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# Management of Municipal Solid Waste in Baghdad, Iraq

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***Abstract*—**The deterioration of solid waste management in Baghdad city is considered as a great challenge in terms of human health and environment. Baghdad city is divided into thirteen districts which are distributed on both Tigris River banks. The west bank is Al-Karkh and the east bank is Al-Rusafa. Municipal Solid Waste Management is one of the most complicated problems facing the environment in Iraq. Population growth led to increase waste production and more load of the waste to the limited capacity infrastructure. The problems of municipal solid waste become more serious after the war in 2003. More waste is disposed in underground landfills in Baghdad with little or no concern for both human health and environment. The results showed that the total annually predicted solid waste is increasing for the period 2015-2030. Municipal solid waste in 2030 will be 6,427,773 tons in Baghdad city according to the population growth rate of 2.4%. This increase is estimated to be approximately 30%.

***Keyword*—**Municipal solid waste, solid waste composition and characteristics, Baghdad city, environment, human health.

## I. Introduction

WASTE management is one of the most complicated problems in Iraq. The increase in population growth in Baghdad has led poorly of solid waste management in most districts of Baghdad. Lack of investment, looting and other problems affected the waste management sector during decades of war, sanctions and instability [1]. Iraq with a population exceeding 32 million in 2013 produced about 31,000 ton/day of solid waste. Baghdad is considered the capital city with a high population density about seven million and generated more than 2.5 million tons of solid waste annually [3]. In Iraq, solid waste is a pollution source especially at the last years due to the war conditions and embargo imposed on the country at the beginning of the nineteenths where there is an absence of modern, efficient waste handling and disposal infrastructure as well as general lack of interest in awareness of health and environmental issues. Municipal solid waste management (MSWM) problem has become severe in Baghdad city and it is one of the significant challenges for the "Ammant Baghdad". The total urban population in Baghdad went up from 2.14 million in 1970 to 6.7 million in 2005 and increased to 7.0 million in 2015[2]. MSWM became one of the major environmental problems in Iraq especially in Baghdad city in the last ten years after 2003since the sharp increase in the volume of solid waste generated as well as quantitative changes in its composition.

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The objectives of this study are to estimate the amount of domestic solid waste generated during period 2016-2030 and the rate of per capita production of municipal solid waste in Baghdad city also the composition of solid waste.

## II. Study Area and Data Collection

Fig. 1 shows Baghdad city of about 885 km$^2$ area. The city is divided into 131 districts on the east and waste banks of the Tigris River. These districts are further subdivided into many neighborhoods. Table I shows the number of population and solid waste generation based on the district of Baghdad city in 2015 [3].

At present, all solid waste is randomly dumped into landfill without separation of waste composition and recycling processes. This has been achieved through the following steps: Initially is the gathering and transportation of solid waste, which is required once or twice a week by 2-3 workers by means of trucks. The working involves poor practices by department of solid waste and environment in the "Ammant Baghdad". However, separation and recycling of all solid waste in Baghdad city are very limited level. Finally, the collected waste transported directly to the landfills sites. The other, larger, portion of the waste goes to treatment or disposal, based on the type of material being dumped.

Currently, there are two landfills in Baghdad; unfortunately, there is no landfill that meets the criteria of environment landfill. Instead, all of the waste is dumped into random holes. Landfills occupy 45.5 km$^2$ of Baghdad land, and this area is expected to increase to 60 km$^2$ by 2025. The required number of landfill in Baghdad city is six based on the future 2027 population and the landfill volume is estimated about 138 million m$^3$ [3].

### *A. Estimation of Solid Waste Generation*

Population forecasting in Baghdad for the period 2016-2030 is estimated based on [4]:

$$P_i = P_\circ(1+r)^n \quad (1)$$

where $P_i$ = future population at the end of period, 2030.$p_\circ$= present population for year, 2015.n = number of years. r = annual rate of growth (2.4%). Fig. 2 showed the population in Baghdad city for the period (1996-2015) [3] and the future population is estimated based on (1) for the period 2016 to 2030, Table II. The annual amount of solid waste generated in Baghdad is estimated according to the following (1) [5]:


