during the week. Fig. 12 shows the comparative analysis of waste composition of low, middle and high income classes. It is clear that the food waste has the highest proportion in all three classes ranging from 36.1 to 45.7%. Proportion of food waste was highest in samples collected from middle income class and lowest in samples collected from high income class. Apart from food waste, the organic waste included were grass/wood and miscellaneous. Fig. 12 depicts that grass/wood waste was negligible in middle income waste samples and highest in high income group. The obvious reason for this higher proportion is that these houses have grassy lawns and plants. Moreover, the low income waste samples also contained grass/wood as people belonging to this group keep goats and sheep for their livelihoods.

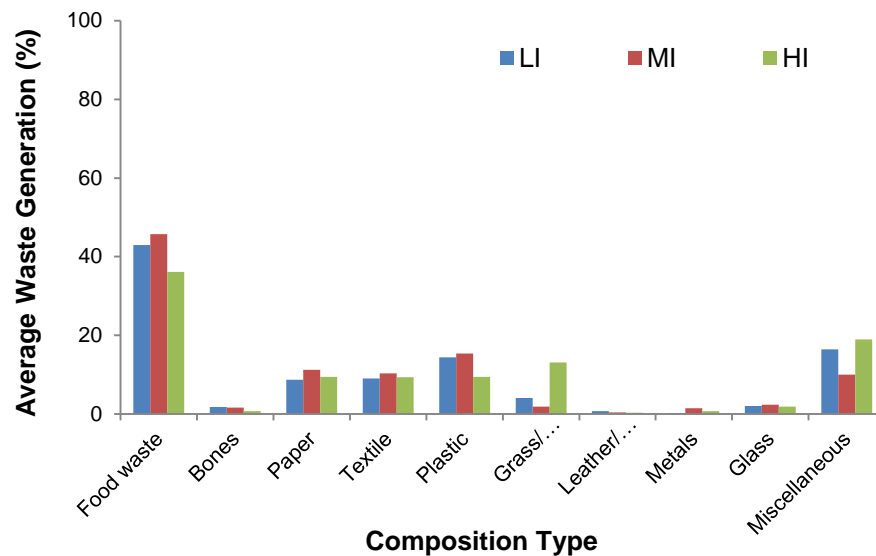


Fig. 12 Comparative waste analysis of all three income classes

Among recyclable waste, plastic content is the highest while leather, metal and glass content is very low. This shows that the households adopt source segregation and sell these value items. It is also observed that paper and textiles products are not segregated at source.

3.3 Household Questionnaire Survey

In order to fulfill the objectives of this study a questionnaire was designed (Annexure – A). Table 3 represents the statistical summary of questionnaire regarding household waste collection and management including hygiene, gender and cultural habits that were filled by inhabitants of all three income groups. It has been observed that LI group has small size containers as compared to MI and HI groups. It is also interesting to observe that family members of HI group do not dispose solid waste rather servants play an important role in solid waste disposal for this income group. While for LI group family members play an important role.

With regard to hygiene practices it can be seen that HI group is more concerned; 53% responded that they cover their waste bins as compared to 28% and 32% responses in affirmative for LI and MI groups respectively. Moreover, 87% people belonging to the HI group responded that they use plastic bag in the waste bin as compared to 74% and 25% positive responses from people of MI and LI groups respectively. All people (100%) belonging to the HI group responded that they wash their hands after giving the solid waste to sweeper as compared to 85% and 96% responses in affirmative for LI and MI groups respectively.

The HI group pays as high as Rs. 2000 per month for solid waste disposal while the LI and MI groups pay as low as Rs. 75 per month for solid waste disposal.

Table 4 shows the statistical summary of questionnaire regarding municipal services. People belonging to LI group (65%) are more satisfied with the municipal services as compared to the people of HI group (47%). It is interesting to note that none of the people belonging to the MI group were satisfied with the municipal services. The majority of people belonging to the LI group (72%) agreed that main problem related to waste disposal was littering on drain while 42% and 66% of the people belonging to MI and HI groups respectively agreed that littering on road was the main problem related to waste disposal.

