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Determination of Present Household Solid Waste Generation Rate, Physical Composition and Existing SWM Practices in Selected Areas of Lahore

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ABSTRACT

Industrialization, urbanization and rising population generates huge and diverse amounts of solid and toxic wastes. The effective and sustainable management of this waste poses a challenge for national and local governments. The present study was undertaken to determine waste generation rate and its physical composition in five areas of Lahore namely Gulberg, Model Town, Valencia, Mozang and Mughalpura. Door to door collection of household waste, 10 from each area, was carried out on daily basis for a week. The average generation rate was estimated to be 0.61 kg/capita/day. Physical composition of waste showed that food waste accounted for major portion (39.38%-64.12%) while glass waste (0.53%-7.4%) was the least. Other components varied according to the area socioeconomic strata. A questionnaire was also designed and household survey (100 households) was conducted. Information related to existing practices and issues of solid waste management, public attitude towards recycling and reuse and willingness to pay for provision of better services were also assessed.

INTRODUCTION

Municipal solid waste (MSW) generation rate increases with growing population, economic growth rate and living standard of community with the result that management of MSW has become a critical issue worldwide (Al-Khatib et al. 2010). In developing countries, generation rates are usually high with trends being a direct consequence of industrialization, urbanization and economic development (Minghua et al. 2009). Gradual increase in waste generation coupled with inadequate services for solid waste management (SWM) intensifies the problems related to SW. This escalating problem has crucial effects on the environment, threatening the health of humans as well as incurring economic, biological and environmental losses (Moftah et al. 2016).

Waste management in cities is the responsibility of municipalities, who are confronted with the challenging task of providing sound and effective system to the populace in the wake of a number of issues arising due to dearth of financial resources, organization, complexity and multidimensional nature of the system (Guerrero et al. 2012).

Following the second half of 19th century, global consumption level has increased and huge amount of non-biodegradable SW is also being generated. Problems including leachate, fly ash and odour etc. arise as a result of poor and inadequate management practices of MSW and associated landfill sites (Tiruneh et al. 2015).

Currently, global annual MSW generation is 1.3 billion metric tons, which is estimated to increase to about 2.2 billion tons by 2025. Whereas, the amount of MSW generation has decreased in member countries of Organization for Economic Cooperation and Development (OECD). In Asia and Africa, the rate has increased due to increase in urban population (Kawai et al. 2016). On the other hand, MSW management sector has not received due attention. Technical challenges apart, other factors such as environmental, political, economic, legal and socio-cultural as well as available resources strongly influence SWM system (Kum et al. 2005). Hence, developing countries are facing critical management issues related to SW.

Like other developing countries, population growth of Pakistan is fairly high. According to statistics, Pakistan ranked 6th with population of 195.4 million in 2016. With an annual MSW generation growth rate of 2.4%, daily per capita waste generation rate varies between 0.283 to 0.612 kg (Pakistan Economic Survey, 2015-2016). But the capacity to deal with proper management and disposal poses a critical issue. Only 60 percent of total solid waste generated is collected and the remaining waste lies along streets, roads and vacant plots (Batool & Chaudhry 2009). Practices like open dumping, burning and unengineered sanitary landfilling frequently used for disposal, result in environmental degradation throughout the country (Nisar et al. 2008).

Effective implementation of sound management systems requires precise updated information related to waste generation so that informed regulatory, institutional and financial decisions can be taken (Kebede et al. 2017). Research is therefore carried out regularly for assessment of SW generation rate, management practices and its potential use for recovery options (Ali 2016, Gedefaw 2015, Mukwana et al. 2014, Jaradat & Al-khashman 2013, Khajuria et al. 2010, Mahar et al. 2007).

Lahore is provincial capital of Punjab and during the last five years major investments have been made to improve its SWM system. The present study was undertaken to determine the current municipal waste generation rate and its physical composition. The present SWM system, its effectiveness and related issues as well as residents concern and inclination to contribute to better management were also important determinants of the study.

