



Sustainable Municipal Solid Wastes Management in Babylon Province, Iraq

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ABSTRACT

Municipal solid waste (MSW) management worldwide represents environmental and economic challenges being a source of recycling and recovering of various materials that conserve and rescue different environmental resources and at the same time most of these wastes can be utilized as energy source. This study was designed to assess the process of collecting and disposing of municipal solid wastes generated in various city and countryside districts within Babylon province-Iraq. A total of 20 residential districts were selected, consisting of 15 and 5 districts in Al-Hilla city and countryside, respectively and daily generated MSW per capita/day covering food residues, plastic, paper, can and glass wastes were considered. It was found that the mean capita/day of Al-Hilla city districts was significantly higher than that of countryside ones which were 0.644 ± 0.16 and 0.416 ± 0.12 kg/capita/day, respectively. Also, all generated municipal solid waste components of towns have been recorded as being similarly greater than of the countryside giving a higher percentage of food residues, plastic, paper, can and glass wastes than those of countryside. In both districts, food residues formed the highest percentage of solid waste components followed by plastic and wastes while the lowest percentage was metal can waste and paper waste for town areas. In the countryside areas, the lowest solid wastes component was paper waste followed by aluminum can wastes. Theoretical calculation of these values has shown that expected means of both daily and annually MSW generated in Babylon province were 1,243,089 and 453,727,485 tons, respectively.

1. INTRODUCTION

During the last decades, a municipal solid waste phenomenon worldwide has received much attention in terms of environmental and economic issues [1-5]. The majority of these works have focused on certain solid waste concepts and targets such as generating solid waste capita [6], solid waste components [7], factors affecting solid waste generation [8], solid waste dumping and incineration [9] and solid waste collection [10]. Apparently, these studies have shown great variation in solid waste per person per day in various international communities and were found to range from 0.11 to 4.54 kg/person/day with an average of 0.74 kg [11]. Similar studies in different countries have reported solid waste capita per day was 1986.7 g (4.38 pound) in USA [12], Africa countries have reported MSW capita to vary from 0.1 to 1.49 kg/person/day [13] whereas in Brazil, MSW capita was varied from 0.4 kg/person/day [14] to 1.07 kg/person/day [15]. India generates MSW of 400 g per capita [16]. Similar study in Japan has reported an average of 940 g as MSW capita per person per day [17]. In contrast, in China, the MSW capita was found between 448.3 g and 653.2 g [18]. Meanwhile, Arabic

states have had various MSW capita where in Jordan, the value was found to be 900 g [19]. In comparison, Egypt has recorded a value varying between 200 and 600 g [20] and Saudi Arabia has had a value ranged between 1500 and 1800 g [21]. Furthermore, Iraqi cities have shown different MSW capita values in Baghdad city was 0.630 kg [22], Mosul city was 0.680 kg [23], Basrah city was 0.620 kg [24], Sulaimaniyah city was 1.320 kg [25], Najaf city was 0.420 kg [26] and Babylon city was 0.670 kg [27]. Nevertheless, several studies have shifted to cover the most crucial targets of municipal solid waste in terms of protecting the environmental resources and generating green energy to reduce and control all forms of environmental pollution [28-30]. Meanwhile, previous work has reported that MSW food residues can be converted into biofuel [31] while another study has shown that most MSW components can be used to synthetic gas [32] and MSW plastic was examined to generate energy [33]. However, such application of MSW may produce biofuel gas of more than 2.2 billion tons per year by 2025, as reported by a recent study [29]. Also, food waste of MSW was utilized to produce biofertilizers [34, 35] and such wastes were recycled to produce cultivated fish foods [36]. In the case of other MSW

components, several studies have reported the possible recycling of such wastes [37, 38]. During the last decades, municipal solid waste phenomena worldwide have received much attention in terms of environmental and economic issues, and so, the current study was carried out to calculate the daily generated MSW of certain residential districts of Babylon province via covering the province center (Al-Hilla city) and five surrounding the countryside.

