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Municipal Solid Waste Characterization, Tehran-Iran

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Abstract: Effective waste management has been greatly restricted by insufficient statistical data on the generation, processing and waste disposal. This study was undertaken in the municipality of Tehran. A total of 6,060 samples were compared by statistically comparing source generation, destination and intermediate stations. The results from these analyses showed that the average per capita waste generation in Tehran was 589 g day^{-1}. It was also observed that, of the total amount of waste generated in the municipality of Tehran, 73% was domestic waste and 27% was non-domestic waste. In addition, 68% of total household waste was organic waste, while 41% of non-domestic waste was organic waste. Furthermore, 61% of waste in Tehran was generated at the source, while 72% of the waste coming into the Aradkoh disposal and processing center was organic waste. The physical analysis was showed that there was no significant difference between the wastes generated in 2004 and those generated in 2009 and that there was not equal percentage of wet waste coming into the disposal center with urban service stations. This indicates that active source separation programs in metropolitan Tehran.

Key words: Municipal solid waste, waste management planning, physical analysis, waste generation

INTRODUCTION

Waste generation in developing countries necessitates the gradual improvement of waste management methods (Davoudi, 2000). Increasing consumption has caused the amount of waste to rise and escalate the costs of waste collection (Gandy, 1994). Some of the problems in waste collection management include limited financial resources for the infrastructure of waste management planning and organizations that deter effective behavior (Agamuthu, 2003). To be successful, initiatives to improve waste management services require the participation of all involved parties. All actions taken must be as credible, transparent, socially sustainable, convenient and practical to participants as possible (Zotos *et al*., 2009).

Furthermore, it is not easy to obtain the quantity of waste produced by diverse activities and resident groups by field surveys since tracking and measuring waste generation through each kind of resident group in different times is impossible. A variety of studies on waste estimation has focused on waste generation throughout the past year e.g., (Lohani and Hartono, 1985; Li *et al*., 2011; Monahan, 1990; Araujo *et al*., 2012). These studies are aimed at helping to discover the waste quantity.

Determining the amount and composition of solid waste generated in a city is one of the main issues in solid waste management.

The design, implementation and operation of the reasonable solid waste management as well as collection, transport and disposal systems require precise information on the quantities and characteristics of the solid waste. A lot of methods have been developed to determine the generated waste (Forouhar and Hristovski, 2012; Otoniel *et al*., 2008; Dangi *et al*. 2011; Thanh *et al*., 2010;Matsuto and Ham, 1990; Daskalopoulos *et al*., 1998).

In recent years the request of reliable data on waste has been increased in cities of Vietnam for basic research, planning and management. Some of the waste generation studies have concentrated on strategy and planning perspective of waste management (Mor *et al*., 2006; Chowdhury, 2009; Mazzanti and Zoboli, 2008; Even *et al*., 1981; Gregg, 2010; Sujauddin *et al*., 2008; Mbuligwe, 2002; Singh *et al*., 2011).

This study was carried out in the municipality of Tehran, which is the largest city in Iran, covering an area of over 700 km^{-2}. The city is currently divided into 22 local municipalities for the ease of administration. Each of these regions has been divided into several areas based on the population density, urban fabric, vastness and some other parameters. Region 9 has the least areas with

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two areas in the urban section while regions 1 and 4 with nine regions each, have the highest number of areas. In Tehran every municipal area produces an average of 7,000 metric tons of waste in per day. Regardless of the nature of the waste, whether it is domestic or non-domestic, it contributes to the waste management issue, according to the amount generated.

A total of 6,060 waste samples from residential areas were collected quarterly between 1984 and 1985 and were analyzed. A total of 303 blocks and 5 households were studied for each sample with random visits every four months by members of the Central Committee of Organic Fertilizers of the Interior .In Recycling Organization of Tehran, Herbal Fertilizer Administration, a plan was formulated for the physical analysis of waste for one year by the Recycling and Conversion Organization of Tehran. This was done separately for each region. This plan involved consultation with experts from the Statistical Center of Iran. Sample households from all regions were selected. Wastes from every region were mixed after weighing; physical analyses were conducted to determine their density. In 1999 and 2000, other physical analyses were carried out at the destination (landfill).The samples were collected each working day from different parts of the semi-trailer carrier (i.e., from the front, the middle and the back) and were analyzed by the Recycling and Conversion Organization of Tehran.

The design and implementation of this study which provides basic information on waste management in Tehran is very important on various aspects. It follows a number of different purposes. The main objectives of this study include identifying the quantity and composition of solid wastes in Tehran at the source of their generation as well as identifying input urban service stations, factors influencing on quantity, composition of the waste and also the mode of influence of each of these factors.

MATERIALS AND METHODS

The wastes generated in Tehran are collected and first transported to an urban service station. They are later transported by larger vehicles to the Aradkoh processing and disposal center. The waste generated varies in quantity and characteristics in different regions.

Special attention was focused on the contribution of domestic or non-domestic wastes from each generation source in Tehran during the physical analyses. Information about domestic and non-domestic waste was obtained by physical analysis of the total waste generated in Tehran. Wastes from every region were mixed and measured after weighing and physical analyses were conducted to determine the waste density. The samples were prepared at the stations in each sampled region (at the source generators) and then coded. They were then analyzed at the Aradkoh processing and disposal center.