MATERIALS AND METHODS

In the present study, five areas of Lahore; Gulberg (Nabipura), Model Town, Valencia, Mozang and Mughalpura were selected (Fig. 1). Methodology adopted for this purpose was divided into following two parts:

Door to door collection of household solid waste: Ten houses from each area were randomly selected for door to door collection of waste on daily basis for a week. Each house was provided with six plastic bags every day, labelled according to waste type, date and address. The bags containing waste of each day were collected on the following/next day. This collected waste was weighed and the weight of each component was recorded. After recording seven day data, total waste, average waste and percentage composition was calculated. Waste generation rate was calculated by using formula:

$$\text{Generation rate} = \frac{\text{Total waste produced}}{\text{Sampling duration (days)} \times \text{total number of people}}$$

Solid waste was categorized into food waste, plastic, paper, glass, garden trimmings and miscellaneous.

The study was conducted in September 2016 followed by questionnaire survey.

Questionnaire-household survey: A questionnaire, designed and administered to 100 households (20 from each area) was aimed at gathering information related to existing practices of SWM, issues related to it, public attitude towards recycling and reuse, and assessing willingness to pay for provision of better services, with an average 80 % response rate.

RESULTS AND DISCUSSION

Waste generation rates: The average generation rate was determined as 0.61 kg/capita/day (Table 1) which is consistent with earlier JICA and Pak-EPA report (2005) showing that generation rate vary from 0.283kg/capita/day (kg/c/d)-0.613kg/c/d. Similar study in Gujranwala shows average per capita waste generation in residential areas between 0.36 kg/c/d and 0.46 kg/c/d (Nadeem et al. 2016).

Overall waste generation rate of Model town and Gulberg was highest followed by Mozang, Valencia Society and Mughalpura. Gulberg and Model town are considered to be among the posh areas of Lahore. It has been shown that people in high income areas use more resources as depicted by generation rate of Model town and Gulberg. Though, residents of Valencia society generally also belong to high income strata, but it was observed that average family size was less than Gulberg and Model town and hence lower generation rate. Within each area also, average waste generation rate varied according to socioeconomic status. For instance in Valencia, households with relatively lower income had generation rate as low as 0.17 kg/c/d, whereas families with higher income had generation rate as high as 0.83 kg/c/d. Earlier study in Lahore also reported generation rate of 0.96 kg/c/d, 0.73 kg/c/d and 0.67 kg/c/d for high, middle and low income groups respectively (Jadoon et al. 2014).

Since Mozang and Mughalpura residents mostly belong to upper middle, middle and lower middle class, likewise the generation rate was also less compared to the rest. Overall results (Table 1) also depict influence of family size and income. This estimation is also consistent with earlier work reported by Liu & Wu (2011) that in developing countries SW generation increases with income of households. Income of urban households and urban development are factors that pose a strong influence on MSW generation rate. Numerous studies correlate household waste generation rate and its composition to the socioeconomic status (Sujauddin et al. 2008, Qu et al. 2009, Gomez et al. 2008) while average income per household, GDP per capita, and CPI are the most important factors effecting MSW generation in Bangkok (Sukholtham & Chanvarasuth 2013).

Physical composition/percentage composition: Physical composition of waste in each area is given in Table 2, according to which food waste was highest amounting to 54.9%, 49%, 59.26%, 39.38% and 64.12% of total waste in Gulberg (Nabipura), Model Town, Valencia, Mozang and Mughalpura respectively, while glass waste was lowest which was 5.5%, 6.2%, 7.4%, 0.53% and 7.33%. Other components varied according to the area.