Table 3 Summary of questionnaire regarding household waste collection and management including hygiene, gender and cultural habits

S.No	Questions	% Response		
		Low income	Middle income	High Income
1	Container size			
	1-3 kg	65	46	27
	5-7 kg	33.3	42	33
	7-10 kg	1.7	12	20
	Greater 10	-	-	20
2	Who Disposes?			
	Servant	0	12	53
	Family member	78.3	24	-
	Local resource (Private sweeper)	11.7	20	40
	City level resource	10	44	7
3	Location of waste bin			
	Kitchen	20	72	54
	Backyard	73.3	16	34
	Car porch	0	-	6
	Any other	6.6	12	6
4	Waste bin cover			
	Yes	28	32	53
	No	72	68	47
5	Use of plastic bag in waste bin			
	Yes	25	74	87
	No	75	26	13
6	Waste bin washing			
	Yes	75	70	80
	No	25	30	20
7	Frequency of waste bin washing			
	Daily	47	32	33
	Weekly	46	40	47
	Monthly	7	28	20
8	Hand washing after giving waste to sweeper			
	Yes	85	96	100
	No	15	4	-
9	SWM expenses/month			
	Rs. 75	5	6	-
	Rs. 250	-	-	13
	Rs. 2000	-	-	7
	No reply	95	94	80
10	Disposal frequency			
	Daily	88	98	87
	Every second day	3	-	13
	Every third day	-	-	-
	Random	9	2	-
11	Waste disposal in?			
	Plastic bag	62	52	60
	Small bucket	29	46	33
	Any other	9	2	7

12	Disposal time			
	Day time	90	92	80
	Night time	2	6	-
	No any	8	2	20

Table 4 Summary of questionnaire regarding municipal services

S.No.	Questions	% Response		
		Low Income	Middle Income	High Income
1	Level of satisfaction			
	Yes	65	0	47
	No	35	100	53
2	Problems related to waste disposal			
	Littering on drain	72	36	33
	Littering on road	15	42	66
	No regular collection	9	16	1
	No dustbin, cause nuisance	4	6	-
3	Collection frequency			
	Daily	55	40	53
	Every second day	7	-	20
	Irregularly	-	30	7
	Don't know	33	30	7
4	Preference for waste collection system			
	Door collection	90	80	67
	Disposal at centralised collection	10	20	13
	Kerb side collection	-	-	20
5	Collection time			
	Morning	98	50	40
	Noon	-	10	33
	Afternoon	1	20	27
	Evening	1	20	-
6	Current collection mechanism			
	Donkeycart	43	-	-
	Wheel barrow	3	64	7
	Cart	1	6	7
	Basket	53	28	33
	Mini truck	-	-	53

Table 5 Summary of questionnaire regarding waste recycling

S.No.	Questions	% Response		
		Low Income	Middle Income	High Income
1	Do you segregate?			
	Yes	85	86	74
	No	15	14	26
2	Who segregates?			
	Servant	5	32	66
	Mother	35	32	20
	Father	7	18	7
	Daughter	3	6	-
	Son	50	12	7
3	Where do you sell?			
	Kabari/Junkyard shop	77	34	20
	Teen dabewala	23	66	80

4	Who segregates if not at household level?			
	Sweeper	45	54	67
	Scavenger	38	46	33
	Transfer station	17	-	-

Table 5 shows the statistical summary of questionnaire regarding waste recycling. The responses from all three groups show that majority of the people: 85% LI, 86% MI and 74% segregate recyclable waste. However, HI group responses were lower as compared to LI and MI groups.

