Chapter

Analysis of Municipal Solid Waste Generation in Dir City

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Abstract

The study is an attempt to analyze municipal solid waste generation Dir City, District Dir Upper Khyber Pakhtunkhwa (KP), Pakistan. This study has utilized primary data collected through a semi-structured questionnaire and direct waste sampling as primary research. Mathematical analysis and descriptive statistical analysis is applied and generation of municipal solid waste at different scales is estimated. Results indicated that the total waste generated was 16.65 million kg/annum (18356.5 tons) or 45624 kg/day (50.29 tons), or 0.37 kg/capita. Average waste produced by residential, commercial, educational and health sectors was 3.3 kg, 21 kg, 12 kg and 7 kg, correspondingly. Among all, residential sector was the leading producer with 40738 kg (89%) follow by commercial sector 4321 kg (9%) per day while remaining in fraction. High income households and large size families were producing average waste of 5.6 kg/day and 4.9 kg/day, respectively. The main components of waste generated in the study area included paper (8%), organic matter (53%), plastics (12%), clay, pebbles, gravels, ashes and broken ceramic objects (24.8%). The spatial distribution of waste generation varies across the city, high rate of generation was found Rehankot and Shaow whereas Fringe areas were characterized by low generation rate.

Keywords: solid waste, income, family size, waste generation, Dir City

1. Introduction

Worldwide, environmental problems are increasing with negatives consequences on human life and environment. Municipal solid waste is one of the current environmental problems particularly in developing countries [1]. Different human activities at domestic, commercial, industrial and agricultural level, as well as construction work are generating solid waste [2]. The quantity of municipal solid waste is increases with increasing population [3]. Improved living standards have and urban living style has intensified the problem of waste generation [4]. Likewise super packing form of various products ready to use and of fast food products has changed waste composition [5]. The population growth and haphazard expansion also contribute in a straight line to waste generation and urban areas are facing environmental problems and public health issues [3, 6]. The solid wastes produced by any urban societies contain rubbish, construction material, leaf litter and other constituents in a fraction [7]. The physical constituents of solid wastes included "food waste, yard waste, wood, plastics, papers, metals, leather, rubbers, inert materials, batteries, paint containers, textiles, construction and demolishing materials and many others" [8]. Various studies indicate that in developing countries 60–85 percent of the municipal solid waste is generated by residential sector

followed by commercial activities with heterogeneous nature and quantity [9, 10]. The focus of this study is the analysis of solid waste generation by residential, commercial, health, and educational sectors of Dir City.

2. Methods and material

2.1 The study area

The district of Upper Dir is situated in the North-west of Pakistan with a total geographical area of 3,699 sq.km [11]. The total population of the district was enumerated as 946,421 with 120,228 households as in 2018. The population density is 156 persons/sq.km [12]. The elevation of study area varies from 5577 meters above mean sea level in the north to 844meters in the south. River Panjkora, fed by rain and melt water, is the main source of water for various purposes particularly at domestic level. The annual rainfall in the area varies from 823 to 2149 mm [13–14].

The target community is Dir City- the oldest settlement with high population density in the entire district. The estimated population of the target area is 121893 persons with 12345 households. Average family size is about 8 persons [15]. Dir City is further divided into many communities like Main Bazaar, Rehankot, Shaow, Kaas, College Colony and Bijli Ghar. Most of the municipal solid waste and entire liquid waste is persistently dumped haphazardly in open spaces and into Dir River which is a source of fresh water. Such anthropogenic activity is polluting precious fresh water resource.

2.2 Data collection and analysis

For achievement of this micro-level research work objectives, primary data is collected using questionnaire based households survey and direct field measurements. The field work was conducted in September, 2020. A detailed semi-structured questionnaire was developed containing questions regarding family size, monthly income, daily solid waste generation in Kilograms (Kg), effects of open dumping and caused of inappropriate disposal as suggested by [16]. The surveys were conducted in the target community using systematic sampling techniques. A total of 112 household's head were interviewed. Population data and households data was acquired from the Tehsil Municipal Authority (TMA), District Upper Dir.

The data regarding monthly income and family size were processed and classified using frequency distribution. The monthly income of the surveyed household was arranged into three classes i.e. *"low income class"* <35,000 in Pakistani Rupees (PKR; 1US$ =160 PKR, 2020), "*middle income class*" ranging from 35,000–70,000 PKR, and "*high income class*" >70,000 PKR. These income classes were used to find out variations in generation of solid waste at household level among various segments of the community. In the same way, family size of the surveyed households was arranged into three groups; *small family* (<7 persons), *medium family* (7–12 persons) and *large family* (>12 persons).

