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Characterization of Household Solid Waste and Management in Tripoli City—Libya

Walid A. S. Moftah[1], Dragan Marković[1], Omar A. S. Moftah[2], Layth Nesseef[2]

[1]Department of Environmental Management, Faculty of Applied Ecology, Singidunum University, Belgrade, Serbia
[2]Department of General Sciences, Faculty of Agriculture, University of Aljabal Algarbi, Garian, Libya
Email: moftahwalid@yahoo.com, draganmarkovic@singidunum.as.rs, Omarali702@yahoo.co.uk

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Abstract

Waste stream characteristics must be understood to tackle waste management problem in Tripoli city, Libya. It is recognized that information on both quantity and composition of generation waste is important for the effective planning of household waste handling infrastructure. So, this study is aimed to evaluating the generation, composition and density of household solid waste in Tripoli city, Libya. The study is carried out according to the Annex 2.1 of: WHO 1996. It was conducted during one week in summer, autumn and winter 2011/2012. The daily household solid waste generation assessment has been carried out for 150 Libyan families where 947 people in three main parts of Tripoli city have been chosen randomly. A questionnaire was prepared according to Buenrostro *et al.* 2001 and Raje *et al.* 2001 using door-to-door surveying. The result showed that the average of total generation quantity, daily generation rate, total volume and density were 1415 kg, 0.64 kg/person/day, 19.3 m^3 and 74.4 kg/m^3 respectively in Tripoli city. Household solid waste contains 36.3% organic matter and 32.5% recyclable materials (glass, paper, plastic, metals). The total generation quantity, daily generation rate, total volume and density were in Tripoli city agreed with those for African and Arabic countries. But the problem is that Tripoli suffers from insufficient municipal solid waste management and lack of sanitary landfills.

Keywords

Household Solid Waste, Generation Rate, Composition, Solid Waste Management

1. Introduction

Solid waste has been produced since the beginning of civilization. During the earliest periods, solid wastes were conveniently and unobtrusively disposed of in large open land spaces, as the density of the population was low.

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As a result of rapid urbanization and changes in consumption of many cities in developing countries, waste generation has increased. However, the waste generated is, in most cases, not properly managed. Hence, this has huge consequences in terms of collection, disposal and the elimination of waste [1] [2]. However, today, one of the consequences of global urbanization is an increased amount of solid waste. About 1.3×10^9 t of municipal solid waste (MSW) was generated globally in 1990 [3], and, at present, the annual generation is approximately 1.6×10^9 t. The urban population in Asia generates around 760×10^3 t of MSW per day, and this is expected to increase to 1.8×10^6 t by 2025 [4] [5]. In almost all developing countries, city solid waste constitutes a hazard, be it from the ecological point of view or the public health point of view. Almost everywhere, there is a distinct lack of policy on efficient waste collection and a total absence of its treatment [2]. Many experts from various cities in developing countries have expressed serious concerns about improper waste treatment and disposal in these countries [4] [6]-[9]. In most developing countries, solid waste management is undertaken by the local authorities. These services include waste collection (either from households or district collection points) to final disposal. However, the low financial base and human resource capacity of these local authorities means that in most cases they are only able to provide a limited service [7]. Inadequate management of solid waste in most cities of developing countries leads to problems that impair human and animal health and ultimately result in economic, environmental and biological losses [9]-[11]. The quantity of municipal solid waste generated depends on a number of factors such as food habits, standard of living, with increasing urbanization and changing life styles, degree of commercial activities and seasons. A number of socioeconomic variables may affect the quantity of solid waste generated each day by a household. These include religion, family size, family employment, age, education; land status and duration of stay [9] [12] [13]. Data on quantity variation and generation are useful in planning for collection and disposal systems [9]. Today waste is also produced as a result of society's attempt to solve other environmental problems such as water and air pollution. Some of these increasing amounts of waste give rise to new problems, such as sewage sludge and residues from cleaning of flue gases [14]. Solid waste management has several functional elements, including waste generation, waste handling and separation, storage and processing, collection, transfer and transport, and final disposal [1]. Solid waste management refers to all activities pertaining to the control, collection, transportation, processing and disposal of waste in accordance with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations. Its scope includes all attendant administrative, financial, legal, planning and engineering functions. To achieve the objectives of solid waste management and to overcome its problems, [12] proper management (storage, collection, and disposal) of solid waste requires accurate information regarding waste-generation rates, and quantities, composition, sources, and locations of waste. This type of information was not available for the cities in Libya. No studies were conducted on solid waste management in the past. There are no records indicating the amount of various types of waste collected and the volumes of waste generated per capita. Therefore, this study aimed to estimate the household solid waste generation, composition and density in Tripoli city in Libya as first step should lead to a better understanding of the solid waste management problems in Libya and estimate the effects of some socioeconomic factors on solid waste generation.