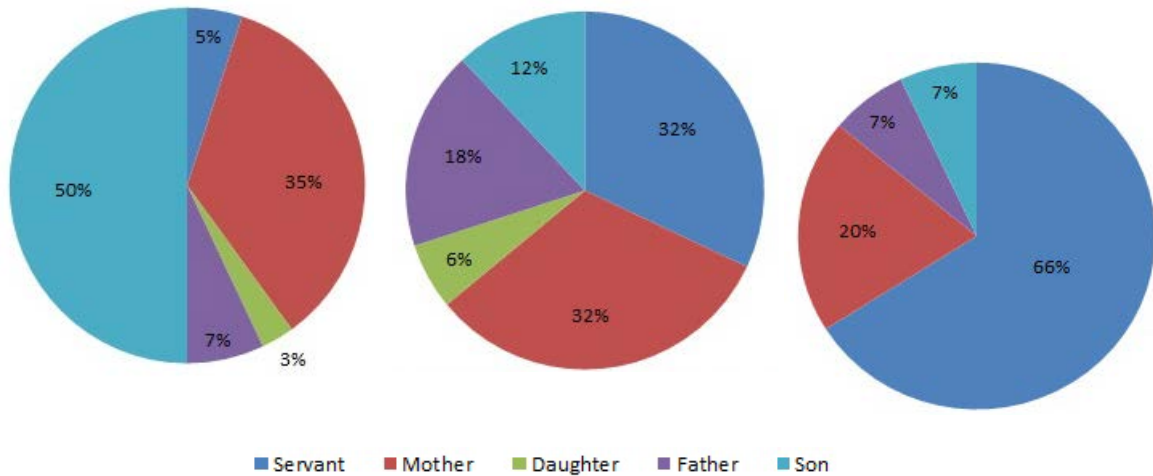


Fig. 13 I (a) gender in recyclable was (b) _ egation (a) LI, (b) MI a (c) , HI.

With regard to gender it can be seen that females play an important role in recycling. For LI and MI groups 38% people responded that females (LI: 35% mother, 3% daughter; MI: 32% mother, 6% daughter) segregate the recyclable waste as compared to 20% (20% mother) for HI group (Fig. 13). Servant composition for LI was 100% female; MI was 97% female and for HI was 6% female. Overall females play a more significant role in recyclable waste segregation in LI and MI groups as compared to the HI group.

3.4 Solid Waste Management at Commercial Level

3.4.1 Collection

Teams for collection of waste from selected commercial areas comprised of sweepers and helpers (Annexure-E). It was noticed that most of the collection took place in late afternoon, as the commercial activities starts in afternoon. Waste collection was comparatively difficult in commercial areas compare to households. Various categories of commercial groups included: banks, travel agency, educational institute, grocery stores,

office, mobile shop and mart (Fig. 14). Garbage collection bags with labels were supplied to independent shops, who agreed to participate in this study. This exercise facilitated in the analysis of solid waste. A private vehicle was hired for transporting the waste for analysis.



Fig.14 Samples collected from mart, restaurant, grocery store and mobile shop selected for commercial areas

Table 6 Statistical data of waste generation from commercial groups

S.No.	Commercial Group	Waste Production kg/d		
		Average	Low	High
1	Travel agency	0.48	0.06	1.2
2	Grocery store 1	3.78	1.08	9.12
3	Grocery store 2	1.35	0.87	2.2
4	Bank 1	2.43	0.15	4.3
5	Bank 2	3.57	0.50	6.3
6	Mobile shop	0.8	0.45	1.32
7	Educational institution	0.71	0.05	1.1
8	Office	0.99	0.1	1.67
9	Restaurant	2.69	0.74	7.83
10	Mart	1.16	0.43	2.16
Average of all groups		1.795		

After collection of waste was completed, samples were analyzed for waste generation which is discussed below:

3.4.2 Waste Generation

After waste collection and transportation the weight of all collected ten samples of all commercial groups was recorded. Waste analysis showed that the average per commercial group waste generation was 1.795 kg/d/shop (Table 6). The minimum waste generation was from travel agent while maximum was from grocery store 1 (Table 6).