The average solid waste generation (Kg/day) for each income and family size class was calculated by using Eq. (1):

$$\mathbf{SW_{average}} = \sum \mathbf{N / n} \quad (1)$$

In the given equation "$\mathbf{SW_{average}}$" is the average solid waste generation, "N" numerical value of each observation and "n" is the total number of observations. While average solid waste per person/day was calculated using Eq. (2):

$$\mathbf{SW_{pc} = SW_{average} / FS_{average}} \quad (2)$$

In the given equation "$\mathbf{SW_{pc}}$" is the solid waste generation per capita and "$\mathbf{FS_{average}}$" is the average family size. The total solid waste generated by residential sector is calculated by using Eq. (3). In the same manner solid waste generation per day for each sector is calculated and then by adding all sectors a grand total "T" for all sectors is estimated.

$$\mathbf{SW_{residential} = (p) * (SW_{pc})} \quad (3)$$

In the given equation "$\mathbf{SW_{residential}}$" is the residential solid waste generated per day, and "p" is the total population. The annual solid waste generation is estimated using the Eq. (4).

$$\mathbf{Annual = [(T) x (365)]} \quad (4)$$

The results are visualized in the form of tables and graphs.

3. Results and discussion

The total population of the 112 surveyed households was counted as 1442 persons. Family size of the surveyed households has divided into three classes. The family included parents, their sons, daughters, nephews, grandfather and grandmother. Medium size families were around 33 percent, though small and large size families were 17% and 50%, respectively (**Table 1**). Average family size of the surveyed households was 9 persons. Solid waste generated by the small, medium and large families was 1.8 Kg/day, 3.2 Kg/day and 4.9 Kg/day, respectively.

Similarly, the monthly income of the surveyed household head was also classified into three groups out of which about 32 percent were low income with a monthly income of less than 35,000 PKR, around 44 percent income was ranging from 35,000 to 70,000 PKR, and about 24 percent falls in high income group having monthly income more than 70,000 PKR (**Table 2**). Daily waste generation increases with the increase in household monthly income. Low, medium and high monthly income households have been generating 1.3 Kg/day, 3.1 Kg/day and 5.6 Kg/day, respectively.

3.1 Municipal waste generation and composition

The rapid population growth, rising urbanization and consumption patterns led to the production of more solid waste [17]. Municipal authorities have to manage

Family Size	Percentage	Kg/day
Small	17	1.8
Medium	33	3.2
Large	50	4.9
Average		3.3

Source: Field Survey September, 2020.

Table 1.
Solid waste generation per day by various size families in (kg/day).

Income Groups	Percentage	Kg/day
Low income	32	1.3
Middle income	44	3.1
High income	24	5.6
Average		3.3

Source: Field Survey September, 2020.

Table 2.
Solid waste generation various income groups in (kg/day).

the solid waste arising from residential, commercial, health and educational activities along with the waste collected from the streets [18]. Normally the municipal authorities manage all type of wastes dropped in the community bins located at street level in the city [19]. In the study area, Tehsil Municipal Authority (TMA) is not working properly and the residents are also disposing the wastes directly in the streets, drains, open spaces, vacant plots and river. The major source of municipal solid waste production is residential sector. The average wastes produced by commercial, educational and health sectors per day were 3.3 kg, 21 kg, 12 kg and 7 kg, correspondingly (**Table 3**). The fruit and vegetable market was generating waste of about 300 kg/day.

Results indicated that the per capita generation of solid waste is 0.37 kg/day. The total waste generated by the entire studied community is 45624 kg/day (50.29tons) whereas total 16.65 million kg/annum (18356.5tons) is the estimated figure for one year. Residential sector was the leading producer with 40738 kg/day (89%) followed by commercial sector 4321 kg/day (9%) presented in **Figure 1**.

The composition of the waste generated by the studied community has different constituent elements. The average physical ingredient of municipal solid waste produced by Dir City comprised of paper (8%), organic matter (53%), plastics (12%), soil, pebbles, gravels, ashes and broken ceramic objects (23.3%) and others things (3.5%; **Figure 2**). The organic matter is one the major constituent because of the use of fresh vegetables, fruits, other food wastes, wood and leaves at household level, and kitchen remains. These results are very near to the findings of [16, 20]. Spatial analysis of results indicates that waste generation rate is highest in Rehankot followed by Shaow. High population density, monthly income and family size are the major factors of more waste generation. The commercial activities are concentrated in a narrow belt along the main road where fruit and vegetable market "*Sabzi Mandi*", hotels and restaurants are located. Therefore, it forms a separate zone of waste generated by commercial activities. Spatially, this zone is extending from north to south in city center covering the entire main market "Main Bazaar". The waste generated in Rehankot, Shaow and Main Bazaar is higher in the city whereas the outskirts are producing low waste because low income group and small to medium size families are settled there.