Sampling size: Samples were obtained each working day of the month from the trash trailers that were carrying the waste. Samples (up to a 60 L barrel in volume) from the front, the middle and the back of the trash trailers were taken and physical analyses were performed on the samples. This was done continuously over a period of 14 months; samples from all regions were used.

Finally, statistical analyses were performed on samples from each stage, according to recommendations from the American Standard Test Method (ASTM, 2006) and the World Health Organization (WHO). Other statistical approaches that are already in use may be adopted in similar cases. For domestic waste generators, with respect to different social levels in regions and areas in Tehran, two-stage stratified sampling method with regards to the population density in each region and the area are separately carried out. In this sampling, the main class is the region while the secondary class is the area in each region. The non-domestic waste generators are also grouped according to the waste generators groups and homogeneous subgroups as well as the sampling method used while a stratified two-stage sampling method is selected. The main floor consists of eight major groups of Tehran's activities and each of the groups depends on the nature of the relevant activities between six to twenty-eight sub-groups that are variable. This group has been selected based on the fact that the information in the Tehran database properties will be appropriate for the necessary findings from the database. The sample size was calculated from the following formula (1):

$$n = \left(\frac{Z \times S}{d}\right)^2 = \left(\frac{Z \times 0.5}{d}\right)^2 \quad (1)$$

Based on the high degree of accuracy (error of 2%), the total sample size required can be determined using the Cochran formula (2) as shown below:

$$n = \left(\frac{Z^2 \times S^2}{d^2}\right)^2 = \left(\frac{1.96^2 \times 0.5^2}{d^2}\right)^2 \quad (2)$$

The total sample size was calculated to be 2,401 units. The desired accuracy for determining the total sample size required was 98%. In order to divide this number of samples between domestic and non-domestic units, the accuracy of the domestic waste unit was considered to be 97% and the remainder was allocated to the non-domestic unit. The number of samples in the domestic sector was calculated as follows (3):

$$n = \left(\frac{Z^2 \times S^2}{d^2}\right)^2 = \left(\frac{1.96^2 \times 0.5^2}{0.03^2}\right) = 1068 \quad (3)$$

The sample size required in each region is calculated based on the proportion of number of households in the region described. Due to lack of sufficient information regarding the number of families living in each urban area and taking into consideration the relationship between the amount of waste in an area with the population and people living in that area, number of samples in each region is calculated according to the weight of the solid waste of the area to the total waste of Tehran in the month before sampling.

The total number of samples in the domestic sector 1084 was calculated. The number of samples calculated was slightly more because of the rounding up of figures when determining the sample size. Using a two-stage stratified sampling method; the city of Tehran was divided into eight groups. The regions of sampling for each of these activities was determined, randomly and with variable probabilities that were proportional to the population of each region were selected.

Metropolitan sampling area

Sampling in the urban services stations: Samples were collected from waste collection vehicles in each region using the Dot-matrix method (ASTM, 2006). Sampling was conducted at night in each of the 123 areas from generation sources and from incoming urban service stations in Tehran. A sample volume of 60 liters was prepared from each vehicle; a sample was selected at random and without replacing and then taken for analysis. Adequate homogenous sampling of waste in Tehran was achieved over a period of 10 nights.

Sampling in the central processing and disposal centre: Wastes collected from service stations in urban areas are discharged into semi-trailers and transported for processing center at the Aradkoh processing and disposal center. Statistical comparisons of the quantity and characteristics of waste between the source of generation, the destination and the intermediate stations were also made after considering the samples. Given the large amount of waste transported by the vehicles (about 60 cubic meters), three samples from the vehicles (the front, the middle and the back) were collected and analyzed. To this end, each night, a sample was obtained from one semi-trailer from each of the service stations in Tehran. The samples were taken and sent for analysis after the contents had been thoroughly mixed. A total of 330 samples, which were obtained from 11 service stations within the city of Tehran over a period of 10 nights at a rate of 33 samples per night, were taken for analysis.

Statistical analysis: The samples were collected from the waste production sources by performing statistical inferences. The relevant results obtained from the statistical comparisons among the origin, middle stations and destination was based on the same. The K-S (alias Kolmogrov-Smirnov) one-sample test down that compared the cumulative distribution function for all variable with a uniform, normal, Poisson, or exponential distribution and the test shows the distributions are homogeneous. The t-test and Kruskal-Wallis statistically test used to statistical analysis.

RESULTS

In Tehran, an average of seven thousand tons of waste is generated per day. Each of municipal waste producers; both domestic and non-domestic regarding to the amount and type of waste produced is responsible for a share of Waste Management. Urban management requires adequate knowledge about its quantity and quality for efficient and optimal management of these wastes.

A Kruskal-Wallis test revealed no statistically relationship across 21 type of waste (non-domestic waste = 20, domestic waste = 20), χ^2 (19, n = 40) = 19, p = 0.457. Wet waste recorded a higher median score (Md = 41) in non-domestic waste and (Md = 69) in domestic waste than other waste. Table 1 indicates that the total domestic waste in Tehran (during the sampling period) was composed of about 9.6% paper and cardboard, some of which can now be recycled and about 4.4% dry bread. In addition, Polyethylene terephthalate (PET) and non-ferrous substances constituted about 1.2% and 0.4%, respectively, of the waste in Tehran.