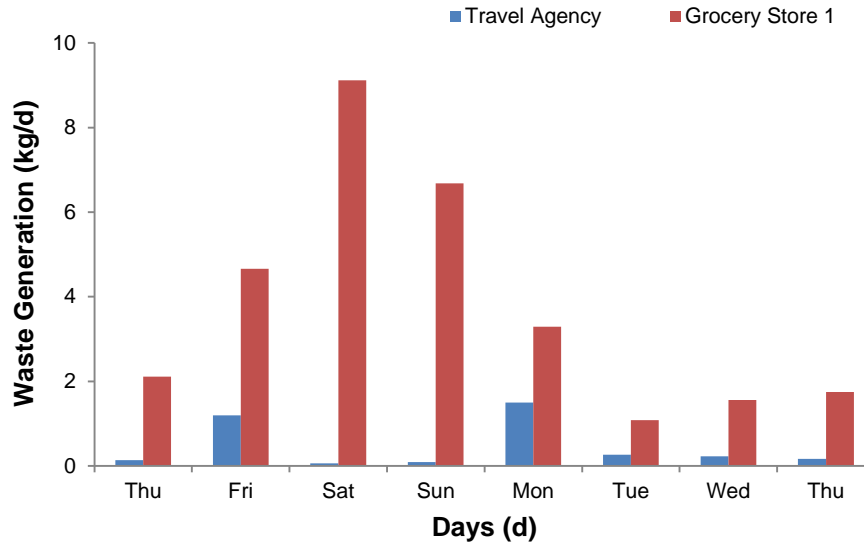


Fig. 15 Daily waste generation from travel agent (minimum) and grocery store 1 (maximum)

It was observed that waste generated from travel agency was lowest while from grocery store 1 was highest. Most of the travel agencies now issue e-tickets and this may be the reason for their amount of lowest waste generation (Fig. 15). The highest waste generation was observed from grocery store, as this type of commercial group deals in consumer products which produce more waste compare to other groups. It is also observed that the highest waste generation was during weekends (Saturday and Sunday), as most of the consumers purchase their grocery on holidays (Fig. 15).

3.4.3 Commercial Level Questionnaire Survey

In order to fulfill the object of this study a questionnaire was designed (Annexure – B). Table 7 represents the statistical summary of questionnaire regarding commercial waste collection and management including hygiene and cultural habits that were filled by employers/owners of commercial outlets. It has been observed that most of the outlets use small sized containers for disposing their solid waste. With regard to hygiene practices it can be seen 80% of the commercial outlets do not use bin covers. Half of the respondents wash their bins regularly while 60% of the respondents do not use bin liners. It was noticed half of the commercial outlets pay amount less than Rs. 200 per month for solid waste disposal and remaining pays more than Rs. 200 per month for solid waste disposal.

Table 7 Summary of questionnaire regarding commercial waste collection and management including hygiene and cultural habits

S.No	Questions	% Response	S.No	Questions	% Response
1	Container size 1-3 kg 5-7 kg 7-10 kg Greater 10	50 30 10 10	6	Waste bin washing Yes No	50 50
2	Who Disposes? Worker Local resource City level resource	100 0 0	7	SWM expenses/month Less than Rs. 200 Greater than Rs. 200 No replies	50 40 10
3	Location of waste bin Inside shop Outside shop	60 40	8	Disposal frequency Daily Every third day Random	80 10 10
4	Waste bin cover Yes No	20 80	9	Waste disposal in? Plastic bag Small bucket Any other	10 60 30
5	Use of plastic bag in waste bin Yes No	40 60	10	Disposal time Day time Night time No any	70 20 10

Table 8 shows the statistical summary of questionnaire regarding municipal services. 70% of the commercial outlets were found satisfied with the current municipal services. Also most of outlets agreed that main problem related to waste disposal were littering on drain, roads and absence of dustbin. All these factors are source of nuisance for the citizens.