The major constituent of solid waste in the Dir City is organic matter (53%). The same is found in the previous studies [4, 16, 21] that municipal solid waste is dominated by organic and recyclable materials.

3.2 Community perception

Community perception on the subject of open dumping of municipal solid waste is also been investigated. The perception across the study area was different about negative outcomes of dumpling waste openly. Results indicated that most of

S.No.	Sources	Average Solid Waste
1	*Residential Area*	
	Households	3.3
2	*Commercial Areas*	
	Hotels	8.5
	Shops	1
	Fruit Market	300
3	*Medical facilities*	
	Hospitals	12
	clinics	1.5
4	*Educational Institutions*	
	Private schools	12
	Govt. schools	14
	Private College	7
	Govt. College	14
5	Parks & grounds	8
6	*Offices*	
	Private	1.2
	Government	3

Table 3.
Sector wise average solid waste generation in (kg/day).

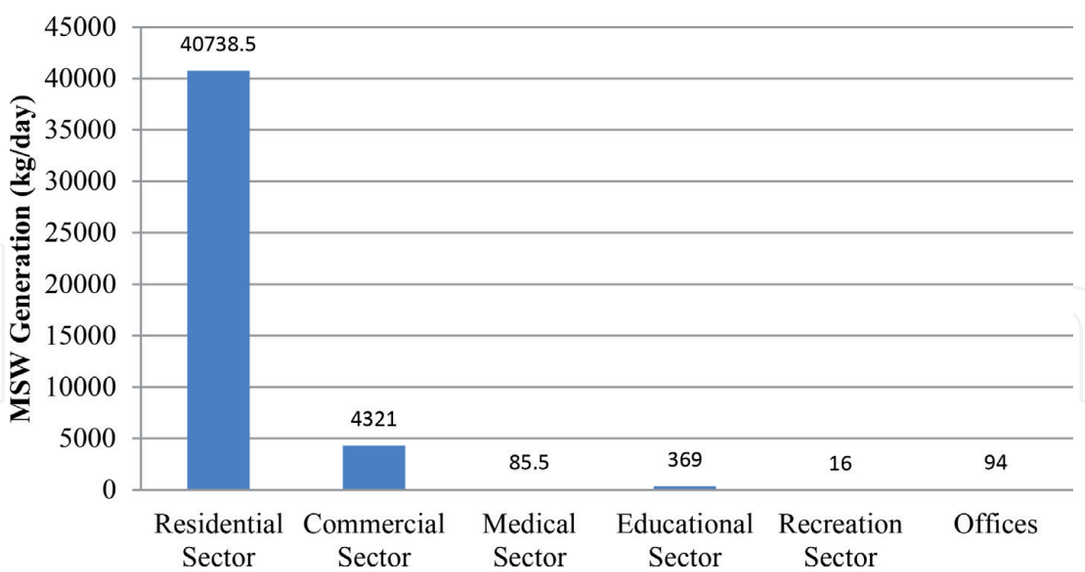

Figure 1.
Sector wise municipal solid waste generation (kg/day).

the residents (68%) were aware of the negative consequences of solid waste open dumping. There view point was that open dumping of solid waste is polluting the environment and causing bad smell and may cause different diseases because it provides breeding grounds for mosquitoes. The remaining (32%) respondents were of view that there is no effect of open dumping of solid waste on health of the environment and people.

The community perception concerning the causes of open dumping of solid waste was uneven. About 63% of the studied population considered that TMA employees are not working properly in residential sector. There is lack of bins at street level. Similarly, there is no one to collect waste from door to door. They just came on request and remove the waste from drains. In some places across the study area, they are unloading solid wastes from hand trolleys directly in the open spaces or in river because there is no waste dumping site. The function of District Government is also poor because the growth of population and expansion of built up land of city has been occurred but there is no improvement has been seen in management of municipal solid waste. The perception of about 37% of the respondents was that Tehsil Municipal Authority employees and residents of the area are accountable for dumping (**Figure 3**). The residents are also throwing the domestic wastes direct in the drains, streets or open spaces. The haphazard dumping is more hazardous for the community. In the study area, drains are not covered and people are throwing waste into it leading to drains obstruction. The blockage further intensifies the problem. The treatment of solid waste is relatively hard subsequent to production.