2. MATERIALS USED

This study was carried out at the house level where the

covered houses were handed five large color polyethylene carrier bags marked as MSW components such as food residues, paper, plastic, metal cans and glass to be used for discharging the generated wastes separately for a single day of June 2024. So, this action represents the waste segregation process, resulting in obvious and complete waste isolation. Also, this MSW collecting method was accompanied with the request of the number of residents of each home covered in the study.

Twenty residential districts were selected randomly which were 15 districts within Al-Hilla city (Province center) and only 5 areas from surrounding districts as shown in Table 1. A single home was considered from all these districts.

Table 1. The residential districts of Babylon city center and the countryside

Districts	Res. No.	Distinct	Res. No.	Distinct	Res. No.	Distinct	Res. No.	
Babylon City Center Al-Hilla City	Al-Krama	7	Al-Murtada	7	Al-Bakerli	8	Mahaweeel	7
	Al-Zhrae	5	Al-Escan	11	Nader 1	2	Hamza Ghrabi	14
	Bustan Alhelo	4	Al-Shawi	14	Nader 2	10	Babylon Countryside	Al- Mashrooa
	Al-Jamyea	6	Al-Tyara	7	Al-Muhandisen	8	Al-Qasim	10
	Al-Ameer	6	Al-Kathat	5	Al-Muharbin	5	Al-Msaeb	8

3. EXPERIMENTAL PART

A measured mixture of 50% virgin PP and 50% recycled PP was charged into the hopper of the injection molding machine. The parameters of the processing machine are mentioned in Table 1. The samples were manufactured using a Korean-made JMI/SPI-150 injection machine with a mold closing force of 150 tons, which consists of a three-part mold with dimensions of $450 \times 500 \times 436$ cm and contains 24 cavities. Initially, five cycles of PP products were manufactured to establish operational stability, after which samples were selected for additional testing.

By the end of the working day, all these colored polyethylene bags were gathered and each bag was weighed by using a portable balance to the nearest gram. To calculate the capita per person of all MSW components, the weight of each bag was divided by the number of each home residents and the obtained data were presented in terms of tables and figures. However, the study was run for a single day only and does not cover other variables effects such as seasonal, educational and family income being initial work focuses only on MSW capita (refer to Figure 1).

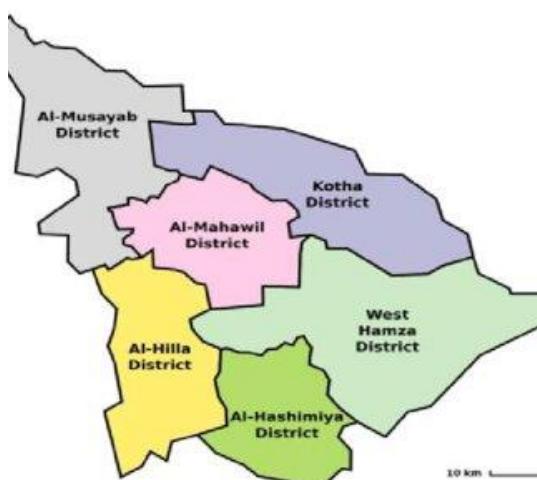


Figure 1. Examined districts

4. RESULTS AND DISCUSSION

Table 2 presents the Weight of all municipal solid waste components, total weight and capita/person/home (kg) of all examined residential homes within Babylon province (Al-Hilla city and surrounding countryside) surveyed in this paper.

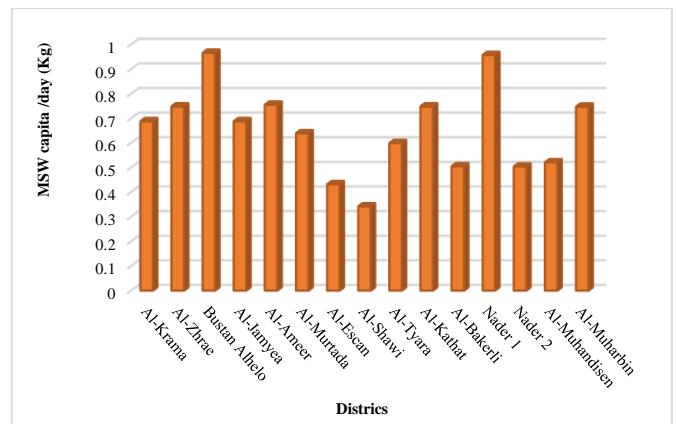


Figure 2. Capita/day of generated (MSW) of the houses from districts within Hilla City