Table 8 Summary of questionnaire regarding municipal services

S.No.	Questions	% Response
1	Level of satisfaction Yes No	70 30
2	Problems related to waste disposal Littering on drain Littering on road No dustbin, cause nuisance	10 40 50
3	Collection frequency Daily Every second day Irregularly Don't know	50 10 30 10
4	Preference for waste collection system Door collection Disposal at centralised collection Kerb side collection	30 40 30
5	Collection time Morning Afternoon Evening	30 50 20
6	Current collection mechanism Wheel barrow Basket Mini truck	40 50 10

Table 9 Summary of questionnaire regarding waste recycling

S.No.	Questions	% Response
1	Do you segregate? Yes No	100 0
2	Who segregates? Sweeper Scavengers at kundi Transfer station	60 30 10
3	Where do you sell? Kabari/Junkyard shop Teen dabewala	50 50
4	Breakup of recyclable waste Paper Plastic Glass Miscellaneous	78 10 3 9

Table 9 shows the statistical summary of questionnaire regarding waste recycling. It can be observed that all respondents segregate their waste at source and sell to junkyard shop and teen dabewala equally. It can be also concluded that sweepers play a significant role

in waste segregation. The major portion of recyclable waste comprises of paper followed by plastic and glass respectively.

3.5 Solid Waste Management at Fruit and Vegetable Market Level

3.5.1 Collection

Teams for collection of waste from selected fruit and vegetable market located at main super-highway comprised of sweepers and helpers (Annexure-E). The commercial activity starts early in the morning and terminates by noon. Due to this it was decided to collect the waste from these shops in late afternoon to represent the true figures for solid waste generation from each shop (Fig. 16). Garbage collection bags were marked for identification and supplied to independent shops, who agreed to participate in this study (Fig. 16-17). This exercise facilitated in the analysis of solid waste. A private vehicle was hired for transporting and analysing the waste from fruit and vegetable market (Fig. 18).



Fig.16 Fruit and vegetable shops of main Sabzi Mandi



Fig.17 Collection and final preparation for transportation and waste analysis



Fig.18 Transportation of samples from Sabzi Mandi for waste analysis

3.5.2 Waste Analysis

After collection of waste was completed, samples were analyzed for waste generation and waste composition which is discussed below:

Waste Generation

After waste collection and transportation the wet weight of all collected fifty samples of fruit and vegetable shops was recorded (Fig. 19). Waste analysis showed that the average waste generation per shop was 11.77 kg/shop/d. Based on this data, the total amount of waste generated in the fruit and vegetable market is 47.08 tons/d. The major portion of this waste is organic in nature.



Fig.19 Weighing of wet solid waste samples collected from fruit and vegetable market shops

It was observed that average waste generated (Fig. 20) was highest during the weekends (Saturday and Sunday). The reason for high waste generation on weekends is probably that sale of fruit and vegetable is high during this time period because of high demand

from consumers. Minimum waste generation was recorded on Tuesday, as it is the mid of the week and demand from consumer is comparatively lower.

