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Influence of Income Level and Seasons on Quantity and Composition of Municipal Solid Waste: A Case Study of the Capital City of Pakistan

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Abstract: The current study aims to analyze and compare the quantity and composition of municipal solid waste (MSW) at three socio-economic levels of population during all four seasons of the year (spring, summer, monsoon and winter). In this study, 2164.75 kg of MSW was evaluated, from 1260 samples collected from 45 households. The average waste generation was estimated to be 0.6 kg per capita per day. Waste generation rate for high, middle and low income groups was 0.890, 0.612 and 0.346 kg per capita per day, respectively. Nevertheless, season specific analysis indicated waste generation rates of 0.78, 0.58, 0.48 and 0.75 kg per capita per day in spring, summer, monsoon and winter, respectively. A two way ANOVA statistical analysis further illustrated a significant effect (p = 0.00) of economic level and seasons on the amount and composition of waste generated by the community. Moreover, the collected waste was segregated into 42 categories, where the highest was the organic fraction (57%), then diapers (12%), followed by plastic (8%), cardboard (3%) and paper (2%). The amounts of textile, diapers and plastics were highest in the lowest income group, while tetra packs, metal, paper and yard waste were maximum in the high income group. It is concluded that the high income group generated the highest amount of waste and waste generation rate is higher in the seasons of spring and winter compared to the other two seasons.

Keywords: integrated waste management; income groups; seasonal influence; generation rate; Islamabad

1. Introduction

The domain of this study comprises urban Islamabad. Islamabad is the capital and the tenth largest city of Pakistan. The city lies at 33°38′ N and 73°07′ E. It has a population of 356,603 [1] and 18 developed residential sectors, which are planned in parallel belts. Each sector is 3.1 km^2 in area and is a self-contained community unit. The sectors have been named in numbers from east to west and in alphabetic order from north to south. Figure 1 shows the map of the study area. The city was built in the 1960s to replace Karachi as Pakistan's capital. It was not developed historically according to site or situation. It is the only well planned city of Pakistan and therefore different from other cities of the country, which are developed historically with downtowns, old city, suburban areas and shantytowns.

Despite being the only well planned city of the country, even after 50 years of establishment the city does not have a proper waste disposal system. The total waste generation of Islamabad is approximately 500–600 tons per day (200,750 tons per year) [1–3]. Sixty percent of the waste is collected by Capital Development Authority (CDA) and the rest is contracted out to private contractors [2].

The authority spends over Rs 300 million ($2.8 million) every year taking care of the capital's waste, but there is neither a waste sorting and segregation system nor a proper waste disposal site.

The waste disposal practice that is being carried out in Islamabad is open dumping without any gas collection or leachate control system to protect surface and ground water resources [3]. The current dumping site, i.e., I-12, is situated in a residential area and is adjacent to a big government hospital, which is not suitability as a waste disposal site. As the population of the capital is increasing, so too is the MSW, resulting in the increase of the problem of proper waste disposal.

Managing this ever increasing waste in a sustainable and socially acceptable manner has become a problem for authorities [2,4,5]. Untreated waste imposes an economic cost for residents of the area, and is also an environmental hazard. Proper waste management is very important for the health and comfort of residents [6–10].