The ratio of non-domestic wet waste was calculated to be about 43%; in fact, this ratio was about 27% greater than the amount of domestic wet waste (by weight). The difference shows that whenever the number of non-residential units or the amount of municipal waste generated by non-residential units is high, there will be a higher ratio of wet waste in that region.

According to 2009 statistics from the city of Tehran, a total of 2,511,693 metric tons of solid waste were collected and sent to the Aradkoh processing and disposal center. About 370,742 metric tons of the waste was composed of sludge, soil and branches, while the remainder was what is known as urban waste. According to Fig. 1 an average of 6,881 tons of waste per day were collected by municipal service stations at which about 1,015 metric tons of waste was composed of soil and branches; 5,866 metric tons of municipal waste out of a total of 6,479 metric tons of total municipal waste in 2009 were generated and managed in Tehran.

Table 1: Physical analysis of non-domestic and domestic wastes in Tehran, 2009

Type of waste	Non-domestic waste components (%)	Domestic waste components (%)
Dry bread	8.8	4.4
Plastic	3.3	2.6
Polyethylene terephthalate (PET)	1.9	1.2
Low-density polyethylene (LDPE)	5.3	3.2
Talc	1.1	0.6
Foam	0.8	0.2
Paper	12.1	5.5
Cardboard	12.7	4.1
Iron	1.5	1.1
Non-ferrous metals	1	0.4
Textile	1.3	1.2
Glass	2.7	1.9
Wood	1.6	0.4
Rubber	0.8	0.3
Leather	0.2	0.1
Soil	1.2	0.5
Tetra-packs	0.4	0.3
Special	1.2	2.5
Wet waste	41.2	69.3
Other	0.9	0.2

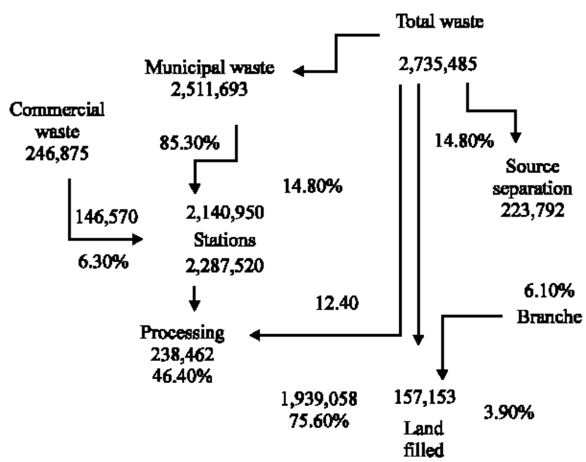

Fig. 1: Metric tons of waste generated

In 2009, Tehran waste generated by household waste represented by 2,511,693 Mt (85.30%) of municipal solid waste, of which only 238,462 Mt (12.40%) was recycled or composted despite over two-thirds of the contents of the average dustbin being recyclable or compostable. Based on the population and the housing census of 1985, the population of Tehran was estimated to be 7,797,520. However, before the 1997 census, the figure was about 6,758,845.

A Kruskal-Wallis test revealed no relationship in across three different group of Tehran domestic , non-domestic and source separation waste in 2009 (weight of domestic waste = 20, weight of non-domestic waste = 20, weight of source separation, n = 20), $\chi^2(19, n = 60) = 19$, $p = 0.457$. Table 2 shows a total of 223,792 metric tons of waste which were separated at the source in 2009. The region 4 recorded a higher median score (Md = 2.3E+08) for source separation than the region 9 which recorded median values of 4.5E+07.

According to Table 2, most non-domestic waste is generated in region 12 and 6. The region 12 recorded a higher median score (Md = 7E+07) for Non-domestic waste than region 9 which recorded median value of 1E+07. The research findings are also consistent with the realities of the environmental and the urban areas because these two regions, especially region 12 constitutes one of the largest non-residential units with a vast commercial centre and a big office complex.

The lowest amount of non-domestic waste generation is in region 22 and 14 which has been shown in Table 2.The least amount of wet waste was collected at region 12. This is because the region is the central. In addition, there is the presence of market and other commercial centers as well as ministries. This may be responsible for the presence of a lot of dry waste in this region. The region 4 recorded a higher median score (Md = 1.9E+08) for domestic waste than the region 9, which recorded median values of 3.5E+07. The highest