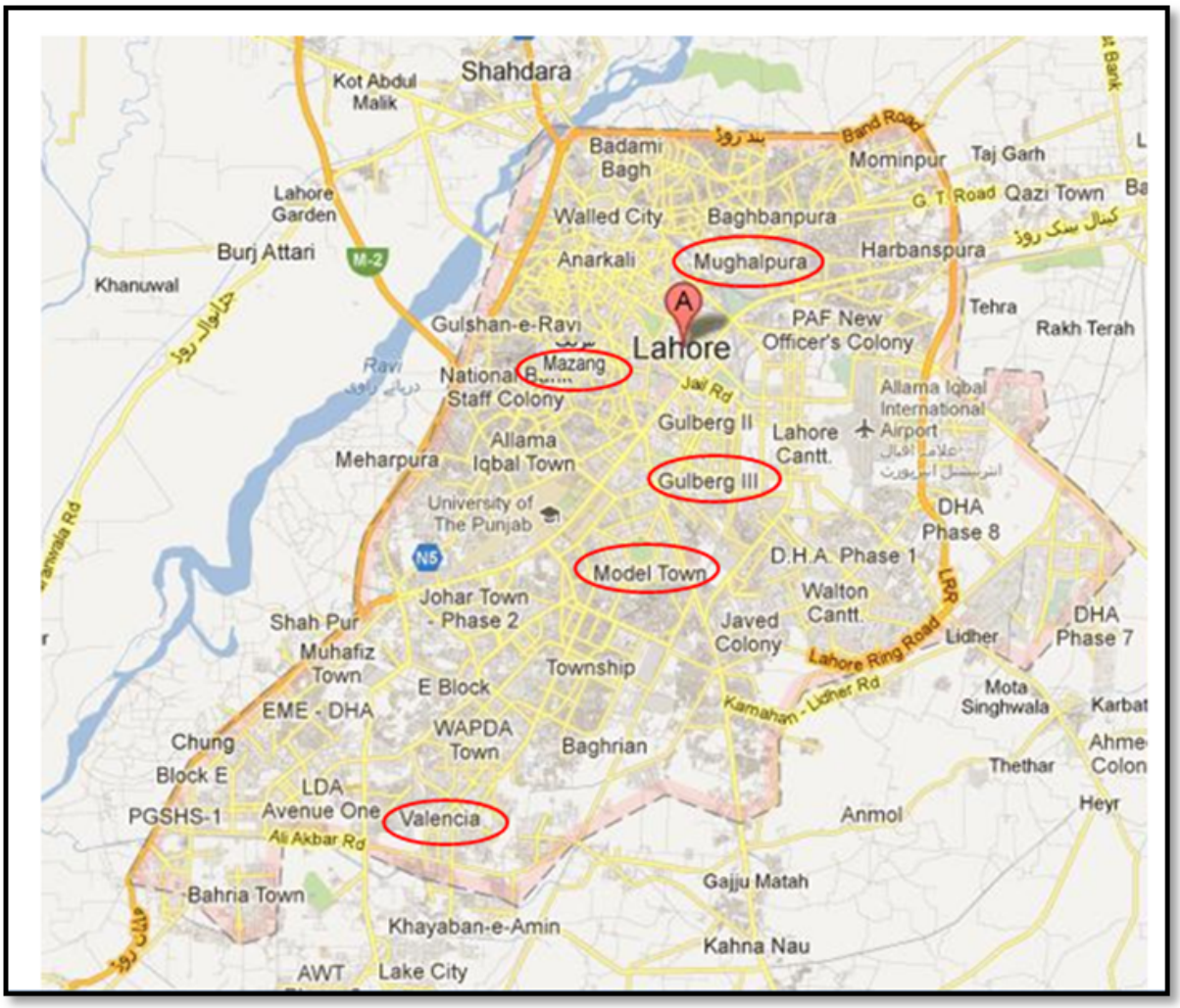

Fig. 1: Location map of study areas.

Similar studies on waste characterization showed that organic fraction accounts for about 65% of the waste weight in Lahore (ISTAC 2012) and between 43-68% in Gujranwala (Nadeem et al. 2016), whereas paper and plastic constitute only 15% while metals and glass contribute very meagre amount of 0.1 and 0.8% only (ISTAC 2012). The present study reports much higher percentages of glass waste, while the highest metal content (10.75%) was estimated in Mughalpura among all the studied areas.