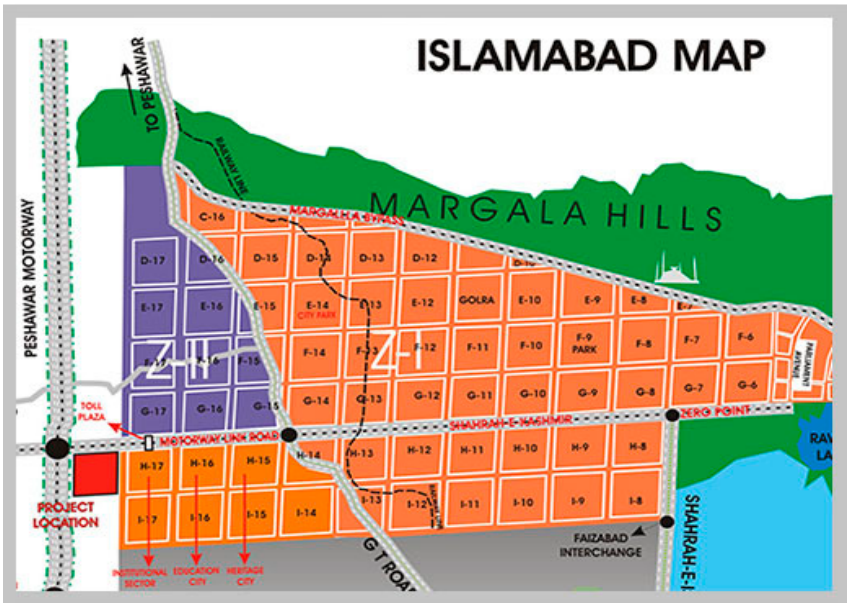

Figure 1. Map of the Study Area (Islamabad).

Contemporary waste management literature/research and best practices suggest that shifting to a more environmentally friendly and sustainable waste management option requires an optimal combination of various management options such as recycling, composting, gasification, pyrolysis and incineration with energy recovery, instead of single waste management method [11–15]. Thus, integrated solid waste management is the only answer to successful MSW treatment and disposal [11,14,16,17]. If the waste management approach is established using authentic data, and is implemented properly, it will be a great breakthrough in reducing air, water and soil pollution caused by improper disposal of solid waste [16,18,19]. Unfortunately, proper management of waste is mostly not possible because authentic data about waste generate rate, composition and the factors affecting both, are not always available [20,21]. If available, these waste characterization studies can be further used as a baseline to generate an optimal waste management plan [6,13,20–22] using life cycle assessment (LCA) approach [23–26]. The importance of waste characterization for the establishment of waste management program is also emphasized by following studies [20,27–37].

To identify a sustainable integrated waste management approach for Islamabad that is socially and environmentally acceptable and economically viable, a waste characterization practice is necessary to determine the generation rate, composition and the factors affecting the municipal solid waste (MSW) which is the aim of this paper.

Although many similar studies have been conducted around in Pakistan and around the globe [16,19,36,38–41], none have been conducted in Islamabad. The findings of this study can be

used as baseline for developing an ideal waste management plan in Islamabad using LCA as well as evaluating the environmental burdens of the current SWM practice.

The study was conducted during four different seasons of the year at three socio-economic groups of population to identify any seasonal as well as social differences in waste generation, because it is established from research that the waste composition and its generation rate largely depend upon the population size and their living standards [33,34,39,42].

2. Methodology

In this study, sampling was conducted daily for one week each during the months of January, March, May and August 2012, representing four different seasons [22,43,44] of the year, i.e., winter (low temperature), spring (changing temperature), summer (high temperature) and monsoon (rainy season, average annual rainfall 790.8 millimeter) (based on data from Pakistan Meteorological Department) [45], at three socioeconomic groups of population. During these sampling periods, to avoid any discrepancy, all the generated household waste was collected from the houses directly.

The process [46] used to characterize the household waste has following steps:

(1) Categorizing the population in socio-economic group
(2) Sample Collection
(3) Classifying and quantifying the fractions
(4) Data Analysis.

2.1. Categorizing the Population in Socio-Economic Groups

As mentioned above, Islamabad has 18 developed residential sectors, and a population of 356,603 residents. The administrative sectors are numbered as G-5 and F-5, which contain diplomatic enclave, administrative and public buildings. The residential sectors are numbered from 6 to 17 (G, F and I), aligned on both sides of the leading civil and commercial centers called Blue Area. Three income level groups, i.e., high (Monthly income more than 30 million Rupees (S2865)), middle [Monthly income more than 10 million Rupees ($955 US)] and low income group (Monthly income up to 10 million Rupees ($955 US)) were classified on the basis of monthly income of the family, property value and plot sizes of the area (EPA, 1996).