Fig. 1 Map of Baghdad City

TABLE I
POPULATION OF BAGHDAD BY DISTRICT AND OF SOLID WASTE GENERATION [3]

| District | Population x $10^3$ | Area ($km^2$) | No. of neighbor-hood | Waste generation rate (kg/cap./day) | Amount of solid waste generation (ton/ day) |
|---|---|---|---|---|---|
| AL-Rusafa | | | | | |
| Rusafa (Centre) | 350 | 24 | 46 | 1.1 | 600 |
| Sadar | 1550 | 54 | 62 | 0.6 | 1150 |
| Shaab | 390 | 98 | 33 | 0.6 | 270 |
| Ghader | 600 | 45 | 41 | 0.7 | 325 |
| Baghdad Al-Jadidah | 650 | 66 | 42 | 0.7 | 325 |
| Karadah | 550 | 68 | 45 | 0.8 | 500 |
| Adhamiyah | 350 | 27 | 28 | 0.8 | 270 |
| AL Karakh | | | | | |
| Karakh(Centre) | 300 | 24 | 33 | 0.9 | 340 |
| Kadhimiyah | 390 | 56 | 24 | 0.7 | 320 |
| Sho'la | 600 | 89 | 40 | ---- | 295 |
| Mansour | 550 | 126 | 58 | 1.2 | 510 |
| Rasheed | 450 | 130 | 53 | 0.8 | 400 |
| Doura | 300 | 78 | 31 | 0.8 | 260 |
| **Total** | **6,630** | **885** | **536** | | **5565** |

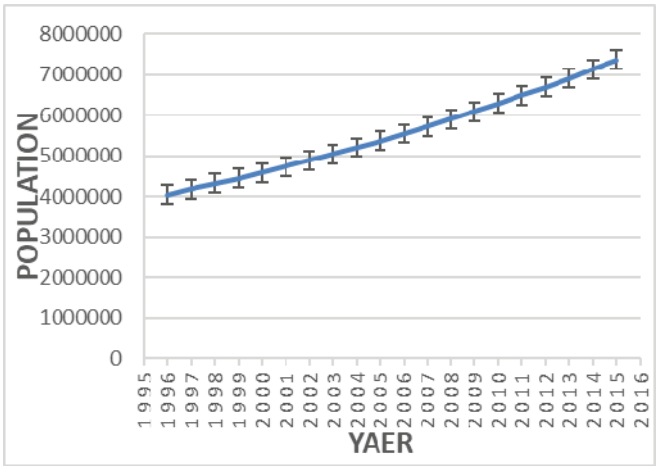


Fig. 2 Population in Baghdad for each Year for the Period (1996-2015)

TABLE II
POPULATION FORECASTING FOR THE PERIOD (2016-2030)

| Year | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|
| Pop. | 7604120 | 7847452 | 8089570 | 8357724 | 8625172 | 8901177 | 9186015 | 9479967 |
| Year | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | — |
| Pop. | 9783326 | 10096393 | 10419477 | 10752900 | 11096993 | 11452097 | 11818564 | — |

Daily production of solid waste in any future years is:

$$P*W_o\,(1 + r)^n(1 + c)^n\ldots. \qquad .(2)$$

where p =future population at the end of period; r =percentage of growth rate; n =difference between the future and the base years; Wo =actual production of solid wastes (kg / person / year); C = percentage annual increase in solid waste (assumed C=0.03 in the records of Ammant Baghdad).

## III. SOLID WASTE COLLECTION AND TRANSPORTATION

The management of solid waste including collection and transportation processes is a major necessary in increasing the productivity and efficiency of the design of tracks of municipal solid waste in Baghdad city, reuse and disposal of solid waste, Fig. 3. In Baghdad city, the solid waste management represented as shown in Fig. 4.

Most of the waste in Baghdad is dumped in a sanitary randomly uncontrolled landfill; about 76% of Baghdad wastes are transported to landfill. Recycling and reuse of solid waste in Baghdad city is still limited and no totally exceeded 20 %.

The department of solid waste and environment in the "AmmantBaghdad" has access to various vehicles to help in the process of collecting and transporting waste from Baghdad city districts to landfill sites. The collection and transportation machineries included trush-trailer vehicles, compacters, dumpers with different sizes, tractors, and others. Heavy machinery is used to modify waste piles at collection sides as well as to construct or clear roads leading to sites. Some of equipment and tools which are used in the process of collect and transportation of solid waste are shown in Fig. 5.


Fig. 3 Solid Waste Management Processes.


Fig. 4 Solid Waste Management System in Baghdad

Fig. 5 Equipment and Tools are Used in Process of Collection and Transportation of Solid Waste in Baghdad City

## IV. Solid Waste Management in Baghdad

The management of municipal solid waste as evident from this study revealed some major problems. However, Solid waste management in the central of Baghdad is a big challenge for "Ammant Baghdad". Solid waste management and disposal sites in Iraq are poorly operated. These sites are randomly distributed in Baghdad and don't to control the environment effect. Lack of regulations, national waste management policy or guidelines makes the problem worst. Moreover, the problem becomes more sever with the lack of financial resources and lack of trained personal and the absence of any adequate records concerning quality and quantity of solid waste. MSW system is inefficient within the municipalities in Baghdad causing exhaustion municipal budgets to consume the large sums of money and increasing the amount of waste generation. Limited financial sources are coupled with our dated machines and equipment, poor maintenance operations, and low wages, in addition to absence of strategies of (MSW) system.