Table 2: Calculation of Tehran domestic and non-domestic waste in 2009

Region	Weight of the domestic waste(kg)	Source separation and incoming Aradkoh (kg)	Weight of non-domestic waste(kg)
1	108,903,773	138,434,851	29,531,079
2	147,486,291	191,283,200	43,796,909
3	72,758,271	122,652,576	49,894,305
4	187,346,616	232,899,247	45,552,631
5	158,492,482	184,720,724	26,228,241
6	54,589,545	107,514,551	52,925,005
7	74,301,640	101,199,733	26,898,094
8	86,908,065	100,164,345	13,256,280
9	34,869,212	44,972,194	10,102,983
10	73,978,234	86,661,542	12,683,308
11	60,724,601	88,035,516	27,310,916
12	53,307,771	123,571,087	70,263,316
13	48,903,921	62,747,046	13,843,125
14	94,454,881	107,732,670	13,277,789
15	125,321,554	170,537,119	45,215,565
16	56,473,613	85,423,329	28,949,716
17	45,474,492	66,615,287	21,140,796
18	70,067,571	95,093,627	25,026,056
19	59,262,152	73,481,454	14,219,302
20	61,138,391	108,816,176	47,677,786
21	29,556,364	41,573,833	12,017,469
22	26,900,484	30,612,306	3,711,822
Total	1,730,927,864	2,364,742,415	633,814,551
Average daily	4,742,268	6,478,746	1,736,478

Table 3: Average weight of the waste generated by households and per capita waste generation (g day $^{-1}$) in Tehran

Region	Total average waste weight of household	Household sample volume (person)	Average domestic per capita
1	2316	3.2	722
2	2077	3.3	627
3	2188	3.3	670
4	2173	3.6	600
5	2176	3.7	583
6	1985	3.2	621
7	2241	3.4	652
8	1938	3.2	614
9	2212	3.8	581
10	2500	4	628
11	2089	3.6	581
12	1909	3.4	558
13	2338	4.3	545
14	1855	3.6	514
15	2310	4.4	531
16	2237	4.2	534
17	2125	4.3	498
18	2011	3.4	597
19	2845	4.4	644
20	2090	4.1	505
21	1867	3.6	524
22	2045	3.4	594
Total	2161	3.7	589

wet waste is from region 14. The highest relative share of domestic waste is generated in these regions because of the fabric of the region i.e. the highest number of residential units; it is thus expected to have a high proportion of domestic waste more than other regions.

The average household wastes in Tehran are 2161 g day^{-1} and the per capita average waste is calculated 589 g day^{-1}. Table 3 the highest per capita waste production is obtained from region 1 and 3 while the lowest is obtained from region 17 and 20. The results of these analyses show that the average per capita waste generated in Tehran (during the sample period) was 589 g per day. It was also observed that, of the total amount of waste generated in Tehran, 73% was domestic waste, while 27% was non-domestic waste. In addition, 68% of total household wastes were organic wastes, while 41% of non-domestic wastes were organic wastes.

A Kruskal-Wallis test revealed no statistically significant different across three different groups waste generated, separated and incoming waste to the Aradkoh disposal and processing centre (kg) in 2009 (sludge, soil and branch = 22, municipal, n = 22, source separation = 22), $\chi^2(21, n = 66) = 21$, $p = 0.459$. The region 20 recorded a higher median score (Md = 6.3E+07) for sludge, soil and

Table 4: Waste generated, separated and incoming waste to the Aradkoh disposal and processing centre (kg) in 2009

Region	Sludge, soil and branch	Municipal waste transported to Aradkoh	Source separation
1	19,710	130,833,626	7,601,225
2	53,709,680	168,800,344	22,482,856
3	543,810	112,108,095	10,544,481
4	18,270	211,896,106	21,003,141
5	6,354,020	166,981,792	17,738,932
6	13,761,610	93,851,094	13,663,457
7	3,357,680	91,937,975	9,261,758
8	1,672,440	86,229,070	13,935,275
9	21,381,140	41,340,516	3,631,678
10	22,360,790	80,595,123	6,066,419
11	22,238,060	75,197,922	12,837,594
12	21,111,880	109,368,559	14,202,528
13	3,043,050	53,281,528	9,465,518
14	4,643,260	97,796,183	9,936,487
15	10,937,010	154,314,004	16,223,115
16	13,282,100	79,468,186	5,955,143
17	52,810,890	61,009,901	5,605,386
18	52,470	92,353,327	2,740,300
19	29,451,800	67,134,778	6,346,676
20	62,735,360	100,600,463	8,215,713
21	27,189,070	38,290,892	3,282,941
22	68,770	27,560,768	3,051,538
Total	370,742,870	2,140,950,254	223,792,161
Average daily	1,015,734	5,865,617	613,129

branch than region 4 which recorded median values of 18270. Table 4 shows the source separation programs that separate recyclable materials, such as dry bread, paper and cardboard and glass. Some recyclable materials, such as plaster, talc, foam, ferrous metal, non-ferrous metal, rubber and leather, were collected from commercial sources. The region 2 recorded a higher median score (Md = 2.2E+07) for source separation than the region 18 which recorded median values of 2740300.

The region 4 recorded a higher median score the region 22 which recorded median value of 2.8E+07.

A Kruska-Wallis test revealed no statistically significant difference in across the average of percentage of household waste components, in each of 22 region of Tehran in the autumn 2009, $\chi^2(21, n = 440) = 21$, $p = 0.459$. Table 5 indicates that the total domestic waste in Tehran is made up of about 9.7% of paper and cardboard and about 4.4% of dry bread. However, some of these wastes can now be recycled. The region 3 recorded a higher median score (Md = 1.9) for PET than the region 20 which recorded median values of 0.6. In addition, Polyethylene Terephthalate (PET) and non-ferrous constitute about 1.2 and 0.4%, respectively of the household waste in Tehran. The region 22 recorded a higher score (Md = 71.60) for organic waste than other regions. Organic materials include a large percentage (72.2%) of the total waste incoming of the landfill.