The classification into three socio-economic groups is done based on field survey, social survey and personal communication with the property dealers in the area, during the reconnaissance visits. However, this criterion for economic class ranking is very different from other cities of the country, where monthly income of high, middle and low income groups is much lower than in Islamabad. i.e., high [Monthly income more than 60,000 Rupees ($700)], middle [Monthly income 20,000 Rupees ($250 US)] and low income group (Monthly income up to 10,000 Rupees ($115)) [16,47]. The demographic information of the 18 residential sectors is displayed in Table 1.

Table 1. Demographic information of study area.

Sr. No	Socioeconomic Group	Sectors in Each Group	Population	Households Studied
1	High Income Group	E-7, 8, 9 F5, 6, 7, 8, 10, 11, 12 and I-8	121,527	15
2	Middle Income Group	G-7, 8, 9, 10,11	172,093	15
3	Low Income Group	I-10 and I-9	62,983	15
	Total	18 sectors	356,603	45

2.2. Sample Collection

The sample collection method in this study was mainly the one used by Gomez et al [4] and also supported by California Integrated Waste Management Board (CIWMB) [48].

This procedure involved:

(1) Survey of households
(2) Collection of samples
(3) Transportation of samples
(4) Segregation of samples
(5) Quantification of components of waste.

The homeowners of designated neighborhoods were requested to contribute in the waste classification process. It was ensured that, during all four sampling seasons, the same houses were included in the program. In each neighborhood, 15 houses [48,49] were approached randomly. The lady of each household was requested to make sure that all generated waste was collected and handed over to us. The waste produced was collected every day of the week and stored in polythene bags. Each sample was labeled with the house and sector number. Every morning, the old bag was replaced by a new empty bag. After collection, the waste was transported in closed vehicle to a designated place, where it was segregated and weighed instantly.

It was assured that the waste was collected directly from houses so that no item is removed by the sweepers or the scavengers to be sold, and the waste collected is truly representative of the area.

2.3. Classifying and Quantifying the Fractions

All waste collected in a day was then emptied on plastic sheets, weighed separately according to the income groups and then segregated according to its composition. Overall, the entire waste was classified into forty-two categories [50]. After sorting the waste, all fractions were weighed separately using a balance. The same routine was followed for the next six days. The same process of classifying and weighing was repeated for all the three socio-economic groups of population and for all the four seasons of the year.

2.4. Data Analysis

Data were statistically analyzed using a two way Analysis of Variance (ANOVA). The ANOVA is used to compare means of two or more variables using F-distribution. This parametric test will authenticate the results by measuring the effect of socioeconomic levels and seasonal variation in the solid waste generation rate, i.e., significant or non-significant. IBM SPSS. 22 was run to obtain the results.

The moisture content of the MSW was also measured by heating the samples in an oven for 24 h at 105 °C.

3. Results

During the entire study period (2012–2013), 1260 samples were collected, weighing 2164.75 kg from 45 houses for one full week in all the four seasons of the year.

The amount of different components of waste was represented as weighted average values. Table 2 shows the results in kg per capita per day for every component of collected waste from every income group throughout the four seasons of the year 2012. The weighted average waste in Islamabad was calculated to be 0.603 kg per capita per day during this study (including 0.890, 0.612 and 0.346 kg per capita per day for high, middle and low income groups, respectively). The waste generation rates in the seasons of spring, summer, monsoon and winter were 0.78, 0.58, 0.48 and 0.75 kg per capita per day, respectively, during the study period. These figures represent the total waste collected from the households; it does not include the reused material at household level (source separation). In comparison to other developing countries, this waste generation rate is higher, owing to the economic status of the city of Islamabad, which is more similar to developed countries rather than developing countries.

Table 2. Seasonal generation rate of waste fractions at middle, high and low income groups (kg/capita/day).