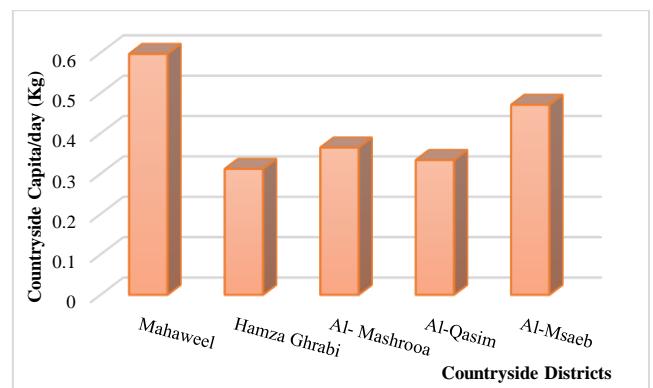


Figure 3. Capita/day (kg) of generated MSW of all houses within all countryside districts

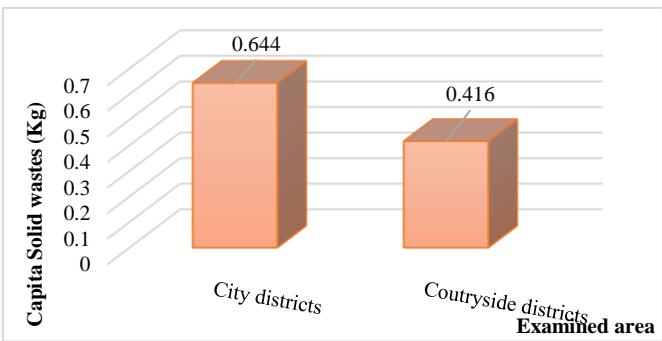


Figure 4. Mean weight value \pm sd of capita/person/home (kg) of both Al-Hilla city and surrounding districts within Babylon province

Table 2. Weight of all municipal solid waste components, total weight and capita/day (kg) of all examined residential homes within Babylon province (Al-Hilla city and surrounding countryside) subjected to the study

Districts	Municipal Solid Waste Weights (kg)					Resid. No.	Total Weight kg	Capita/day kg	
	Food Residues	Plastic	Paper	Cans	Glass				
Babylon city center (Al-Hilla city)	Al-Krama	1.390	1.256	0.698	0.670	0.802	7	4.816	0.688
	Al-Zhrae	0.968	0.898	0.680	0.590	0.604	5	3.740	0.748
	Bustan Alhelo	1.046	1.007	0.704	0.320	0.787	4	3.864	0.966
	Al-Jamyea	1.326	1.021	0.543	0.612	0.624	6	4.126	0.688
	Al-Ameer	1.139	1.304	0.769	0.589	0.730	6	4.531	0.755
	Al-Murtada	1.021	1.345	0.670	0.632	0.805	7	4.473	0.639
	Al-Escan	1.188	1.035	0.932	0.806	0.795	11	4.756	0.432
	Al-Shawi	1.175	1.096	0.897	0.838	0.789	14	4.795	0.342
	Al-Tyara	0.957	1.189	0.587	0.593	0.867	7	4.193	0.599
	Al-Kathat	0.961	0.976	0.598	0.487	0.720	5	3.742	0.748
	Al-Bakerli	1.078	0.885	0.642	0.684	0.754	8	4.043	0.505
	Nader 1	0.345	0.570	0.311	0.276	0.411	2	1.913	0.957
Babylon Countryside	Nader 2	1.399	1.296	0.702	0.702	0.942	10	5.041	0.504
	Al-Muhandisen	1.225	0.996	0.602	0.598	0.750	8	4.171	0.521
	Al-Muharbin	1.143	0.889	0.523	0.580	0.598	5	3.733	0.747
	Mahaweelel	1.101	1.180	0.501	0.610	0.784	7	4.176	0.597
	Hamza Ghrabi	1.355	0.970	0.632	0.704	0.702	14	4.363	0.312
	Al- Mashrooa	1.518	0.910	0.559	0.698	0.693	12	4.378	0.365
	Al-Qasim	0.834	0.830	0.490	0.593	0.589	10	3.336	0.334
	Al-Msaeb	0.976	0.840	0.653	0.680	0.622	8	3.771	0.471