The region 6 recorded a higher median (Md = 11.3) for paper than the region 16 which recorded median values of 3. Region 1 recorded a higher score (Md = 7.8) for cardboard than the other regions. Percentages of combustible components that are usable for Refuse-Derived Fuel (RDF) e.g. paper/cardboard and plastic in municipal solid waste were 1.2 and 1.4%. The highest per capita waste production is obtained from region 1 and 3 while the lowest is from region 17 and 20.

Kruskal-Wallis test recorded no statistically relationship across 22 regions for incoming waste to the urban service stations in each region of Tehran in 2009 (urban service stations = 22), χ^2 (21, n = 418) = 21, p = 0.459. According to Table 6, the data collected from the regions showed that more than 67% of the waste collected is wet waste while the remaining 33% is dry waste. Wet waste recorded a higher median score (Md = 47.9) in region 14 than other regions. Ferrous metal recorded higher median score (Md = 5.2) in region 19 than other regions. The least amount of wet waste was collected at region 12. This is so because the region is the central and in addition, there is the presence of market and other commercial centers and ministries. This may be responsible for the presence of a lot of dry waste in this region. Paper recorded a higher median score (Md = 2.6) in region 9 than other regions.

Approximately 81% of waste by mechanized vehicles and 19% by traditional vehicles (pickup track) are transported to landfill in two shifts, day and night. Seventy-two percent (72%) waste is transported during 21 pm to 6 am and 28% is during 6 am to 21 pm. The highest amount of waste was transported from Azadegan station which is the most hours of waste transported is between 24 pm to 1 am. The actual collection time within the city is 1.0 h and 3-4 times discharge in the urban service station .The dumping site is about 150 km far from Tehran city and the actual travel time to and from the

Table 5: Average of percentage of household waste components, in each of 22 region of Tehran in the autumn 2009 (%)

Region	Dry bread	Plastic	PET	Plaster	Talc	Foam	Paper	Cardboard	Ferrous-metal	Non ferrous-metal	Textile	Glass	Wood	Rubber	Leather	Soil	Tetra pack	Special	Organic waste	Others
1	3.70	3.70	1.60	2.30	0.60	0.20	7.50	7.80	1.40	1.20	0.40	2.50	0.10	0.00	0.30	0.00	0.10	1.10	65.10	0.60
2	3.50	3.00	1.30	4.50	0.50	0.10	8.30	3.20	2.00	0.60	0.80	2.50	0.40	0.10	0.20	0.30	0.30	2.70	65.40	0.40
3	2.40	3.00	1.90	4.10	0.30	0.20	7.10	4.40	1.10	0.30	0.80	1.40	0.90	0.40	0.00	0.00	0.30	2.30	69.30	0.00
4	4.80	2.50	0.80	3.70	0.70	0.40	3.90	5.50	1.50	0.40	1.10	1.80	0.60	0.60	0.10	0.70	0.30	1.80	68.90	0.00
5	4.20	2.70	1.30	2.90	0.70	0.10	7.00	4.30	0.80	0.90	0.70	2.00	0.60	0.10	0.10	0.40	0.20	2.90	68.10	0.10
6	3.30	2.70	0.80	2.60	0.10	0.10	11.3	4.50	1.30	1.00	1.20	3.40	0.00	0.30	0.10	0.00	0.30	4.50	62.00	0.30
7	5.40	2.90	1.20	2.90	0.30	0.20	5.60	2.80	2.80	0.80	1.00	3.60	0.20	0.00	0.30	0.60	1.10	2.80	65.50	0.00
8	5.30	3.10	1.50	3.00	0.70	0.30	5.90	3.50	1.60	0.10	2.90	1.60	0.00	0.30	0.00	0.10	0.30	2.00	67.60	0.10
9	4.60	3.70	1.20	3.90	0.60	0.30	5.30	3.60	2.90	0.30	2.00	2.20	1.90	0.40	0.10	1.30	0.30	2.90	62.60	0.10
10	4.40	1.90	0.90	1.90	0.80	0.90	3.90	3.50	3.10	1.40	2.60	1.20	3.00	1.70	1.20	2.20	1.20	4.80	58.90	0.50
11	6.10	2.60	1.50	2.40	0.40	0.50	5.40	2.60	4.00	0.00	1.20	1.90	0.00	0.10	0.00	0.10	0.50	0.00	70.70	0.00
12	3.00	4.20	1.60	2.80	0.30	0.20	5.60	4.70	1.70	0.20	1.50	1.20	0.00	0.00	0.10	0.20	0.20	3.60	67.40	1.40
13	5.30	2.20	1.00	4.40	0.80	0.40	5.10	4.20	2.50	0.50	1.10	1.90	0.20	0.20	0.10	1.10	0.30	3.80	64.70	0.10
14	3.80	2.20	0.80	2.40	0.30	0.10	3.60	6.70	1.90	0.20	1.30	0.50	0.40	0.00	0.10	0.00	0.20	1.00	74.50	0.00
15	5.70	2.40	1.00	3.60	0.80	0.10	4.50	3.70	2.80	0.00	1.50	2.00	0.10	0.10	0.10	0.00	0.10	3.10	68.00	0.30
16	5.80	1.40	1.00	4.10	0.60	0.20	3.00	4.60	1.80	0.00	0.60	0.90	0.10	0.00	0.00	0.70	0.10	4.00	71.00	0.00
17	5.30	3.00	0.90	3.30	0.50	0.20	4.50	2.90	2.00	0.10	0.70	1.30	0.30	0.00	0.20	0.20	0.10	0.80	73.40	0.40
18	3.00	2.60	1.20	2.20	1.40	0.10	5.50	0.80	2.40	0.10	0.80	2.10	0.10	0.90	0.00	1.50	0.10	2.40	72.70	0.00
19	5.10	2.70	1.70	3.60	0.20	0.20	3.60	4.30	2.20	0.20	1.80	1.20	0.30	0.00	0.00	0.40	0.10	3.50	68.80	0.20
20	3.00	1.20	0.60	2.50	0.40	0.20	3.00	2.60	1.60	0.20	1.20	2.30	0.10	0.60	0.00	0.70	0.50	2.20	77.00	0.00
21	5.40	2.50	1.70	3.50	0.90	0.40	5.50	4.10	3.20	0.50	1.30	1.40	0.20	0.00	0.50	0.10	0.50	1.30	66.60	0.30
22	4.20	2.40	0.90	3.10	0.60	0.20	4.80	4.00	2.70	0.20	1.70	2.10	0.00	0.00	0.10	0.00	0.20	1.40	71.60	0.00