Waste Components		High Income Group					Middle Income Group					Low Income Group				
		Spring	Summer	Monson	Winter	Weighted	Spring	Summer	Monson	Winter	Weighted	Spring	Summer	Monson	Winter	Weighted
Organic Waste	Vegetable Food Waste	0.845	0.459	0.260	0.524	0.495	0.311	0.374	0.338	0.429	0.376	0.192	0.197	0.183	0.163	0.183
	Yard Waste, Flowers	0.093	0.040	0.040	0.056	0.052	0.009	0.004	0.008	0.003	0.005	0.005	0.000	0.000	0.006	0.003
	Animal Food Waste(bones)	0.000	0.000	0.000	0.007	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	News print	0.047	0.030	0.024	0.022	0.029	0.014	0.003	0.004	0.011	0.007	0.005	0.005	0.007	0.007	0.006
	Magazines	0.009	0.009	0.004	0.002	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Advertisements	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000
	Books, Phone Books	0.014	0.001	0.000	0.000	0.002	0.002	0.000	0.000	0.007	0.002	0.002	0.000	0.001	0.002	0.001
	Office paper	0.000	0.000	0.000	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Paper	Other Clean Paper	0.008	0.001	0.002	0.011	0.005	0.001	0.006	0.000	0.000	0.002	0.001	0.000	0.002	0.004	0.002
	Paper And Card Board	0.070	0.015	0.019	0.037	0.030	0.012	0.009	0.022	0.026	0.017	0.011	0.005	0.013	0.016	0.011
	Kitchen Towels	0.010	0.004	0.000	0.000	0.003	0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000
	Dirty Paper (Tissue)	0.015	0.000	0.006	0.020	0.010	0.001	0.000	0.001	0.004	0.002	0.002	0.000	0.000	0.005	0.002
	Dirty Cardboard	0.004	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.003	0.002
	Cigarette Butts	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other Clean Card Board	0.000	0.014	0.000	0.000	0.005	0.000	0.004	0.000	0.003	0.002	0.000	0.000	0.000	0.000	0.000
Tetra pack	Tetra Packs	0.062	0.034	0.018	0.044	0.038	0.011	0.012	0.020	0.020	0.016	0.009	0.008	0.011	0.012	0.010
	Juice Carton (Carton/Plastic/Aluminum)	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Soft Plastic (Polythene. Gloves, Disposable Plates)	0.050	0.031	0.013	0.033	0.031	0.017	0.009	0.015	0.023	0.016	0.011	0.007	0.010	0.023	0.013
	Plastic Bottles	0.037	0.007	0.002	0.006	0.010	0.004	0.001	0.006	0.014	0.007	0.003	0.005	0.002	0.003	0.004
Plastic	Hard Plastics (Plates)	0.001	0.001	0.002	0.001	0.001	0.003	0.001	0.004	0.003	0.003	0.000	0.001	0.001	0.004	0.002
	Non Recyclable Plastic	0.011	0.014	0.003	0.008	0.009	0.011	0.002	0.002	0.011	0.006	0.006	0.002	0.004	0.007	0.005
	Plastic Products (Toys, Hangers, Pens, Empty Tubes)	0.006	0.017	0.008	0.015	0.013	0.016	0.018	0.019	0.012	0.016	0.001	0.003	0.005	0.011	0.006
Diapers	Diapers	0.131	0.026	0.042	0.051	0.052	0.058	0.064	0.060	0.078	0.067	0.062	0.055	0.038	0.112	0.071
Textile	Textile	0.015	0.005	0.005	0.027	0.013	0.031	0.006	0.018	0.002	0.010	0.004	0.003	0.010	0.011	0.007
	Disposal Sanitary Clothes	0.000	0.000	0.000	0.002	0.001	0.003	0.001	0.000	0.004	0.002	0.000	0.003	0.002	0.005	0.003
Others	Wood	0.007	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
	Shoes, Leather	0.013	0.006	0.000	0.000	0.004	0.000	0.012	0.000	0.008	0.007	0.001	0.002	0.003	0.000	0.001
	Rubber	0.000	0.000	0.002	0.010	0.004	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.001
Glass	Clear Glass	0.013	0.023	0.008	0.016	0.017	0.012	0.002	0.010	0.016	0.010	0.003	0.006	0.000	0.004	0.004
	Green Glass	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
	Brown Glass	0.031	0.003	0.006	0.000	0.007	0.009	0.006	0.001	0.016	0.008	0.006	0.001	0.004	0.004	0.003
	Non-Recyclable Glass	0.000	0.000	0.000	0.000	0.000	0.007	0.001	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000
Metals	Beverage Cans	0.013	0.000	0.000	0.000	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Aluminum Foil And Container	0.007	0.000	0.000	0.010	0.004	0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000
	Food Cans (Tinplates/Steel)	0.015	0.004	0.004	0.000	0.004	0.000	0.002	0.002	0.008	0.003	0.000	0.000	0.000	0.000	0.000
	Plastic-Coated Aluminum Foil	0.000	0.000	0.001	0.011	0.003	0.002	0.005	0.004	0.000	0.003	0.000	0.000	0.003	0.000	0.001
	Other Metals	0.007	0.015	0.001	0.011	0.010	0.000	0.002	0.007	0.004	0.003	0.000	0.000	0.000	0.001	0.000
Other Non-Combustibles	Soil	0.023	0.000	0.000	0.000	0.003	0.003	0.000	0.002	0.002	0.001	0.002	0.000	0.000	0.000	0.000
	Stones, Concrete	0.018	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Ash, Coal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Ceramics	0.029	0.004	0.000	0.003	0.006	0.010	0.004	0.006	0.015	0.009	0.005	0.003	0.001	0.007	0.004
	Batteries	0.007	0.004	0.002	0.003	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other Non-Combustibles	0.003	0.009	0.001	0.015	0.008	0.007	0.002	0.016	0.009	0.007	0.000	0.000	0.000	0.005	0.002
Total	Total	1.608	0.776	0.475	0.949	0.890	0.556	0.550	0.568	0.733	0.612	0.335	0.310	0.306	0.416	0.346

