



Analysis efficiency of solid waste compactors in Baghdad governorate using GIS

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تحليل كفاءة عمل مكابس النفايات الصلبة في محافظة بغداد باستخدام نظم المعلومات الجغرافية

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قسم الدراسات والتخطيط / رئاسة الجامعة العراقية

Abstract:

The development work and use of geographic information systems (GIS) in spatial studies contributed to improving the site management of service projects through spatial efficiency analysis, including the efficiency of solid waste compactors in Baghdad Governorate. The study showed the presence of many compactors concentrated in the city of Baghdad without its suburbs, as well as many official and unofficial sanitary landfills geographically linked to the work of these compactors, which contributed to treating a large amount of solid waste, especially in the Rusafa side with a high population density compared to the Karkh side. The analysis of the efficiency of these compactors using the empirical bayesian kriging (EBK) showed that both Mahmoudiyah and Abu Ghraib districts have least spatial solid waste treatment, especially the southwestern parts of Baghdad Governorate. that is attributed to the poor distribution of these compactors in the districts of Baghdad Governorate, which contributed to the exacerbation of the problem of waste accumulation and failure to treat it in the districts and surrounding areas in Baghdad City.

Keywords: solid waste, compactors efficiency, production, sanitary landfill, geographic information systems,

المستخلص

: اسهم تطور عمل واستخدام نظم المعلومات الجغرافية (GIS) في الدراسات المكانية في تحسين الإدارة الموقعية للمشاريع الخدمية ومن خلال تحليل الكفاءة المكانية ومن ضمنها كفاءة عمل مكابس النفايات الصلبة في محافظة بغداد أذ بينت الدراسة وجود العديد من المكابس المتركة في مدينة بغداد دون ضواحيها وكذلك العديد من مطامر النفايات الصحية المرخصة وغير المرخصة المرتبطة جغرافيا بعمل هذه المكابس والتي أسهمت في معالجة جزء كبير من النفايات الصلبة خصوصاً في جانب الرصافة ذو الكثافة السكانية المرتفعة مقارنةً بجانب الكرخ والتي يظهر تحليل كفاءة عمل هذه المكابس باستخدام اداة الكريكنغ البايزي التجريبي (EBK) المناطق او الاقضية التي تكون فيها نسبة معالجة النفايات الصلبة اقل من باقي المناطق خصوصاً تلك المناطق التي تقل فيها كفاءة العمل والانتاج ويعزى ذلك الى سوء توزيع هذه المكابس في اقصية محافظة بغداد والذي أسهم في تفاقم مشكلة تراكم النفايات وعدم معالجتها في الاقضية والنواحي المحيطة بمدينة بغداد .

Introduction

Currently, the analysis efficiency of solid waste compactors is considered as one of the important studies that through this way can measure population growth in urban areas and also can measure the bad impacts on the surrounding environment. several technologies can be used to apply analysis efficiency of any project problem

especially in geographical areas, using GIS tools, day by day The problem is exacerbated by population growth and lack of awareness, which results increase in the amount of solid waste. In Baghdad, the largest urban cluster in Iraq, solid waste is considered as one of the increased problems and the main cause of this problem is the population. In the same time, there are several technologies within GIS with experimental statistical methods that are used to solve these problems and prevent them from being treated. the study aims to collect information on the solid waste compactor positions treat waste problems and explain its relationship with sanitary landfill sites. This relationship is demonstrated by obtaining data on waste compactor processing and the quantities transported to landfill sites. It is worth noting here solid waste causes high damage to natural resources. If not calculated and submitted in recognition of true may result in serious damage and losses cannot be compensated.