Questionnaire survey results: This section provides information obtained through questionnaire survey, according to which average waste generation per household at Gulberg (Nabipura) varied between 3-8kg per day. In Model town, Mughalpura and Valencia daily waste production/ household was higher (5-10kg), whereas in Mozang, the amount of waste generated varied as low as < 1kg to between 5-10kg.

Use of different types of recyclables was enquired from surveyed population. Among residents of Gulberg, soft drink pet bottles were invariably used in every income level, while tetra packs (milk, juices), oil tins and beverage tins were utilized by 73.33%, 80%, 53.33% and 60% households respectively. In comparison, in Model town, tetra packages (milk) were the most used followed by soft drink pet bottles i.e., 100% and 67% respectively, while oil tins, soft drink glass bottles (disposable), plastic oil bottles, tetra pack juices, and beverage tins utility were 53%, 47%, 60%, 40% and 33% respectively. Practice of using recyclables among residents of Mozang was 70% (soft drink pet bottles), 10% (soft drink glass bottles), 30% (oil tins), 40% (tetra pack juices) and 60% (milk tetra packs), while beverage tins were not consumed by anyone.

Table 1: Household solid waste generation rate.

Sr No.	Sample area	HouseHolds	Total number of people	Sampling duration(Days)	Total wt. of sample(kg)	Generation rate (kg/capita/day)
1.	Gulberg	10	65	7	360.1	0.79
2.	Model Town	10	76	7	422.1	0.793
3.	Valencia	10	44	7	136.86	0.44
4.	Mozang	10	52	7	238.4	0.65
5.	Mughalpura	10	50	7	79.05	0.22
						Average 0.61

Table 2: Physical composition/percentage composition of waste.

Area	Physical composition						
	Food waste %	Paper %	Plastic %	Glass %	Garden trimming %	Metal %	Misc.%
Gulberg	54.9	3.02	10.2	5.5	10.3	6.5	9.5
Model town	49	8.5	6.6	6.2	10	4.18	15
Valencia	59.26	5.8	14.73	7.4	11	-	1.9
Mozang	39.38	14.46	21.68	0.53	-	0.53	23.4
Mughalpura	64.12	5.67	4.1	7.33	2.27	10.75	5.69

A large percentage of recyclables should make it incumbent upon households to practice source segregation to reduce the amount of total waste requiring sound management and disposal. According to an approximation, 30-40% reduction in waste can be realized by separating recyclables in addition to curtailing transportation expenditures and most importantly minimizing environmental pollution issues (Delgermaa & Matsumoto 2016). However, in Lahore city, waste collection coverage is only 68% and no official recycling system exists in city. In the absence of door-to-door collection services by LWMC in its designated 133 Union councils it caters, informal waste collectors fill in the gap and perform the task of primary collection and an estimated ~27% of waste (by weight) is being recycled through informal sector. It is important to encourage recycling behavior by creating public awareness and integrating the informal sector in the present system to make it sustainable and financially viable (Masood et al. 2014).

In the present study, more than 80% respondents affirmed their willingness to participate in 'at source' segregation and recycling programs (Fig. 2). It is reported that when citizens are made aware and educated about ways to segregate and benefits of recycling, they are more probable to join in such endeavours (Guerrero et al. 2012).

Opinions of respondents regarding the adequacy of present services being provided for household collection system of solid waste were gathered. The responses of people concerning their satisfaction level are represented in Fig. 3, while their opinion about issues encountered in provision of sound management of waste are categorized in Fig. 4.

In Mughalpura, 87% of people were reasonably satisfied by the services of waste management company operational there, though some were of the view that the workers were not efficiently trained for this task. The SWM Company provides door to door and container based collection services in Mughalpura. It is also responsible for mechanical washing of the area. Fifty to 55 workers are associated with this organization for the collection of waste from specific area. Containers are placed at three different zone of the whole area, with approximately, 20-30 containers in each zone. Forty seven containers are placed on the main road and along drains to avoid dumping in drains by general public. Minimum one and maximum three vehicles (compactors) are in charge of collecting waste from this area and round the area five times a day, while manual sweeping of area is done thrice a day.