Comparative analysis of generation and composition of collected waste with other historically developed metropolis of Pakistan, e.g., Lahore (more than 2000 years old), indicated little difference in overall generation rate (0.7 kg per capita per day of Lahore compared to 0.6 kg/capita/day of Islamabad) and characteristic of waste, but, by income group, the difference was very prominent (0.96, 0.73 and 0.67 kg per capita per day for high, middle and low income groups, respectively). The major reason for this difference is more organic fraction in the waste of Lahore compared to Islamabad, because, in Islamabad, the trend is using more processed food compared to fresh vegetables [16,47].

In Table 3, the moisture content of the MSW is provided during four seasons of the year and in all three income groups. It indicated no effect of income groups on moisture content but slight difference during the seasons, with lowest moisture percentage in spring. The knowledge of moisture content is very significant in planning proper integrated waste management.

Table 3. Moisture content of MSW of Islamabad over the year.

Seasons of the Year	Moisture Content Percentage		
	High Income Group	Middle Income Group	Low Income Group
Spring	72.3	72.4	71.63
Summer	90.59	89.09	90.77
Rainy season	88	88	88.8
Winter	92.95	78.5	74.99
Average	85.96	81.9975	81.5475

4. Discussion

4.1. Socio-Economic Influence on the Composition and Generation Rate of Waste

Figure 2 shows the comparison of the amounts of different fractions of waste from three socio-economic groups during four seasons of the year in Islamabad. As indicated in the Table 1, it is clear that, in Islamabad, the low income group has the lowest average annual waste generation, while maximum waste is generated in the high income group as compared to the other two income groups.