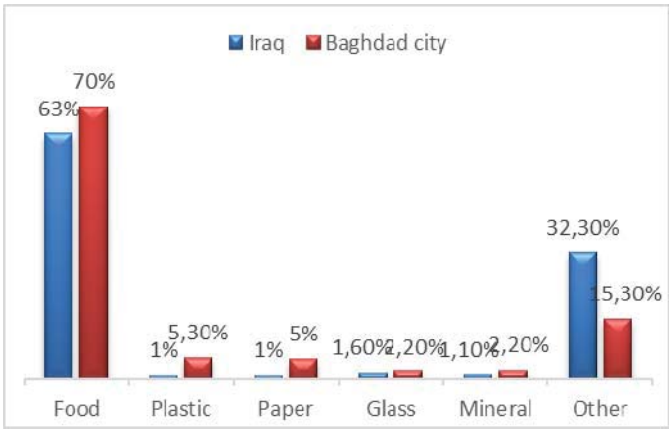


Fig. 6 Composition of MSW Iraq and Baghdad City

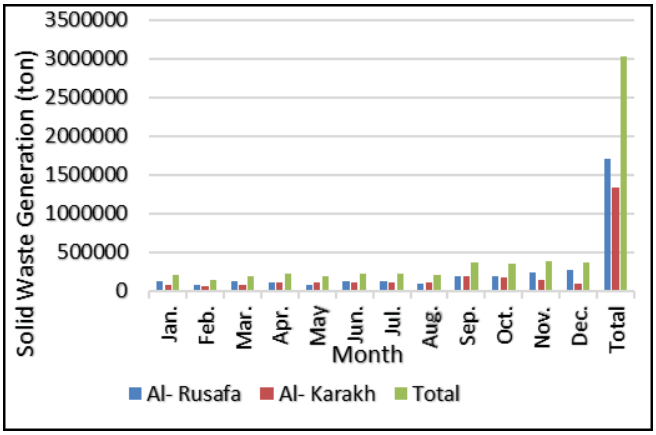


Fig. 7 Quantity of (MSW) Generation (Jan. 2012-Dec. 2012)

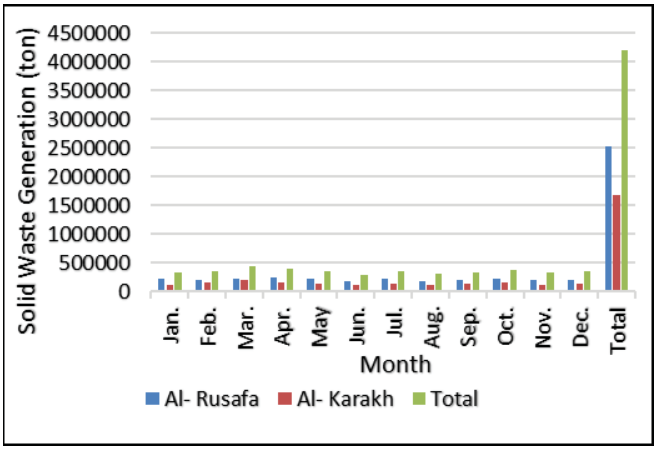


Fig. 8 Quantity of (MSW) Generation (Jan. 2013-Dec. 2013)

## V. Results

Baghdadis are now producing now more solid waste with each passing year. Over the past 25 years, the waste produced in Baghdad city has more than five times, from 0.45 million tons in 1990 to about 3.126 million tons in 2015. Some of this increase is related to Baghdad population growth as shown in Fig. 2.

The percentages of different types of waste in the MSW in Baghdad city and Iraq are represented in Fig. 6, organic waste was the largest proportion of waste, over 70%, whereas plastic and paper come in second and third positions with 5.3% and 5%, respectively. Several studied have been carried out to analyze the composition of municipal solid waste generated in Iraq and Baghdad areas. In general, these studies reveal a declining percentage of vegetable and organic fractions, possibly resulting from changing consumption patterns [6]-[8].