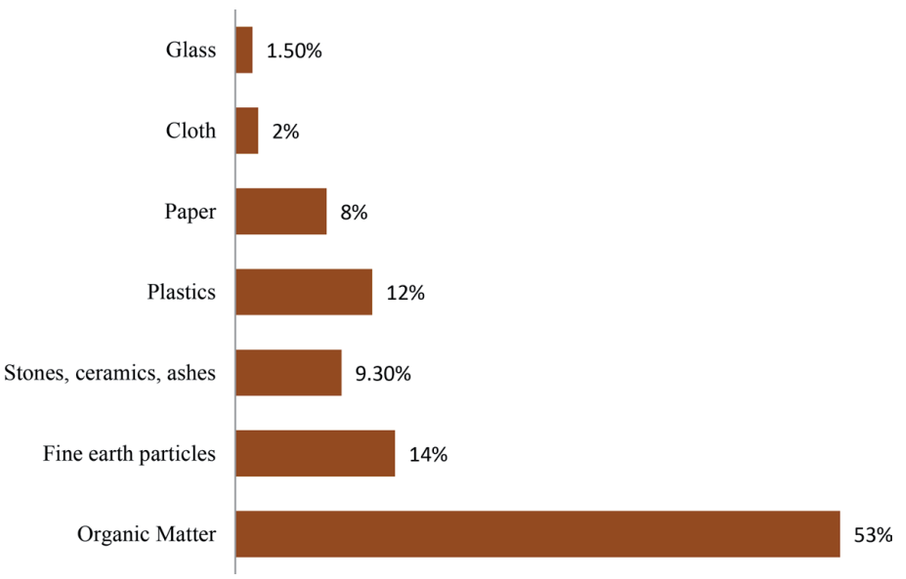

Figure 2.
Composition of the sample solid waste at domestic level.

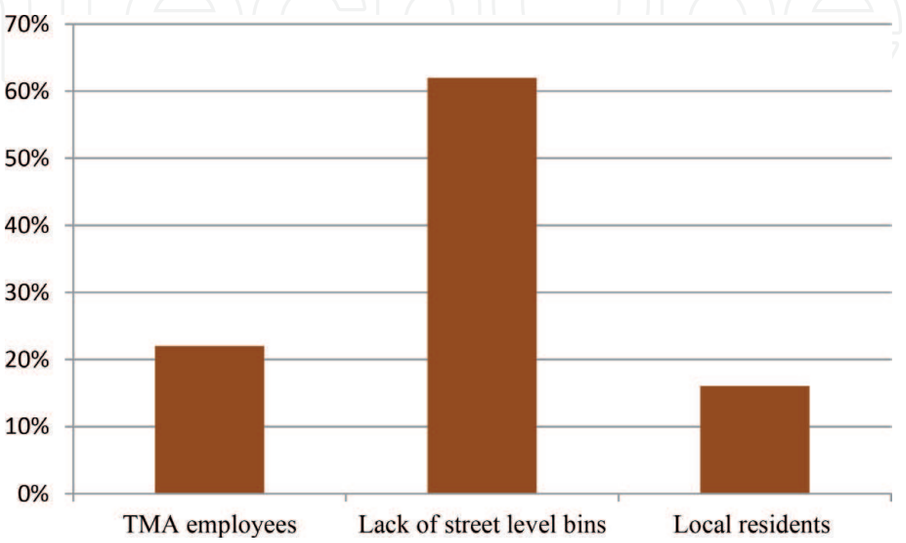

Figure 3.
Community perception.

Well planned mechanism for collection and disposal is required to dump the waste in landfill site [22, 23]. Both the land filling and open dumping is causing leaching. This may pollute the fresh water resources. Polluted water is causing the accumulation of harmful substances in aquatic animals. Consequently affect the aquatic life negatively. In the same manner it can cause human health problem [24].

4. Conclusions and recommendations

It is concluded from the analysis that about 89% of the solid waste is generated by residential sector. The major constituent elements of sampled wastes were organic matter, plastic and paper.

The related authority and departments has poor performance to manage solid waste properly because of limited available resources. Dumping in drains, open spaces, and streets is very common and most of the community is unaware of its negative consequences on environmental health and human health. Similarly, dropping the waste direct in the river is also one of hazardous activity because it pollutes river's water and may lead to aquatic life. Hazardous environmental and health impacts might be the fate residents of Dir City, if the issue is not managed properly. It is the demand of time to design solid waste management plan for Dir City in order to reduce the risk environmental and health problems.

Future Prospects.

Municipal solid Waste management is a challenge for waste managers and dealing departments/authorities. In this regard, development of proper waste management system is highly required. It will not only reduce risk of environmental problem but also generate revenue. Alongside site suitability analysis for damping of waste is also needed. It will protect the rivers. Similarly, awareness campaigns regarding reuse, recycle and reduce strategies is also highly required at household level.

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