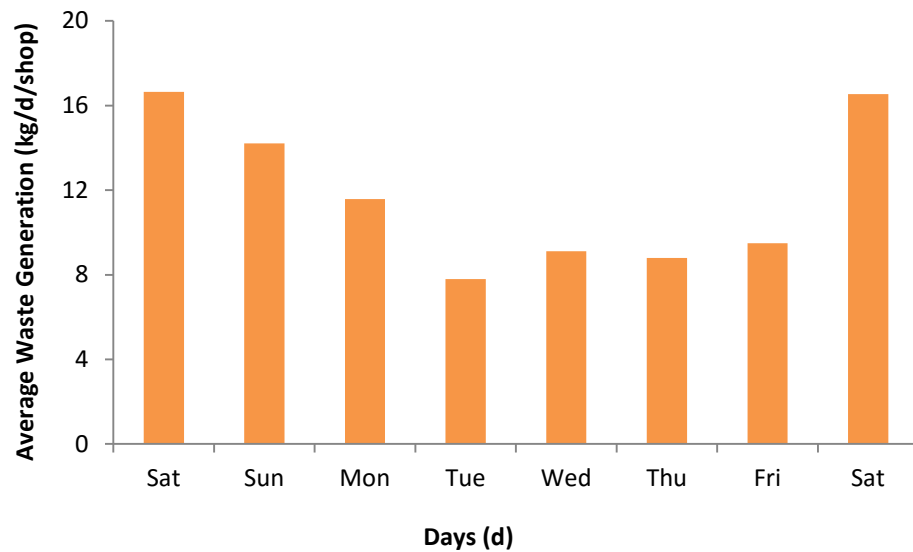


Fig.20 Daily variation in average waste generation

Waste Segregation

After recording the weight of all collected fifty samples of all samples, twenty five samples were randomly selected and categorized for waste composition (Fig.21-22).



Fig.21 Selection of twenty five random samples from fifty collected samples



Fig. 22 Segregation and re-weighing of solid waste samples collected from fruit and vegetable shops

Fig. 23 shows the average waste composition category wise on lowest (Tuesday) and highest (Saturday) waste generation day for fruit and vegetable market samples. It is observed from Fig. 23. Food waste has the highest composition on both days. It is inferred that major composition of fruit and vegetable market waste samples is organic fraction.

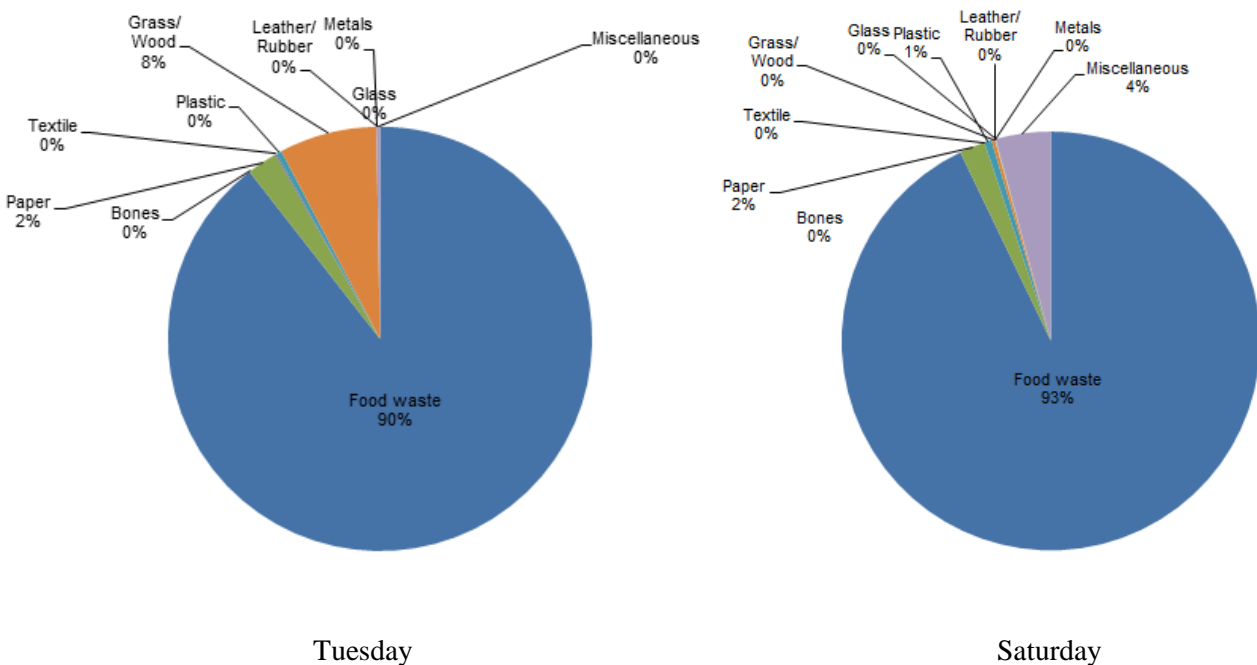


Fig. 23 Average waste composition category wise on lowest (Tuesday) and highest (Saturday) waste generation day for fruit and vegetable market samples