Table 2 contains capita values of food, residues, plastic, paper, cans and glass wastes of all examined homes of both Al-Hilla city and countryside. It seems that there were significant differences between these values where in case of food residues, the values of food residues generated in examined houses within Al-Hilla city were varied from 0.345 kg capita/day in Nader 1 to 1.399 kg in Nader2 whereas values of plastic wastes ranged from 0.570 to 1.345 kg in Nader1 and Al-Murtada respectively. Regarding paper wastes, it was found lower values varying from 0.311 Kg to 0.932 kg capita/day again in Nader1 and Al-Escan homes respectively while can wastes were recorded to range from 0.276 Kg in Nader1 to 0.838 kg in Al-Shawi district and finally glass wastes have varied from 0.411 to 0.942 kg capita/day in Nader1 and Nader2 respectively (Figure 5). It seems very clear that home within Nader1 district has generated much less MSW components. However, the highest capita values of food residues, plastic, paper, can and glass wastes were recorded in Nader2, Al-Murtada, Al-Escan, Al-Shawi and Nader2 (Table 2 and Figure 5).

For the houses of the surrounding countryside, Food residues values varied from 0.834 Kg to 1.518 kg capita/day of Al-Qasim and Al-Mashrooa respectively whereas values of plastic wastes ranged from 0.830kg of Al-Qasim homes to

The capita/day of generated MSW of all districts within Al-Hilla city was found to vary greatly where it was ranged from minimum value of 0.342 kg capita/day in a home of Al-Shawi district to maximum value of 0.957 kg capita/day in a house of Nader 1 (Figure 2) while in countryside homes, these data were found to vary from 0.334 kg to 0.597 kg in Al-Qasim and Mahaweelel homes respectively (Figure 2). However, it seems very clear that the MSW capita of Al-Hilla districts were much higher than that of the countryside houses (Figures 2 and 3).

Furthermore, for the mean value, it was found that the mean weight value of Al-Hilla city houses within all examined districts was greater than that of the surrounding districts which were 0.644 ± 0.16 and 0.416 ± 0.12 kg capita/day, respectively (Figure 4).

1.180 kg capita/day of Mahaweelel houses. Paper wastes values varied from 0.490 to 0.653 kg capita/day of Al-Qasim and Al-Msaeb homes respectively while can waste values were ranged from 0.593 of Al-Qasim to 0.704 kg capita/day of Hamza Ghrabi and finally glass wastes values were found to vary from 0.589 to 0.784 kg capita/day of Al-Qasim and Mahaweelel homes respectively. Al-Qasim home within the countryside has generated the lowest values of all MSW components (Table 2, Figure 6).

For the comparison of MSW components generated in Al-Hilla city and surrounding countryside districts, the mean data of these components were given in Table 3 in addition to the data of grand total of these values.

The mean value \pm sd of all examined MSW components generated in all houses within Al-Hilla city and countryside are presented in Table 3.

The mean value recorded for food residues was 0.167 ± 0.04 and 0.117 ± 0.04 kg capita/day for city center and countryside respectively while plastic wastes had mean value varied from 0.100 ± 0.04 kg in countryside houses to 0.167 ± 0.05 kg capita/day in Al-Hilla city homes. Similarly, paper, can and glass wastes had higher mean values in city houses than those of countryside homes which were 0.103 ± 0.03 , 0.091 ± 0.02 and 0.116 ± 0.04 kg capita/day for Al-Hilla city houses and

0.059 ± 0.0 , 0.068 ± 0.02 and 0.071 ± 0.03 kg capita/day for countryside districts (Figure 7).

The grand means recorded were 0.587 ± 0.18 , 0.146 ± 0.04 , 0.150 ± 0.057 , 0.085 ± 0.02 and 0.105 ± 0.04 kg for capita, food residues, plastic, paper, can, and glass wastes respectively (Figure 8).