2. Place of Study

Tripoli is the capital city and the largest city of Libya. As of 2011, the Tripoli metropolitan area (district area) had a population of 2.2 million people. The city is located in the northwestern part of Libya on the edge of the desert, on a point of rocky land projecting into the Mediterranean and forming a bay. This study was conducted in three main parts of Tripoli city which have been chosen randomly.

3. Preparations

The areas of study (area1, area 2 and area 3) have chosen according to the type of houses (old fashion houses, flats and modern houses) to be representing the low income, middle income and high income levels respectively. Equipment and collection route have been determined. Box volume has been measured and the workers instructed as to how should carry out their work. The plastic bags distributed in study areas.

4. Procedure of Study

The first phase of study carried out according to the Annex 2.1of: WHO (1996) [14]. Therefore, the plastic bags

from houses collected according to the pre-specified collection route from (area1, area 2 and area 3) to the dump site where all measurements have been conducted. Each plastic bag weighed and recorded the weight in the data sheet according to the numbers assigned to households. 10 - 15 plastic bags chosen randomly of each sample area then opened and emptied in the boxes of volume unit it became full and then emptied, spread on the plastic sheet. Wastes separated into different types, weighted and recorded to be a composition of household wastes by weight. The volume of generated household solid waste measured by empting all plastic bags in the boxes and counting the number of boxes to be the total volume. This procedure repeated every day /week in summer, autumn and winter 2011/2012.

In the second phase of the study, a questionnaire survey was carried out on 150 randomly selected houses in various areas in the city. A questionnaire was prepared according to Raje *et al*. 2001 [15] and Buenrostro *et al*. 2001 [16] using door-to-door surveying in order to obtain data about household solid waste quantity, daily disposal, availability of containers, collection frequency and satisfaction level, etc. The data collected from the survey was analyzed using Microsoft Excel for calculating simple statistics.

5. Results and Discussion

From the data of collecting questionnaire, the responsive percentage to the study was 100% whereas 150 questionnaires have been distributed and collected in study places and the number of people was 947. **Table 1** explains the concluding data. On the other side, the information about household solid waste services refers to, all chosen families in area 1 pay about 15 - 20 €/month for private companies for solid waste services twice a week and they are almost satisfy, ni gnivres ynapmoc tnemnrevog on si ereht tub secivres lacol referp yeht dna this side of Tripoli. 50% of families produce 7 - 10 garbage bag per week, 30% producing 4 - 6 bags per week and 20% producing 0 - 3 bags. All chosen families in area 2 didn't pay for private companies of solid waste services. 43% of families produce 7 - 10 garbage bag per week, 36% producing 4 - 6 bags per week and 21% producing 0 - 3 bags. 40% of chosen families in area 3 didn't pay for private companies of solid waste services and 60% are paying. 60% of families produce 7 - 10 garbage bag per week, 30% producing 4 - 6 bags per week and 10% producing 0 - 3 bags.

6. Household Solid Waste Generation, Volume and Density in Places of Study

In order to determine generation, volume and density in places of study approximately 4650 kg household solid waste were collected from 150 Libyan families representing some 947 persons in (area1, area 2 and area 3) at Tripoli city during one week in summer, autumn and winter 2011/2012. From **Table 2**, the results shown that the total generation quantity, daily generation rate, total volume and density were 1464.5 kg, 0.66 kg/person/day, 19.73 m^3 and 74.7 kg/m^3 respectively in Tripoli city.

Comparisons between the Tripoli city results and those for African and Arabic countries, the generation rate agreed with All Arabic countries [17], and Cameroon, Burkina Faso, Guinea, Namibia, Senegal and Zimbabwe [18] but it is higher than 0.39 reported in Allahabad, India [19], 0.23 kg in Beijing [20], 0.55 kg in Abuja [21], 0.59 kg in Mexican city [22], and the 0.4 kg in Dares Salaam [23], but it is less than the 1.1 kg reported in Lagos [24] and 0.84 in Lahore city, Pakistan [25].