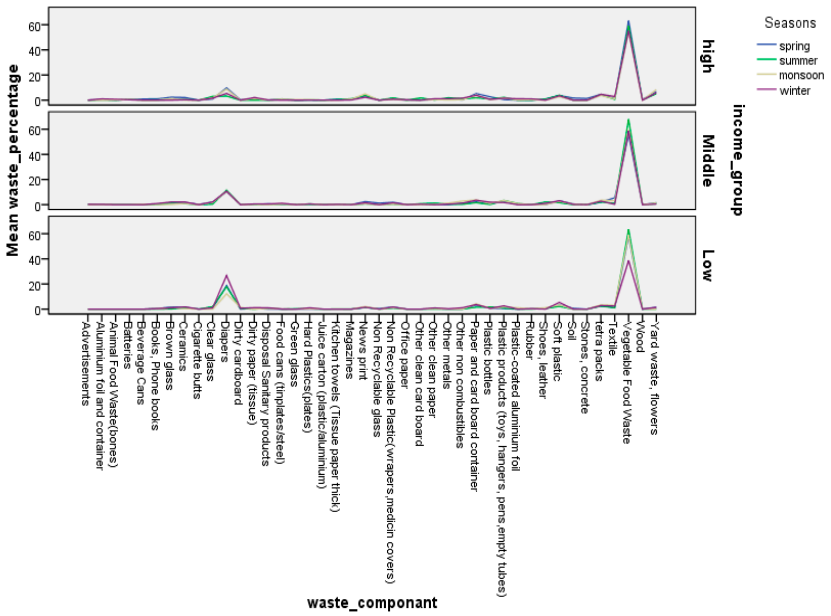

Figure 2. Quantitative comparison of waste fractions from three socio-economic groups during four seasons of the year in Islamabad.

A Two Way ANOVA statistical analysis (Tables 4 and 5) also showed a significant effect of the income level of the household on waste generation (p = 0). The value of p is less than 0.05, showing strong correlation between the two variables, which are income level of population and waste generation rate in this study.

This tendency of greater waste generation in high income groups is also seen in studies in other developing countries, where economy is booming [4,30,51,52].

Table 4. ANOVA results showing the effect of income of the household on the amount and composition of waste.

	Sum of Squares	df	Mean Square	F (Value)	Sig.
Income	0.054	2	0.027	59.658	0
Components	4.474	41	0.109	242.092	0
Income * Components	0.679	82	0.008	18.383	0
Total	6.173	1512			

Note: * Indicates the product.

Table 5. Showing Multiple Comparisons of income groups Dependent Variable: Weight of the Components.

(I) Income of the Socio-Economic Groups	(J) Income of the Socio-Economic Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
High	Middle	0.00833850 *	0.00134	0	0.0052	0.01148
	Low	0.01455692 *	0.00134	0	0.01142	0.01769
Middle	High	−0.00833850 *	0.00134	0	−0.0115	−0.0052
	Low	0.00621842 *	0.00134	0	0.00308	0.00936
Low	High	−0.01455692 *	0.00134	0	−0.0177	−0.0114
	Middle	−0.00621842 *	0.00134	0	−0.0094	−0.0031

Based on observed means; The error term is Mean Square (Error) = 0.000; * The mean difference is significant at the 0.05 levels.

4.2. Socioeconomic Influence on the Composition and Generation Rate of Waste

A Two Way ANOVA statistical analysis (Tables 6 and 7) revealed a significant influence of seasons on the amount and composition of waste generated ($p < 0.05$) in Islamabad.

This parametric test authenticated the results by measuring the effect of socioeconomic levels and seasonal variation in the solid waste generation rate, i.e., very significant effect of summer with spring and slightly less significant effect of rainy season (monsoon) with winter.

It is also clear in Figure 2 that, in middle and low income groups, maximum waste is generated during winter season, but, in high income localities, maximum waste generation turned out to be in spring due to increase in food and yard waste. The reason for this is that the houses in the high income group occupy space more than 836.12 m^2 so they have the luxury of lawns and kitchen gardens resulting in the increase of organic fraction in their waste (food and yard waste).

Table 6. ANOVA results showing the effect of income of the household on the amount and composition of waste.