Table 6: Physical analysis of the incoming waste to the urban service stations in each region of Tehran in 2009 (%)

Region	Dry bread	Plastic	PE	Plaster	Talc	Foam	Paper	Cardboard	Ferrous metal	Non Ferrous metal	Textile	Glass	Wood	Rubber	Leather	Soil	Tetra pack	Special	Organic waste
1	1.2	3	0.6	4.7	4.9	3.2	0.9	0.2	2.2	1.9	0.1	0	0.3	0.2	0.3	6.6	0.4	1.3	68
2	0.8	1.7	0.4	7.2	3.9	5.4	1.4	0.1	1.8	2.1	0.2	0	0.3	1.2	0.3	4.1	0.4	1.2	67.4
3	1.4	2.5	0.9	6.2	4.3	3.7	0.9	0.1	1.4	2.2	0.1	0	0	0.8	0.6	4.7	1.1	0.9	68.2
4	0.8	1.9	0.4	5.4	3.7	3.3	1.3	0.1	1.7	1.7	0.1	0.3	0.2	0.9	0.4	4.7	0.5	1	71.7
5	1.6	2.1	0.5	6.3	3.4	4.7	0.8	0.1	1.6	1.9	0.1	0	0.2	2.2	0.4	2.2	0.4	1.1	70.4
6	0.7	2.8	0.6	5.7	8.2	7.3	1.4	0.2	1.5	1.5	0.1	0.1	0.3	0.3	0.5	5.7	0.8	0.9	60.7
7	1.8	2	0.7	6.7	6	3.4	1.1	2.6	2	2	0.5	0.1	0.1	0	0.4	4.8	0.4	0.9	64.5
8	2.2	2.8	1	5.4	3.8	3.5	1.8	0	1.2	2.4	0	0	0.2	0.5	0.6	6.4	0.4	0.9	66.8
9	0.1	2.4	0	6.8	3.6	6.9	5.6	0	5.1	0.1	0	0	0.2	0	2.4	0.6	0	1.4	59.8
10	0.5	2.6	1.1	7.9	4.5	4.9	0.8	0.1	2.4	1.4	0.2	0.5	0.5	1.8	0.2	4.3	0.3	0.9	65
11	1	1.6	0.4	6	4.7	3.7	1.2	0.2	2.8	2.6	0	0.1	1.8	0.4	0.2	2.9	0.1	1.3	66.5
12	0.7	2.8	1.4	7.5	6.6	9.5	1.3	1.2	4.8	1.3	0	0	2.3	0.4	0	1	0.8	0.8	57.5
13	0.1	1.5	0.6	4.9	1.5	6.3	0.8	0.1	2.5	1.4	0.1	0.4	1.8	0.2	0.2	4	0.5	2.5	70.6
14	0.2	1.4	0.6	4.3	2.7	4.4	0.8	0.1	3	2	0.3	0.2	0.4	0.8	0.2	2.6	0.2	1.1	74.9
15	0.3	1.8	0.4	5.7	4.7	5.9	1.9	0.1	2.7	1.8	0.6	0	0.4	1.6	0.2	2.9	0.3	1	67.8
16	1.3	1.8	0.2	8.8	3.2	4.9	1.1	0	4.9	1.7	0.5	0.1	0.5	0.4	0.2	2	0.4	0.8	67.3
17	0.1	1.6	0.1	7.3	1.6	1.7	0.5	0	3.7	3.1	0	0	1.4	0.7	0.1	4.2	0	1.4	72.4
18	0.6	2	0.7	6.3	4.4	4.2	1.5	0.1	2.8	1.4	0.5	0.8	0.7	0.9	0.1	4.2	0.2	1.3	67.3
19	2.2	1.6	0.5	6.1	3.6	4.9	1.1	0.1	5.2	1.4	0.6	0	0.1	0.3	0.3	3.8	0.5	1	66.6
20	0.2	1.8	1.5	8.1	3.7	5.1	1.6	0	2.7	1.9	0.1	0.1	0.5	0	0.9	5	0.5	1	65.3
21	1	2.8	0.3	7.4	4.6	3.2	1.5	0	1.8	1.9	0.4	0.7	0.7	0.7	0.4	3.3	0.3	1.7	67.3
22	0.6	1.8	0.4	7.3	4.5	4.7	1	0	1.4	1.3	0	0.1	0	0.5	0.1	4	0.2	0.8	71.3
Total	0.9	2.1	0.6	6.5	4.2	4.8	1.4	0.2	2.7	1.8	0.2	0.2	0.6	0.7	0.4	3.8	0.4	1.1	67.2