Table 1. Families characteristic.

Gender	Male	Female				
	417	530				
Age (year)	Under 6 (yr)	15 - 20	21 - 25	26 - 35	36 - 55	>55
	133	216	130	111	300	57
Education	High school	Diploma	College	Postgraduate	Students	Non
	94	163	213	25	429	23
Income (LYD)	≤300	301 - 500	501 - 1000	1000 - 2000	>2000	
	33	326	127	28	14	
Occupation	Housewife	Student	Teachers	Self employed	Employee	Retired
	98	429	128	77	200	15

7. Household Solid Waste Generation According to the Family Size

The analysis of the 150 sample observations in the study areas indicates that an average household in the Tripoli Area generated 0.7 kg of wastes per day. It also reveals that the rate of waste generation varies in the different places studied, as shown in **Tables 2-5**, the waste generation rate was found to be 0.59 and 0.74 kg/capita/day in

Table 2. Average values of Tripoli city.

Value		Summer	Autumn	Winter	Average
Total (kg)	Quantity	1563.7	1318.2	1511.7	1464.5
Generation rate (kg/person/day)		0.7	0.59	0.69	0.66
Volume (m^3)		20.7	18	20.48	19.73
Density (kg/m^3)		75	74.7	74	74.7

Table 3. Average values of Tripoli household solid waste during summer.

Value	Area 1	Area 2	Area 3	Average
Total quantity (kg)	1572.1	1460.4	1760.5	1563.7
Generation rate (kg/person/day)	0.59	0.74	0.78	0.7
Volume (m^3)	19.2	18.9	24	20.7
Density (kg/m^3)	74.3	77.4	73.3	75

Table 4. Average values of Tripoli household solid waste during autumn.

Value	Area 1	Area 2	Area 3	Average
Total quantity (kg)	1280	1062.7	1611.8	1318.2
Generation rate (kg/person/day)	0.53	0.54	0.71	0.59
Volume (m^3)	17.8	14.4	21.6	18
Density (kg/m^3)	71.8	73.8	74.6	74.7

Table 5. Average values of Tripoli household solid waste during winter.

Value	Area 1	Area 2	Area 3	Average
Total quantity (kg)	1378	1444.9	1712.1	1511.7
Generation rate (kg/person/day)	0.57	0.74	0.76	0.69
Volume (m^3)	18.2	20.2	23	20.5
Density (kg/m^3)	75.8	71.7	74.5	74

Table 6. Solid waste generation according to the income level.

Income value	Number of persons	Days							Total	Generation rate
		1	2	3	4	5	6	7		
≤300	60	4.9	4.19	4.73	4.3	4.83	4.89	4.92	34	**0.56**
301 - 500	45	1.83	2.61	3.83	4.34	5.04	5.42	5.8	28.87	**0.64**
501 - 1000	37	1.91	2.77	3.92	4.41	5.17	5.67	5.92	29.77	**0.8**
1000 - 2000	35	1.99	2.87	3.93	4.6	5.37	5.85	6.15	30.76	**0.88**
>2000	30	2.01	2.94	4.11	4.94	5.64	6.03	6.87	32.54	**1.08**
	207								**155.94**	**0.75**

Table 7. Solid waste generation according to the family size.

Family size	Number of persons	Days							total	Generation rate
		1	2	3	4	5	6	7		
≤3	19	1.83	1.99	2	2.01	1.91	1.91	1.99	13.64	**0.72**
4	28	2.87	2.87	2.9	2.75	2.91	2.90	2.61	19.9	**0.70**
5	50	4.98	4.11	4.93	4.1	4.83	4.89	4.92	34	**0.68**
6	42	3.34	4.6	4.5	4.94	4.89	4.51	4.41	32.2	**0.67**
7	56	5.42	5.44	5.64	5.37	5.17	5.04	5.17	37.3	**0.66**
8	64	6.03	5.67	5.85	5.88	5.92	5.42	5.75	40.52	**0.63**
>8	67	6.87	6.53	6.17	5.88	5.92	6.15	6.25	40.77	**0.61**
	326	31.34	31.21	31.99	30.93	31.55	30.82	31.1	218.3	**0.67**

Table 8. Household solid waste composition in Tripoli city in summer.