Dependent Variable: Weight of the Components					
	Sum of Squares	df	Mean Square	F	Sig.
Season	0.018	3	0.006	7.070	0.000
Components	4.474	41	0.109	125.542	0.000
Season * Components	0.171	123	0.001	1.602	0.000
Total	6.173	1512			

Table 7. Multiple comparisons of four seasons (dependent variable: weight of the components).

(I) Season of the Year	(J) Season of the Year	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Spring	Summer	0.00687789 *	0.0021444	0.007	0.0013618	0.0123939
	Monsoon	0.00913399 *	0.0021444	0	0.0036179	0.01465
	Winter	0.0031782	0.0021444	0.449	−0.002338	0.0086943
Summer	Spring	−0.00687789 *	0.0021444	0.007	−0.012394	−0.001362
	Monsoon	0.0022561	0.0021444	0.719	-0.00326	0.0077722
	Winter	−0.0037	0.0021444	0.311	−0.009216	0.0018164
Monsoon	Spring	−0.00913399 *	0.0021444	0	−0.01465	−0.003618
	Summer	−0.002256	0.0021444	0.719	−0.007772	0.00326
	Winter	−0.00595574 *	0.0021444	0.028	−0.011472	−0.00044
Winter	Spring	-0.003178	0.0021444	0.449	−0.008694	0.0023378
	Summer	0.0036997	0.0021444	0.311	−0.001816	0.0092157
	Monsoon	0.00595574 *	0.0021444	0.028	0.0004397	0.0114718

Note: * Indicates the product.

It was also inferred from the results that the maximum amount of waste in all income groups during all season is food waste. This trend of food waste being the major fraction is also apparent in other metropolises of the country such as Lahore as well as in many other developing countries [6,21,53,54]. However, since developed countries mostly use processed packed food, this trend is not necessarily followed in developed countries [24,38,55,56]. The presence of higher percentage of food waste indicates that the waste of Islamabad has a high potential for composting or bio-gasification.

Paper and Cardboard fraction was calculated to be highest in high income group followed by middle and then low income group. The reason would be that the households with higher income can afford more products packed in cardboard containers (processed and ready to eat food products, toys, electric equipment, crockery, etc.) than the ones with low income.

In all three income groups, generation rate of PET is highest in the months of monsoon. The reason for this trend is the high temperatures and more humidity in these months, which ultimately lead to increased use of drinks in plastic containers (juices, water, flavored drinks, etc.).

Tetra packs are used mostly for milk products, tea whiteners and juices. The generation rate of tetra packs is higher in summer due to high temperature, thus use of more fruit juices, etc. and again, there is an increase viewed in these products in winter because of the use of more milk products for tea and coffee. However, overall, the low income group has the lowest amount of this waste production due to their low purchasing power and their tendency of buying milk from the milk-man rather than buying pasteurized or UHT treated (and expensive) tetra pack milk.

This study indicates significant generation of diapers in all seasons, showing that the use of disposable diapers has increased a lot in the past few years. As opposed to the other related study in Lahore this fraction was discovered to be more in low income group as compared to the two other income groups. The reason is that the people of high and middle income groups are more conscious about the kind of waste they gave us compared to the low income group who considered giving us all of their waste a way to escape paying the waste collection fee to the sweepers for the period of the study.

Textile and shoe fractions were found to be least in high income areas because these items are generally given away to maids, etc., while middle and low income families, who do not have the luxury of housemaids, reuse clothes as much as they can and throw them in waste when they cannot be used any further. The same trend was observed in other cities [19,40,57].

Fraction of glass in the waste was found highest in the middle income group, the reason being low purchasing power: low income households cannot buy expensive drinks packed in glass containers. Seasonal variation in glass generation rate is negligible.

Generation of metals (ferrous and nonferrous metals such as beverage tin cans, aluminum food containers, etc.) was directly related to the economic level of the population. It was maximum in the high income area and the amount of metal found in the lowest income group was negligible because of their low purchasing power for tinned food as well as because they sell the metal to hawkers and earn money from their waste. Metal fraction was found to be more abundant in waste during spring and winter as compared to the other two seasons.