Table 7: Physical analysis of the incoming waste to the landfill from each station in 2009 (%)

Region	Dry bread	Plastic	PET	Plaster	Talc	Foam	Paper	Cardboard	Ferrous metal	Non Ferrous metal	Textile	Glass	Wood	Rubber	Leather	Soil	Tetra pack	Special	Wet waste
Darabad	0.6	1.6	1.1	3.1	3.7	6.2	2	0.1	2.2	1.6	0.5	0	0.4	0.1	0.3	3.8	0.4	1.3	71.1
Zanjan	1.3	1.5	0.5	4.4	4.5	6.6	1	0.2	1.3	1.9	0.3	0	0.4	0.3	0.2	2.9	1.7	1.6	69.6
Banihashem	0.8	1.5	0.8	3.1	3.8	6.7	0.7	0.1	3	1.8	0.3	0.1	0.4	1.6	0.3	3.1	0.5	1.5	69.8
Chitgar	0.5	1.4	0.6	3.6	3.6	5.3	1	0.1	2.3	1.9	0.2	0	0.5	0.4	0.3	2.7	0.6	1	74.1
Bayhaqi	1.7	2.3	0.4	2.8	3.6	7	0.9	0.1	3.4	2.3	0.9	0	0.6	0.1	0.3	4.4	0.7	0.9	67.6
Hakimieh	2.1	1.2	1	2.8	3.4	4.6	1.1	0.1	1.9	1.4	0.3	0	0.5	0.4	0.1	2.6	0.5	1	74.9
Shosh	0.6	1.5	0.7	3.3	5	5	0.8	0.1	2.9	1.1	0.2	0	1	0.1	0.7	2.6	0.9	1.4	71.9
Azadegan	1.1	1	0.5	2.7	2.2	5.4	1.2	0.1	3.5	2.5	0.3	0	0.7	0.4	0	5.1	0.5	0.8	72.1
Jade save	0.8	1.4	0.3	3.2	2.6	4	1.6	0.1	3.9	1.3	0.3	0	0.6	0.8	0.2	3.2	0.5	1.4	73.9
Jahad	0.2	1.1	0.5	2.7	2.8	3.3	1.1	0.2	4.9	1.1	0.5	0	1	0.9	0.2	3.9	0.4	1.1	74.1
Shahre Rey	1.7	1.2	0.5	3.1	3	2.8	0.9	0.1	4.9	0.9	0	0	0.5	0.9	0.1	3.4	0.5	0.7	74.7
Total	1	1.4	0.6	3.2	3.5	5.2	1.1	0.1	3.1	1.6	0.3	0	0.6	0.5	0.3	3.4	0.7	1.1	72.2

disposal site is 3 times/day Howo dump truck and 5-6 times Volvo Fh truck.

A Kruskal-Wallis test for the incoming waste to the landfill from each station in 2009 revealed no statistically relationship across each station (landfill, n = 11), χ^2 (10, n = 209)=10, p=.440. As it is shown in Table 7, there is not much difference between incoming wet wastes in the urban service station. Wet waste recorded a higher median score (Md = 74) in Hakimieh station than other stations. The lowest amount of wet waste was collected at Zanjan station and the highest wet waste was collected from Hakimieh station. Ferrous metal recorded a higher median score (Md = 4.9) in both Jahad and Shahre Rey station.

The t-test results were rejected on the assumption of an equal percentage of wet waste at the Aradkoh processing and disposal center to the incoming wet waste in urban stations. There was no significant difference between the physical analyses performed on the waste generated in 2004 when compared with those generated in 2009. Furthermore, 68.3% of waste in Tehran was generated at the source while 72% of the incoming waste to the Aradkoh disposal and processing center was organic waste. This observation indicates that incoming waste that arrived at the urban service stations differed by about 4% from the wet waste coming into the Aradkoh processing and disposal center. At some service stations, the vehicles discharged waste onto the station platform after it had been separated by workers. Therefore, there may be some differences or variations in the total amount of waste between the urban service stations and the Aradkoh processing and disposal center. Waste was conveyed from the urban service stations using larger vehicles, known as trash trailers, to the Aradkoh processing and disposal center.