3.6 Market Chain Analysis of Recyclable Waste

In order to determine the mechanism of scavenging by waste pickers at the dumping site and selling to different dealers, a market chain analysis was carried using participatory appraisal approach in which interviews were conducted from sweepers and junk yard operators (Annexure-C1 & C2). In first phase nineteen sweepers were interviewed and it was observed that 100% responded that they segregate paper, 93% segregate plastic, 43% segregate glass and 29% segregate metal. Fig. 8-10 represent that the waste composition of all three classes of household waste consists of high proportion of paper and plastics as recyclable waste reflecting that paper and plastic is not segregated at source unlike metal and glass. Due to this, the market chain analysis reflects that the highest recovery of paper and plastic in the category of recyclable waste.

Survey also reveals that the daily average income generated from selling of recyclable waste is Rs. 170. This shows that there is a financial incentive for the sweepers which assist in segregation of waste at collection level of the solid waste management system in informal sector. The average selling price (Rs./kg) of plastic and paper is 15 and 7.5 respectively.

In the second phase, sixteen different junk yard operators were interviewed (Fig. 24) located in different areas of Karachi. It was observed that 20% of the respondents purchase the recyclable from scavengers while 80% purchase their recyclable from teendabe wala. The average quantity of recyclable waste received by the junkyard dealers is shown in Fig. 25.



Fig. 24 Entrance and inside view of junk yard dealer facility

It can be observed from Fig.25 that the maximum quantity (by weight) of recyclable waste include metal and paper. The reason of high amount of metal in the proportion of recyclable waste is likely due to the collection and subsequent selling of metals by scavengers to the junkyard operators. It was observed that metal is the most valuable recyclable waste among all six categories shown in Table 10 while glass and pet bottle are cheapest recyclable waste. Different industries include plastic, package, furniture, paper and metal involve in processing of recyclable waste.

Table 10 Cash price and primary industries involve in processing of recyclable

S.No.	Items	Cash price Rs/kg	Primary industries
1	Plastic	29	Plastic crockery, sun shade, pipe, plastic furniture, bucket, mug
2	Cardboard	9	Package, hardboard, cardboard
3	Glass	5	Glassware
4	Paper	15	Cardboard
5	Metal	34	Reprocessing
6	Pet bottle	5	Reprocessing

