

Estimation of Domestic Solid Waste Amount and Its Required Landfill Volume in Najaf Governorate, Iraq for the Period 2015-2035

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Abstract

Solid waste management is one of the most important challenges facing the local administration in the governorate of Najaf. This paper investigates the domestic amount generated in Najaf governorate for period 2015-2035 and the required landfill volume for the disposal of the waste. The daily per capita waste generation in Al-Najaf is 0.42 kg, the humidity content about 43% and the density of waste around 473 kg/m³. The total amount was about 5,914,415 ton and the required landfill volume is 11,828,829 m³.

Keywords

Najaf Governorate, Iraq, Domestic Solid Waste, Landfill

1. Introduction

In the 20th century, due to industrial revolution and technology development, consumption patterns of the people all over the globe have changed and the use of natural resources and goods has increased manifold. Due to this, huge quantities of different types of solid wastes are produced every day creating an alarming problem of their disposal.

In Iraq, after decades of turmoil and international sanctions many of the key infrastructures within Iraq have fallen into disrepair, leading to a terminal decline in the provision of basic and essential services. This is particularly true of waste and resource management which has seen years of underdevelopment and deterioration. This has resulted in a lack of provision of basic public services in the waste sector which have been replaced by a burgeoning black market in waste collection, disposal and recycling [1].

In Najaf governorate (**Figure 1**), solid waste management aspect is regarded as one of the major challenges faced by the local administration. This issue is one of the reasons of the political conflict in the governorate because of the saintliness of the city and the increasing in solid waste generation.

Generation rate in Iraq is between (0.35 - 0.65 kg/capita. day) as middle-income country [2]. This rate varies from place to place where it reaches (0.42 kg/capita. day) in Najaf governorate [3], (0.44 kg/capita. day) in Kirkuk city [4] and (0.496 kg/capita. day) in Mousel city [5].

The main aims of this study are to:

- 1) Estimate the amount of domestic solid waste to be generated during period 2015-2035 for future planning for solid waste management and land in Najaf governorate.
- 2) Calculate the required landfills volume for the disposal of this amount in a safety way without any environment risks.

2. Study Area

The study area hosts the shrine of Ali Ibn Abi Talib, making it a holy place for both Shia and Sunni Muslims. Wadi Al-Salam (valley of peace) is also located in this governorate which is an important Shia burial ground and it is a prominent center of Shia learning. Najaf governorate lies between coordinates latitudes (32°21'N and 29°50'N), longitudes (44°44'E and 42°50'E) with total area 28,824 sq. km (6.6% of Iraq). Administratively, Al-Najaf governorate includes three qadhaas (Administrative units comprising the Governorate) (Al-Manathera, Al-Kufa and Al-Najaf Qadhaa) (**Figure 1**).

Based in data from [6], the population and growth rate for the study area is as shown in **Table 1**.

3. Calculation of Domestic Solid Waste Volume

Domestic solid waste (domestic waste and portion of commercial waste (visitors waste) were calculated as