In response to 'willingness to pay' for better services, 46% people answered in the affirmative and agreed to contribute around Rs. 100-200 per month for better solid waste system. The rest were of the view that it should be the duty of the municipality or increased cost should be covered by the general taxes.

Sixty percent people in Gulberg were reasonably satisfied with available services rendered by the relevant service provider Company. The company is responsible for collection of solid waste with stationary container system in place, while door to door collection is carried out by a family of 9 people in the studied households; not on payroll of any government or private company. Nevertheless, they are assisted by councillor of the area. Each house pays Rs 100 to

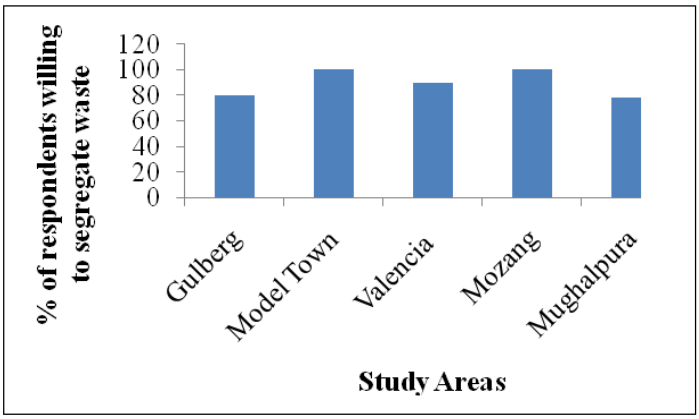

Fig 2: Respondents willingness for segregation of waste.

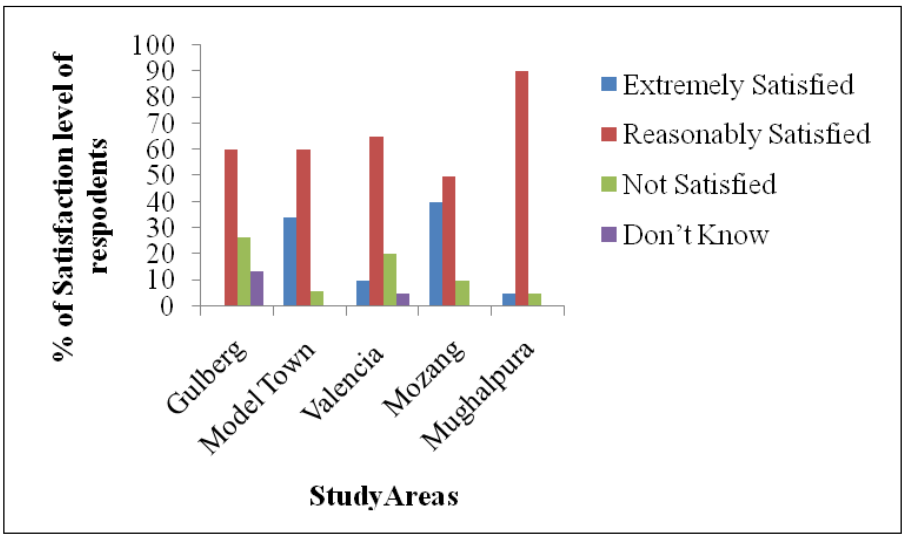

Fig 3: Satisfaction level of people regarding solid waste collection services.

Rs 200 monthly to the family which amounts to approximately Rs 8,000-Rs 9,000 per month. They also separate recyclables (plastic, metals, paper, bottles) and even hairs to earn additional income by selling these. The waste is then disposed in large containers, placed at different sites in Gulberg, from where collection vehicles collect the waste. The major issues highlighted were inadequate service coverage, followed by lack of financial resources and lack of legislation and enforcement measures and capability. Only 13.4% respondents attributed lack of vehicles and equipment's and trained personnel as contributing towards problems in sound SWM. Almost all the households were willing to pay Rs 100 to Rs 250/month for improved collection facilities.