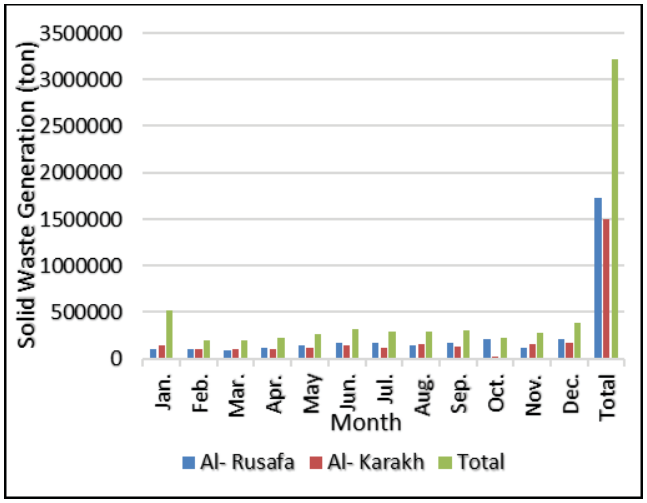


Fig. 9 Quantity of (MSW)Generation (Jan. 2014-Dec. 2014)

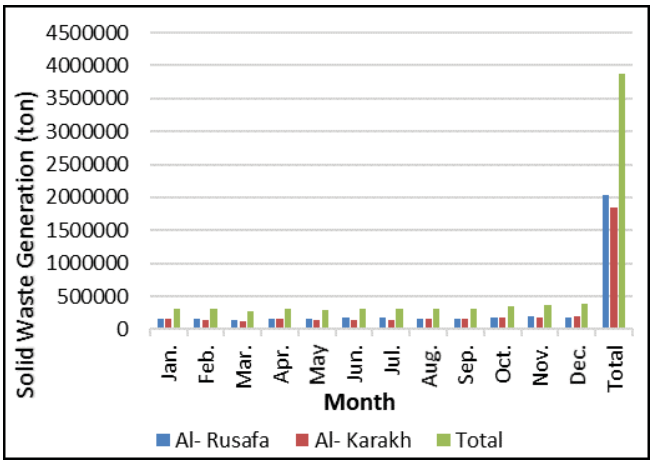


Fig. 10 Quantity of (MSW) Generation (Jan. 2015-Dec. 2015)

Quantities of municipal solid waste in Karkh area, Rusafa area and Baghdad city as a whole for the period (2012-2015) are calculated according to (2), Figs. 7-11. Comparison of the solid waste generation rate showed that the annual waste generation in Karkh, Rusafa and Baghdad city was 6,357,881 tons, 7,984,077 tons and 14,341,958 tons, respectively during the period (2012-2015). However, different sides of Karkh and Rusafa have population of different sizes that may have additional influence on the amount and types of waste produced. The solid waste generated in Baghdad is relatively fluctuated extremely in terms of the seasons and climate.

The value of solid waste generation rate during the months for the period (2012-2015) is a relatively the same expected in 2012. According to the results of study, there was no significant difference in the quantities of municipal solid waste especially during the months of 2013 and 2015, (as shown in Figs. 8 and 10) in which there was a remarkable increase in solid waste generation during the months (Sep., Oct., Nov., Dec., 2012), Fig. 7.

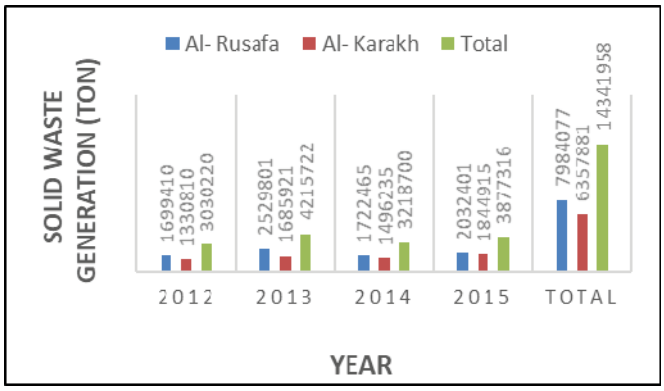


Fig. 11 Total Quantity of MSW Generation (2012-2015)

## VI. Conclusions

The basic conclusions from this study are:

1- The total yearly municipal solid waste (MSW) generation in Baghdad city is 14,342,958tons for the period (2012-2015), whereas, the amount of (MSW) generation in Karkh area was 6,357,881 tons. However,r in Rusafa area it was 7,984,077 tons for the same period.

2- Solid waste generated per capita in Baghdad ranges between (0.6-1.2) kg/day in 2015 and the daily solid waste generation is about 5565 ton for the same year.

3- Baghdad city suffers from a poor waste management system. This requires applying an integrated municipal solid waste management which focuses on finding alternatives to the current disposal methods.

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