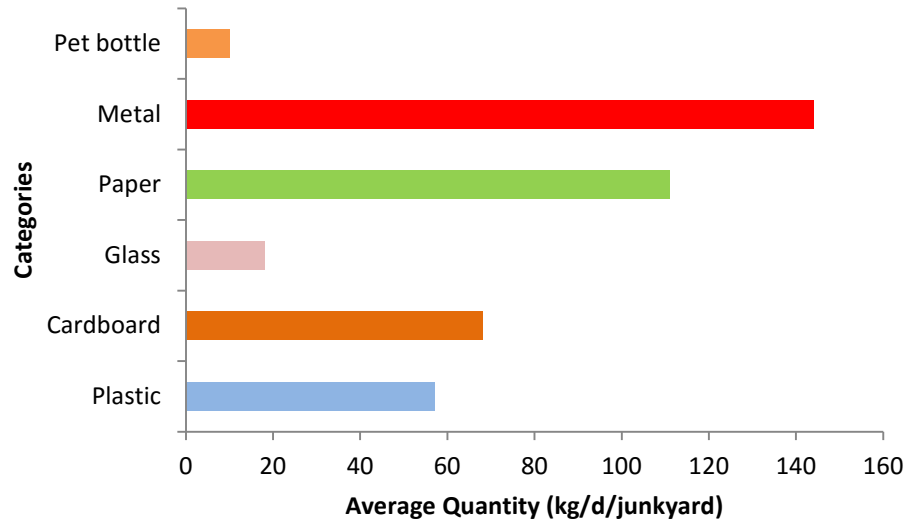


Fig. 25 Average quantity of recyclable waste received by the junkyard dealers

3.7 Organic Compost

In the city of Karachi there is no formal production of organic compost. However, efforts have been made by research organizations such as Pakistan Council of Scientific and Industrial Research (PCSIR) and NGOs (SAIBAN). PCSIR has been producing compost on a small scale using the windrow method and their selling rates are approximately Rs.80/kg for bulk supply and Rs.100/kg for individual supply. SAIBAN initiated a project named “Khuda ki Basti” to help the urban poor acquire legal titles to residential lots with a minimum affordable down payment. The project also developed a solid waste management system. The organic waste generated was collected and converted to organic fertilizer using box composting technique. They sold the product at cost of Rs.20/kg to individual consumers; however the commercial market for the product was never explored. The total amount of waste required to run the compost facility was 3 tons/day. The scheme failed because the organic fraction and overall solid waste generated from the households was not enough to run the compost plant economically.

4. Conclusions

- Using Master Plan of Karachi, the estimated solid waste generation for Karachi city is 12,280 tons which is 0.595 kg/c/d.
- This study reveals that the average household solid waste generation for the city of Karachi is estimated to be 0.44 kg/c/d and average waste generation of low, middle and high incomes was 0.19, 0.29 and 0.84 kg/c/d respectively.
- Waste analysis of commercial group showed that the average per commercial group waste generation was 1.795 kg/d/shop. The minimum waste generation was from travel agent while maximum was from grocery store. With regard to hygiene practices most of the commercial outlets do not use bin covers nor bin liners. And majority of the commercial outlets pay service charges for solid waste disposal up to Rs. 200/month.
- Waste analysis of fruit and vegetable market, Main Sabzi Mandi of Karachi showed that the average waste generation per shop was 11.77 kg/shop/d. The waste characterization showed that the organic fraction (food waste) has the highest proportion in composition i.e. in excess of/exceeding 90%.
- The waste composition analysis shows that organic fraction (food waste) has the highest proportion in all three classes ranging from 36.1 to 45.7% (weight/weight).
- The household solid waste disposal charges vary for the three groups, the HI group pays to the maximum of Rs. 2000 per month for solid waste disposal while the LI and MI groups pay to the minimum of Rs. 75 per month for solid waste disposal.
- From questionnaire survey, it can be revealed that majority of the people: 85% of LI, 86% of MI and 74% of HI responded that they segregate their recyclable waste and in recycling females play a significant role.
- Market chain analysis revealed that composition of metal was the highest followed by plastic and paper. The primary industries involved in recycling include plastic, package, furniture, paper and metal.

5. Recommendations

- Currently two landfill sites are available for solid waste management. The area available at these sites is not adequate to fulfill the landfilling of waste generated in the city. Moreover, these sites are located far away and it is not economically viable to transport waste over large distances. There is a need to develop new landfill sites.
- Awareness raising seminars/ campaigns should be organized to sensitize masses on SWM issues.
- Modern techniques can be used to improve the existing overloaded system. For example;
 - Introducing skips.
 - Providing separate bins for recyclable waste and disposable waste.
 - Designated waste collection points.
- Source segregation should be adopted thereby providing independent containers for organic fraction and recyclables. This will assist primary recycling industries and development of facilities for bio fertilizer production such as compost.
- Illegal dumping of solid waste/garbage in drains can be avoided by training the local communities through awareness programmes and implementing a stronger decentralized collection system.
- Organic fraction of municipal solid waste from household and fruit and vegetable market can be used as feedstocks for renewable energy production and bio fertilizer.