Model town residents also seemed to be satisfied with services of the company responsible for waste collection and mechanical washing of the area. Sanitary workers are managed by the sanitary supervisors in the Union Council and each sanitary worker has its own defined beat (area). During manual sweeping operation in 1st shift, waste is also collected by sanitary workers from households i.e., collected from their house entrance. A total of 28 workers are associated with manual sweeping and washing in the study area. Waste bags are also used by sanitary workers to collect the waste from the roads, streets and households which are then hauled through wheelie bins and hand carts to the waste containers. Solid waste generated is stored in waste containers; a total of 53 waste containers are in place in the Union Council at 34 different points.

A large percentage of respondents (73%) showed their willingness to pay, if required, Rs100-Rs 300 per month, for improved waste collection and would prefer the local gov-

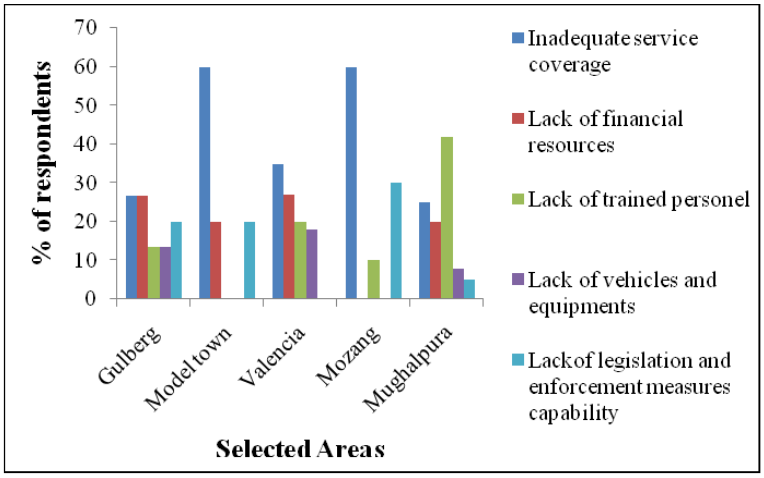

Fig 4: Public views regarding problems encountered in SWM services in study areas.

ernment to take this responsibility, whereas 27% believe that taxes should cover the cost of this service. The idea of paying through re-usable waste such as empty bottles, newspapers, stationary items etc. instead of money was proposed by a respondent.

Sixty six (66%) respondents of Valencia were reasonably satisfied, while 13% were extremely satisfied. Valencia society, with a total of 3900 houses, has signed contract with two private companies for door to door collection of waste and 5-7 mini-trucks of designated companies collect the waste (daily between 9:00 a.m.-9:30 a.m.) from the container present outside every house. These containers are provided by the society and residents have to pay a fine of Rs 3000 if the container is not kept in good condition or its nonexistence. Service charges (Rs 170) levied on residents are used to pay for the facility. After collection from all blocks, waste is transferred to specified stations for further processes. In response to their readiness to pay for improved collection services, 73% of the respondents were willing to pay between Rs100-500 per month.

Presently, in Mozang, a private company is associated with collection of the waste for which each residence pays Rs 200 as service charges. The waste is collected at study area daily between 8:00 a.m. and 9:00 a.m. on a Suzuki pickup van. The residences are also provided with green polythene bags for waste storage and disposal to large drums, placed by the company, in the locality. The collected waste is then disposed off to the nearby station-Tibia Village, Ferozepur Road. In general, 40% households were very satisfied and 50% were reasonably satisfied with the services. Ninety percent respondents agreed to pay Rs 50 - Rs 200 for better solid waste system. 60% of the respondents believed that inadequate service coverage was the major problem in SWM, whereas 70% were extremely concerned about whether the final disposal is environmentally safe and acceptable.

CONCLUSION

It can be concluded that food waste constitutes a major portion in the waste stream. Deficiencies and shortcomings in the present system especially collection of waste and coverage of services were identified. The public is concerned about sound management of waste and is willing to pay for a better collection system. Presence of appreciable amount of recyclables and public positive response for participation in recycling initiatives call for the development of formal recycling facilities/sector incorporating scavengers in the main stream.

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