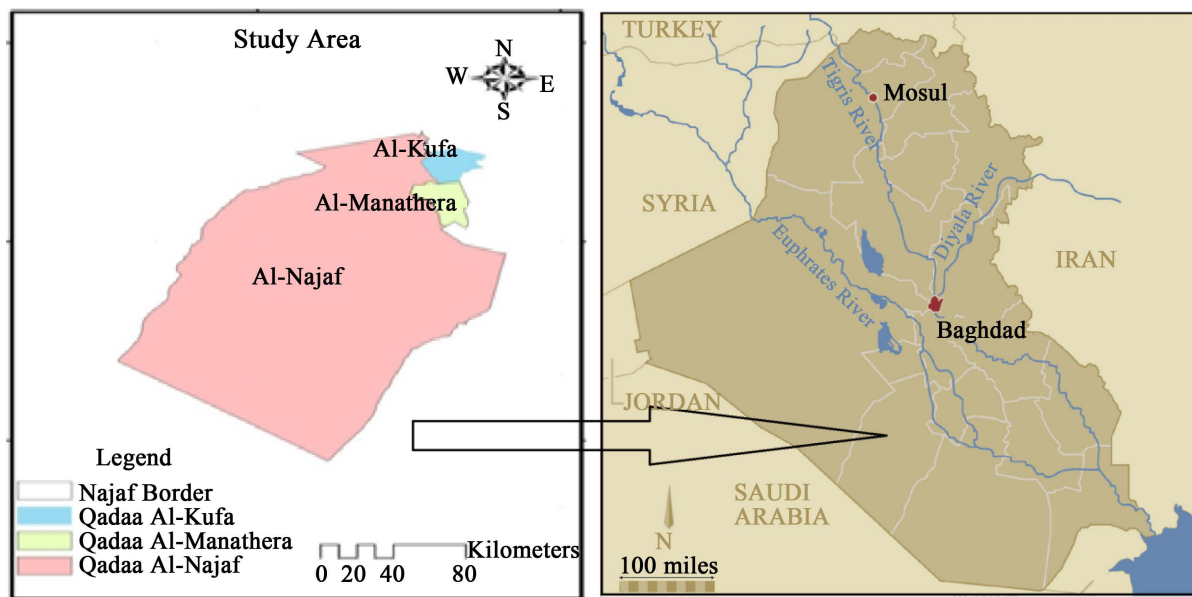


Figure 1. Map of study area.

Table 1. Population and growth rate for each Qadhaa.

Qadhaa	2014 Population	Growth rate%
Najaf	786,804	2.7
Kufa	346,145	2.5
Manathera	256,599	2.3

well as the approximate amount to be generated in the coming 20 years (2015-2035). This information was used to find out the required landfill volume based on the following steps.

3.1. 1-Estimation the Population for Each Qadhaa

Population for each Qadhaa for period study (2015-2035) was estimated based the flowing equation [7]:

$$P_i = P_o (1 + r)^n$$

P_i = population in target year

P_o = population in base year

n = number of years.

r = Growth rate.

For each Qadhaa, the growth rate used was for Al-Najaf, Al-Kufa and Al-Manathera Qadhaa is 2.7%, 2.5%, 2.3% [6].

3.2. Calculating the Amount of Domestic Solid Waste for Period from 2015 to 2035

Based on population estimated from previous equation and domestic and visitors waste generation rate (0.42 kg/capita. day and 0.23 kg/capita day) respectively [2] [3] the Amount of domestic waste for period from 2015 to 2035 for each Qadhaa is:

1) Al-Najaf Qadhaa

Based on the population in 2015 and 2016 and the growth rate (Table 1); 1,485,000 individuals visit Al-Najaf Qadhaa each year. These visitors generate waste 0.23 kg/capita. day. The generated waste rate for the visitors, the population and solid waste amount for Najaf Qadhaa for the period (2015-2035) is show in Table 2 and Figure 2.

Table 2. Solid waste in Al-Najaf Qadhaa and its population.

Year	Population	Visitors [10]	Total Solid waste(ton)
2015	808,048	1,485,000	*122,518
2016	829,865	1,485,000	125,817
2017	852,271	1,485,000	129,205
2018	875,283	1,485,000	132,684
2019	898,915	1,485,000	136,258
2020	923,186	1,485,000	139,927
2021	948,112	1,485,000	143,696
2022	973,711	1,485,000	147,567
2023	1,000,001	1,485,000	151,542
2024	1,027,001	1,485,000	155,624
2025	1,054,730	1,485,000	159,817
2026	1,083,208	1,485,000	164,123
2027	1,112,455	1,485,000	168,545
2028	1,142,491	1,485,000	173,086
2029	1,173,338	1,485,000	177,750
2030	1,205,018	1,485,000	182,540
2031	1,237,554	1,485,000	187,460
2032	1,270,968	1,485,000	192,512
2033	1,305,284	1,485,000	197,700
2034	1,340,527	1,485,000	203,029
2035	1,376,721	1,485,000	208,502
SUM			3,399,902

* = ((808,048 × 0.42 × 360) + 1,485,000 × 0.23)/1000.

2) Al-Kufa Qadhaa

Amount solid waste based on the population and growth rate (Table 1) for Al-Kufa Qadhaa for the period (2015-2035) was calculated as shown in Table 3 and Figure 3.

Table 3. Population and solid waste in Al-Kufa Qadhaa.

Year	Population	Solid waste(ton)
2015	354,799	*53,646
2016	363,669	54,987
2017	372,760	56,361
2018	382,079	57,770
2019	391,631	59,215
2020	401,422	60,695
2021	411,458	62,212
2022	421,744	63,768
2023	432,288	65,362
2024	443,095	66,996
2025	454,172	68,671
2026	465,527	70,388
2027	477,165	72,147
2028	489,094	73,951
2029	501,321	75,800
2030	513,854	77,695
2031	526,701	79,637
2032	539,868	81,628
2033	553,365	83,669
2034	567,199	85,760
2035	581,379	87,904
SUM		1,458,262

* = $(354,799 \times 0.42 \times 360)/1000$.