Category	%			
	Area 1	Area 2	Area 3	Average
Food	13.5	15.3	5	11.3
Vegetables	8.1	10	6.7	8.3
Bones	2.7	3	5	3.6
Fruits skin	7	10	8.3	8.4
Bread litter	6.2	3	5	4.7
Paper	12	14	20	15.3
Textiles	14	8.6	12	11.5
Plastic	20	18.2	17.6	18.6
Glass	4.1	3.2	3.1	3.5
Metals	8.4	4.7	7.2	6.7
others	4	10	10.1	8
total	100	100	100	100

Table 9. Household solid waste composition in Tripoli city in autumn.

Category	%			
	Area 1	Area 2	Area 3	Average
Food	11.5	14.1	7.8	11.1
Vegetables	6.5	11.2	8.8	8.8
Bones	2.5	2.2	4.8	3.2
Fruits skin	3.2	4.1	6.2	4.5
Bread litter	5.4	3.4	4.7	4.5
Paper	15.6	15.6	18.2	16.5
Textiles	12.5	10	8.3	10.3
Plastic	18.7	18	19	18.6
Glass	5.3	5.1	7.2	5.8
Metals	9.8	5.1	8	7.8
others	9	11.2	7	9.1
total	100	100	100	100

Table 10. Household solid waste composition in Tripoli city in winter.

Category	%			
	Area 1	Area 2	Area 3	Average
Food	10.7	13.6	10	11.4
Vegetables	7.6	9.3	9.2	8.7
Bones	3.5	5.1	6.2	5
Fruits skin	4.7	7.3	7	6.1
Bread litter	7.5	2.2	5.1	5
Paper	11.2	14.7	16.4	14.1
Textiles	15.1	11.3	12	12.8
Plastic	16.2	20.5	22	19.6
Glass	4.5	4.2	1.8	3.5
Metals	7.8	4.3	5.3	5.8
others	11.2	7.5	5	7.9
total	100	100	100	100

Table 11. Household solid waste composition in Tripoli city.

Category	%			
	Summer	Autumn	Winter	Average
Food	11.3	11.1	11.4	11.3
Vegetables	8.3	8.8	8.7	8.6
Bones	3.6	3.2	5	4
Fruits skin	8.4	4.5	6.1	6.3
Bread litter	4.7	4.5	5	4.7
Paper	15.3	16.5	14.1	15.3
Textiles	11.5	10.3	12.8	11.5
Plastic	18.6	18.6	19.6	18.9
Glass	3.5	5.8	3.5	4.3
Metals	6.7	7.8	5.8	6.8
others	8	9.1	7.9	8.3
total	100	100	100	100

Table 12. Household solid waste composition in Tripoli city (%).

Category	Summer	Autumn	Winter	Average
Organic matter	37.5	41.3	30	36.3
Paper	12	14	20	15.3
Textiles	14	8.6	12	11.5
Plastic	20	18.2	17.6	18.6
Glass	4.1	3.2	3.1	3.5
Metals	8.4	4.7	7.2	6.7
Other	4	10	10.1	8
total	100	100	100	100

area 1 and area 2 respectively and 0.78 kg/capita/day in area 3. The generation of household waste was found to be positively correlated with family size **Table 4**, which means families with more individuals generate a larger

quantity of solid waste per day, the income level of family was also found to be positively correlated and the generation of solid waste, which reveals that families earning more per month have the tendency to generate a larger quantity of solid waste each day **Table 6**. An inverse correlation was found between the waste generation rate and families size as apparent in **Table 7**.

8. Composition of Household Solid Waste

In order to estimate the composition of household solid waste in Tripoli, 178.5 kg, 180.7 kg and 176.1 kg in summer, 168.3 kg, 180.1 kg and 169.4 kg in autumn and 173.5 kg, 183.7 kg and 179.1 kg in winter of waste mixed samples from (area 1, area 2 and area 3) were separated as groups and weighted. The results of the analyses show that household solid waste contains 36.3% organic matter as shown in **Tables 8-12**. The percentage of recyclable materials (glass, paper, plastic, metals) was 32.5%.

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