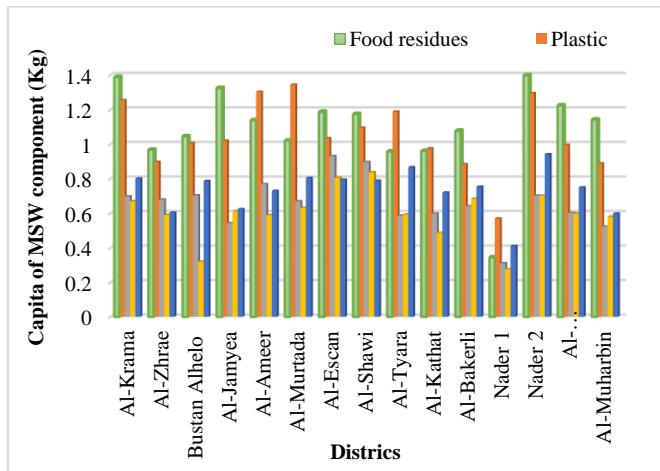


Figure 5. Capita/ day (kg) of food residues, plastic, paper, can and glass wastes generated in houses within Al-Hilla city

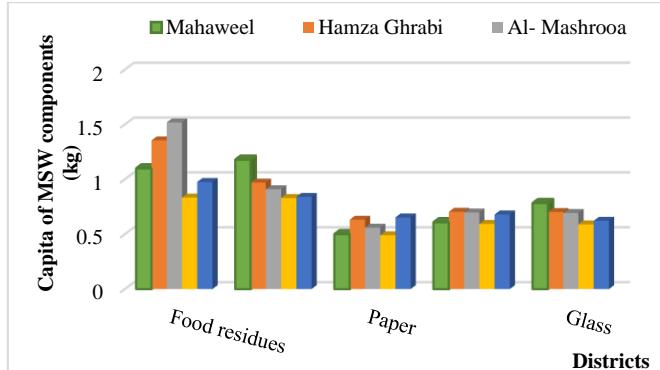


Figure 6. Capita /day in (kg) of food residues, plastic, paper, can and glass wastes generated in houses within countryside districts

In similar studies carried out in other national provinces, various findings of capita/day have been reported where in Mosul, a value of 0.680 capita/kg was detected [23]. Basrah had a value of 0.620 kg capita/day [24], in Najaf, a value of 0.420 kg capita/ day [26], in Baghdad, a mean of 0.818 kg/day were recorded [7], Sulaimanyiyah province has had much

higher value which was 1.320 kg capita/day [25] while in Erbil, similar higher value (1.338 kg) capita/ day was reported [39, 40].

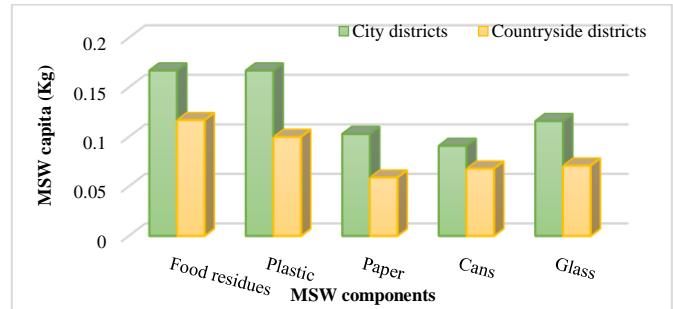


Figure 7. Capita/day (kg) of mean value of food residues, plastic, paper, can and glass wastes generated in houses within Al-Hilla and countryside districts

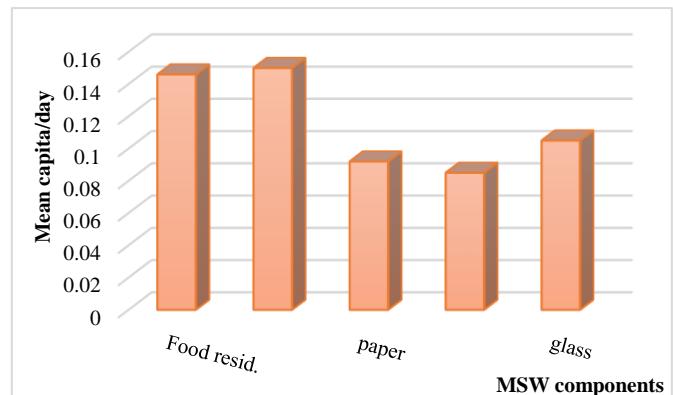


Figure 8. Grand mean of capita /day (kg) of food residues, plastic, paper, can and glass wastes generated in houses within Al-Hilla and countryside districts

Regarding MSW components, much lower capita/ day values for examined components (paper, plastic, can and glass wastes) were recorded in similar work carried out in Baghdad [7].