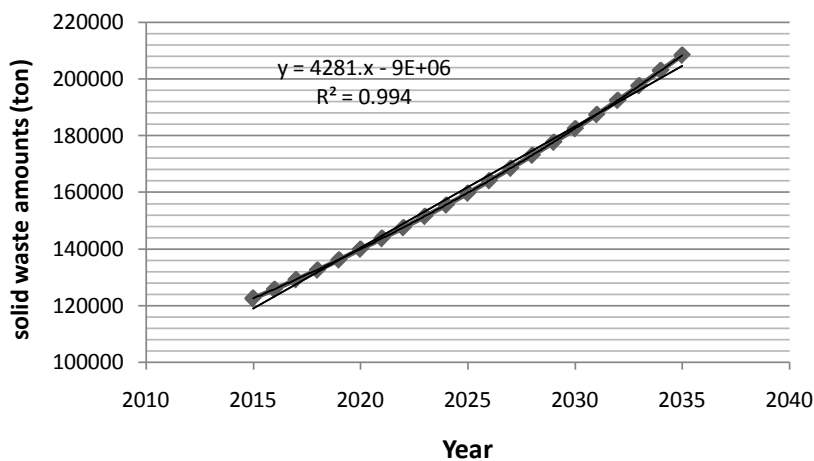


Figure 2. Expected solid waste in the Al-Najaf Qadhaa.

3) Al-Manathera Qadhaa

Amount solid waste based on the population and growth rate (Table 1) for Manathera Qadhaa for the period (2015-2035) is shown in Table 4 and Figure 4.

The accumulated domestic waste quantities for the coming twenty years for the three Qadhaas are illustrated in Table 5 and Figure 5.

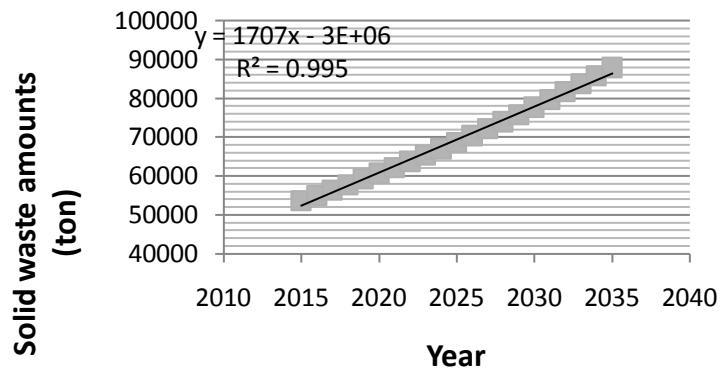


Figure 3. Population and solid waste in Al-Kufa Qadhaa.

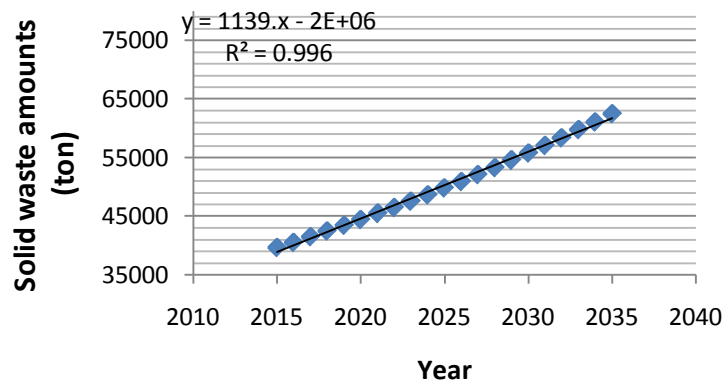


Figure 4. Solid waste in Al-Manathera Qadhaa with its population.

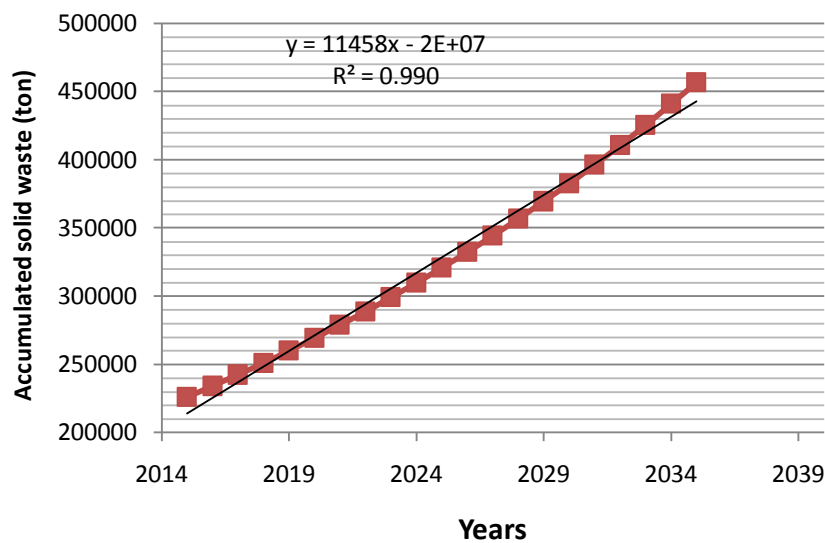


Figure 5. Accumulated solid waste quantities for Al-Najaf, Al-Kufa, and Al-Manathera Qadhaa with time.