Higher concentration of paper glass and textile in high income group is in accordance with other waste characterization studies [57,58] of the country.

As plastic utensils are cheaper than glass or ceramic ones, they are more within the purchasing power of the lowest income group than the other two income groups. Thus, the lowest income group has higher generation rate of plastic than middle income group, while high income group generates the least amount of plastic as waste fraction. This trend is unique compared the findings in similar study in Lahore [40]. Moreover, more of this fraction was collected in winter and spring than in the other two seasons. Table 8 shows the comparison of Islamabad waste composition of Islamabad with similar studies in Lahore.

Table 8. Showing comparison of Islamabad waste composition with similar studies in Lahore.

Sr. No	Waste Fractions	Islamabad City	Gulberg Town (Lahore) [56]	Aziz Bhatti Town (Lahore) [57]	DGB Town (Lahore) [16]
		%	%	%	%
1	Paper	7.26	4.13	6.38	5.04
2	Glass	2.79	4.1	2.3	2.19
3	Ferrous Metals	0.64	-	0.7	0.02
4	Nonferrous Metals	1.04	0.4	0.4	0.47
5	Rigid Plastic	3.11	4.11	1.9	5.55
6	Film Plastic	4.38	4.22	5	12.94
7	Organic	59.95	68.07	63.8	67.02
8	Textile	1.81	4.19	0.4	1
9	Others	19.2	10.78	19.12	5.77
10	Total	100.18	100	100	100

Waste electrical and electronic equipment (WEEE) and furniture were not part of the study because in Islamabad these items are given away by the high income group or in case of other two income groups are sold to the junkyards, where they are dismantled and sold in parts.

In the absence of a proper waste separation system, almost all of these waste categories end up in open dumps on the dumping site, where they become a source of health and environmental problems. For example, due to the absence of proper landfills, the leachate from organic waste is contaminating the ground water. This can be easily avoided by separating this fraction to make compost. Much revenue can be generated by recycling paper, plastic and glass, which would also help reduce resource depletion [58]. Emission of greenhouse gases from dumping site would consequently decrease [3], although the high percentages of moisture in MSW would need to be catered first.

5. Conclusions

In this study, municipal solid waste was collected from three different localities of Islamabad with different socio economic structure during four seasons of the year (spring, summer, monsoon and winter of 2012) to better understand economic as well as seasonal effect on the generation rate and composition of waste in the city. This waste was then categorized in 42 categories.

For this study, 2164.75 kg of MSW was evaluated, from 1260 samples collected from 45 households during four seasons of the year. As a result of this study, the waste generation rate of Islamabad was calculated to be 0.6 kg/capita/day.

The results indicate that standard of living and waste generation in Islamabad are directly related, i.e., high income group has the highest waste generation rate and low income group has the lowest. The waste generation rates of high, middle and low income groups were 0.89, 0.612 and 0.346 kg/capita/day, respectively, during the study period.

As far as seasonal influence was concerned, it was observed that waste generation in the summer and monsoon was lower compared to higher amounts of waste generated during the seasons of spring and winter. Moreover, the seasonal influence was more profound on the food and yard waste than on the other fractions of waste. The waste generation rates in the seasons of spring, summer, monsoon and winter were 0.78, 0.58, 0.48 and 0.75 kg/capita/day. Respectively, during the study period. Comparison with other national and international studies confirmed the influence of seasons and income groups on generation rate and characteristics of waste. Statistical analysis also indicated strong relation of waste to different seasons and socioeconomic structure in the study area.

Higher percentage of recyclables (plastic and paper) and organic waste in the municipal waste stream of Islamabad makes recycling and composting an encouraging prospect to reduce the environmental burdens of open dumping as well as offsetting the cost of solid waste management by reducing the quantity of the waste to handle as well as by selling of compost and recycled products.

The results of this study can be used by planners, recycling industries and decision makers as reliable baseline data source for the establishment of an effective integrated waste management plan for the city of Islamabad.

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