However, the theoretical calculation and analysis of the obtained results were proceeded and given in Table 4 which also displays the calculated mean capita/day of MSW generated in all examined homes within Al-Hilla city and countryside districts of the Babylon province and all its components. Also, it includes the calculated daily and annually expected values according to the province population of 2,119,403 individuals as stated in a recent study [41].

Table 3. Mean value \pm sd of all examined MSW components generated in all houses within Al-Hilla city and countryside

Region	Food waste	Mean Municipal Solid Waste (Kg) \pm Sd			Capita in kg	
		Paper-waste	Cans-waste	Glass-waste		
Hilla/center	0.167 \pm 0.04	0.167 \pm 0.05	0.103 \pm 0.03	0.091 \pm 0.02	0.116 \pm 0.04	0.644 \pm 0.16
Countryside	0.117 \pm 0.04	0.100 \pm 0.04	0.059 \pm 0.00	0.068 \pm 0.02	0.071 \pm 0.03	0.416 \pm 0.12
Grand mean	0.146 \pm 0.04	0.150 \pm 0.057	0.092 \pm 0.03	0.085 \pm 0.02	0.105 \pm 0.04	0.587 \pm 0.18

Table 4. Daily and annually expected quantities of generated MSW in Babylon province according to its population

MSW	Capita/day (Kg)	Generated MSW (kg)			
		Food Residues	Plastic	Paper	Cans
Capita/person/day	0.587	0.146	0.150	0.092	0.085
Expected daily (ton)	1,243,089	309,433	317,915	194,989	180,149
Expected annually (ton)	453,727,485	112,943,045	116,038,975	71,170,985	65,754,385
					222,537
					81,226,005

From this Table, the calculated data shows that the expected annual generated value was 453,727,485 tons. Meanwhile, annual values of food residues, plastic, paper, can and glass wastes were 112,943,045; 116,038.975; 71,170,985; 65,754,385 and 81,226,005 tons respectively. Interestingly, these great values need proper and scientific attentions where several studies have mentioned of possible utilization of MSW incinerated ashes in stabilization of sand dune [33, 42-44] while it would be much better using of un-incinerated food wastes which is surely environmentally sound to handle sand dune nearby lands which may enhance the plant cover and such process may reduce the possible impacts of climate change. Also, the food residues can be used in generating biogas for energy [29]. In addition, these wastes may be used as organic fertilizers to improve soil fertility for agricultural utilization as examined in other studies [45, 46].

Regarding MSW plastic wastes, it is usable to produce energy as reported by other studies [33, 41]. At the same time, such waste can be recycled to produce various materials [47]. But paper, can and glass municipal wastes can be recycled [48, 49].

Finally, MSW may be considered as national wealth that saves thousands of jobs, increases revenue, generates clean energy, helps stop dune and desertification, enhances the green belt to protect environmental resources, contributes to control climate change and many invisible targets.

5. CONCLUSIONS

Several previous studies have examined certain applications using certain MSWs in construction via mixing with other constructing materials while others have succeeded in generating energy from such wastes. However, similar applications can be applied by utilizing such MSWs. Also, there is an environmental problem in Iraq known as sand dunes that are characterized by their instability and often creep into neighboring areas and may cover transportation routes and thus may cause traffic disasters. Therefore, some types of these MSWs can be used to treat these dunes to control their spread to external transport routes and then prevent these traffic accidents. Also, Iraq suffers from desertification which significantly affects climate change. So, food waste would be ample to enhance green plants that may positively affect such climate changes. Meanwhile, proper management of such MSWs may save thousands of jobs and leave the environment sound and clean.

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