Table 4. Solid waste in Al-Manathera Qadhaa with its population.

Year	Population	Solid waste(ton)
2015	262,501	*39,690
2016	268,538	40,603
2017	274,715	41,537
2018	281,033	42,492
2019	287,497	43,470
2020	294,109	44,469
2021	300,874	45,492
2022	307,794	46,538
2023	314,873	47,609
2024	322,115	48,704
2025	329,524	49,824
2026	337,103	50,970
2027	344,856	52,142
2028	352,788	53,342
2029	360,902	54,568
2030	369,203	55,823
2031	377,695	57,107
2032	386,382	58,421
2033	395,268	59,765
2034	404,359	61,139
2035	413,660	62,545
	SUM	1,056,251

* = $(262,501 \times 0.42 \times 360)/1000$.

According to the principle methods used for landfilling in dry areas it can be classified as: 1) Area, 2) Trench, and 3) depression. The adopted method in this research is the area method that is more suitable with Najaf environments lands of shallow ground water. Waste in the landfill should be covered daily in order to minimize health hazards and maintaining safety environment. The volume of daily cover in the landfill varies between 10% and 15% of the waste volume [7] [8]. Adopting a value of 12% of the waste volume, the accumulated weights and volume of waste for each Qadhaa and the required capacity of each landfill over the next twenty years can be estimated as shown in **Table 6** and **Table 7**.

4. Conclusions

Al-Najaf Governorate is located south-West Iraq. It covers an area of 28,824 square kilometers and its population in 2014 was 1,158,648 inhabitants. This city is visited regularly by what is called religious tourists. For this reason large quantities of solid waste are generated. In this research the generated solid waste was calculated based on the existing population and the expected population growth rate. This calculation was extended to 2035.

The total amount of solid waste was about 5,914,415 ton and the required landfill volume is 11,828,829 m³ to accommodate this waste. Qadhaa Al-Najaf solid waste generation was the highest relative to the other two Qadhaas

Table 5. The sum of the solid waste in twenty years for the three Qadhaas.

Year	Solid waste (ton) in Al-Najaf Qadhaa	Solid waste (ton) in Al-Kufa Qadhaa	Solid waste (ton) in Al-Manathera Qadhaa	Total (ton)
2015	122,518	53,646	39,690	215,854
2016	125,817	54,987	40,603	221,407
2017	129,205	56,361	41,537	227,103
2018	132,684	57,770	42,492	232,946
2019	136,258	59,215	43,470	238,943
2020	139,927	60,695	44,469	245,091
2021	143,696	62,212	45,492	251,400
2022	147,567	63,768	46,538	257,873
2023	151,542	65,362	47,609	264,513
2024	155,624	66,996	48,704	271,324
2025	159,817	68,671	49,824	278,312
2026	164,123	70,388	50,970	285,481
2027	168,545	72,147	52,142	292,834
2028	173,086	73,951	53,342	300,379
2029	177,750	75,800	54,568	308,118
2030	182,540	77,695	55,823	316,058
2031	187,460	79,637	57,107	324,204
2032	192,512	81,628	58,421	332,561
2033	197,700	83,669	59,765	341,134
2034	203,029	85,760	61,139	349,928
2035	208,502	87,904	62,545	358,951
Sub.Total	3,399,902	1,458,262	1,056,251	5,914,415

Table 6. The accumulated weighs and volume of waste for each Qadhaa.

Qadhaa	Accumulated Waste from 2015 to 2035 Weight (ton)	Volume in Landfill (m ³)**
Al-Najaf	3,399,902	6,071,254
Al-Kufa	1,458,261	2,604,038
AL-Manathera	1,056,251	1,886,163

**Density for compacting waste at landfill = 0.56 t/ m³ [9].

Table 7. Cumulative and compacted waste volumes for the landfills and its required areas.

	Al-Najaf landfill	Al-Kufa landfill	AL-Manathera landfill
Accumulated Volume (m ³)	6,071,254	2,604,038	1,886,163
+12% Cover	728,550	312,484	226,339
Total volume (m ³)	6,799,804	2,916,523	2,112,502
Area 2 m for 3 m depth	2,266,601	972,174	704,167

simply because the religious tourists generate at least 342 ton.

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