DISCUSSION

By comparing the statistical data on the sources of waste generation, it was possible to identify and analyze the waste management system. According to the literatures the obtained results have been showed that the composition and the moisture content of the solid waste sources have been analyzed. Furthermore, previous studies analyzed solid waste from sources such as markets, residential areas, restaurants and offices produce.

According to the specification of the street waste for organic wastes, the lowest rank is from 57% (Delhi) (Mor *et al*., 2006) to 70% (Afganestan) (Forouhar and Hristovski, 2012). Comparing the generation rate of municipal solid waste between Iran and other selected countries, it has been shown that Iran has got the fourth rank according to United States Environmental Protection Agency in terms of the total amount of organic waste.

Solid waste is composed of different materials such as paper and cardboard, plastic, glass, metal and textile. The composition of these wastes are in this ascending order: Iran waste paper 1.6%; plastic 2.1%; glass 0.2%; metal 4.5% and textile 0.2% while Nepal with waste paper 10.2% (Dangi *et al*. 2011), China 6.9% (Zhang *et al*., 2010), Afganestan 5.5% (Forouhar and Hristovski, 2012), Delhi 3.7% (Mor *et al*., 2006; Talyan *et al*., 2008), Europ (average) 32% (Viswanathan, 2006) and United States 37% (US EPA, 1999) which has got the maximum rank.

Tchobanoglous *et al*. (1993) ranked the distribution of components in residential municipal solid waste into low- income (per capita less than US$750), middle- income (percapita US$750-5000) and upper-income (percapita more than US$5000) countries.

Iran is ranked between low and middle-income group. The percent of other solid wastes such as plastic,glass metal and textile is similar to waste paper. Based on the study of Hui *et al*. (2006), China's percapita waste production rate is 0.8-1.0 kg capita/day; whereas production rate in a typical developed country is 1.43-2.08 kg capita/day (Troschinetz and Mihelcic, 2009). Daily waste generation rate was estimated between 0.31 and 0.43 kg/capita/day in the city of Kabul and it is well correlated with the low range estimates for low income countries (Hoornweg, 2000).

In 2005, the average household waste generation in Kathmandu, Metropolitan City in Nepal has been the actual average of 0.5 kg capita/day in the field study (Dangi *et al*., 2011). Sharholy *et al*. (2008) calculated that generation of solid waste in Kharagpur municipality is 0.40 kg capita/day which is much less compared to other cities in India or other countries.

In 2009 there was an average of 0.589 kg per capita waste generated per day in Iran which it has been reduced comparing with developed countries. Recyclable components such as plastic, paper, metal and textiles are smaller fraction in developing countries compared to advanced cities/countries which may be correlated with the more usage of plastic and paper in electronic media in those cities/countries.

Based on the findings, adequate planning can be effected to optimize each stage of waste management using methods such as recycling, if necessary. Also, information from waste analysis can identify weak process points and help decrease the costs of waste collection.

In addition to the above mentioned main objectives, some of other important conclusions are also available due to the amount and type of data. These results can be very valuable and important in the development or modification of waste management techniques. Some of these results are as follows:

- To calculate the per capita solid waste in various urban regions
- To determine the amount of municipal waste generated in residential and non -residential sources
- To provide of a part of baseline data to create Waste Management information layers for GIS in Tehran
- To access to the latest information on the physical and chemical composition of solid waste in Aradkoh disposal and processing center.(destination)
- To access to the differences in quantity and composition of waste at the source of generation and at the disposal and processing centers
- To provide much of the basic data for various utilization in waste management

CONCLUSION

The study of the statistical analysis of the samples showed a good result of household waste production in Tehran. The results showed the average households waste generation and the per capita waste separately in each region in Tehran. In calculating the averages, there is the need to consider the fact that the sample size in a sector is different from those in other sectors; therefore, the average weight is used.

Generation and characterization of household waste help to identify potential reuse and recycling; to investigate waste type for managing storage, collection and transport and identify the best approach for minimization.

In Tehran, some of middle stations were designed with the MRF (Material Recycling Facility) and recycling valuable materials from waste is done whereby the quality and quantity of the waste were sent to the disposal and processing centre, for example Aradkoh has proved the station to be effective. Tehran authority should have complete controls over which materials are to be processed and the degree of waste sorting capability. The contracting authority is at risk if the merchant of MRF is not capable of producing quality products and has little negotiating power over the gate fee charged by the MRF. Both the quality and quantity waste will impact the MRF operation and obviously in determining urban service station operating costs (periodic audits of incoming recyclables help to characterize the nature and the extent of the contaminants in the mix). With comparison of the statistical data on the sources of waste generation, the waste management system can be identified and analyzed and if necessary, is an adequate planning to optimize each stage of waste management by recycling on the findings and this can be very effective. The information data of waste analysis can identify the weakness points of the process hence decrease the costs of waste collection and can be used as a control tool to improve the management system. Dry recyclables material such as foam, talc, plastic bag, ferrous metals and soil are more than other dry recyclable while the wet waste was sent to the landfill from all urban middle stations. There was no significant difference between incoming wastes from the urban service stations to the landfill. Based on the developing source separation program, it has decreased quite a number of papers and cardboard of waste in the land fill. Results showed that waste in Tehran has good potential for the production of compost.

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