Date and methodology

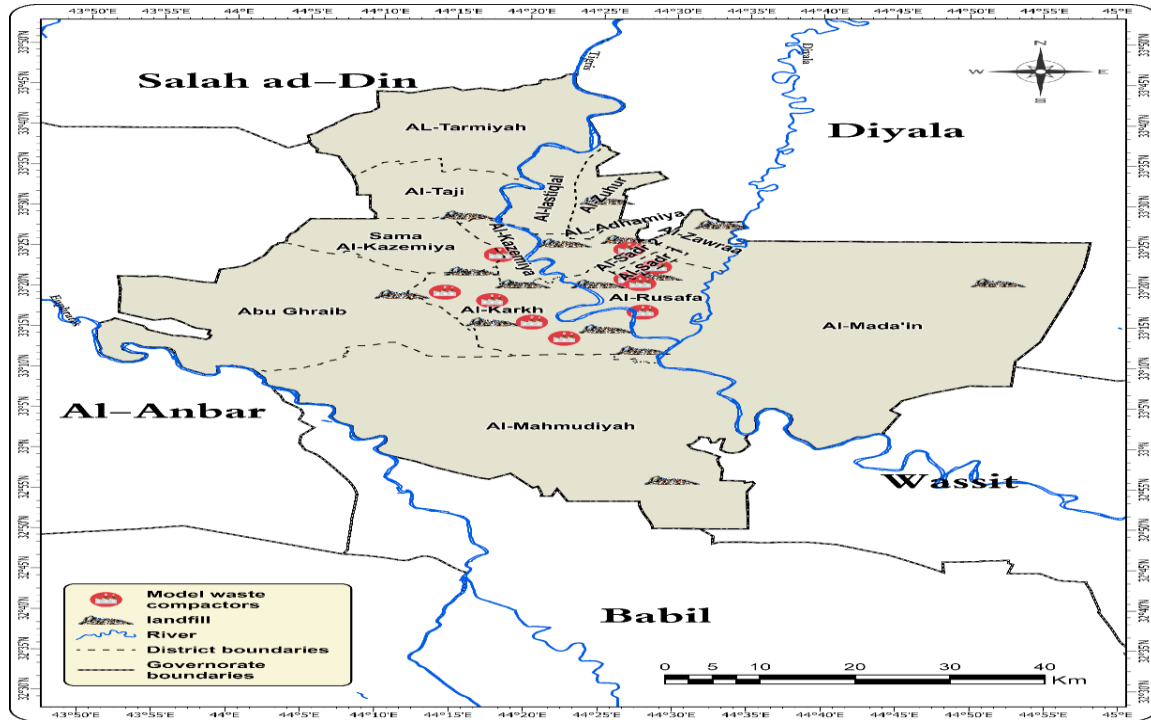
Depending on available data which was obtained from the Baghdad Municipality of 15 Landfills 10 waste compactors which have been established in Baghdad governate information's have been tabulated as a database in GIS environment and analysis (EBK) is a geostatistical interpolation method that automates the most difficult aspects of building a valid kriging model. Other kriging methods in Geostatistical Analyst require you to manually adjust parameters to receive accurate results, but (EBK) automatically calculates these parameters through a process of subsetting and simulations. also differs from other kriging methods by accounting for the error introduced by estimating the underlying semivariogram. Other kriging methods calculate the semivariogram from known data locations and use this single semivariogram to make predictions at unknown locations; this process implicitly assumes that the estimated semivariogram is the true semivariogram for the interpolation region. By not taking the uncertainty of semivariogram estimation into account, other kriging methods underestimate the standard errors of prediction.

Study Area

According to the latest statistics of Baghdad Governorate / Department of Urban Planning, the area of Baghdad Governorate is (5245 km²) and includes (15) districts and 47 sub-districts for the year 2023. This location is strategic as it represents a link between the governorates and makes it one of the most attractive locations for many people. Among other economic activities that have contributed to attracting large numbers of residents from the rest of the governorates, Baghdad Governorate is located within the astronomical position of (01 - 14 44°) longitude to the east, (47 - 44 33°) north latitude from the north, and (11 - 35 44°). (37-48 32 degrees) north latitude from the south, (40-56 44 degrees) east longitude, (33-25 58 degrees) north latitude from the east, and (32-50 43 °) east longitude (54 - 13 33 °). **Solid Waste Recycling in Baghdad** : in 2013 , established the first specialized project in Baghdad Governorate for sorting and recycling solid waste in the Yusufiyah, which belongs to the Mahmudiyah District, specifically in the Al-Jabsiyah District, near the Mahmudiyah Extension at a cost of 15 million US dollars and an area of 64 dunums, which is equivalent to 160,000 square meters. With a production capacity of 200 tons per working day and a number of operating hours of 8 hours per day, The project works by producing raw materials (aluminium, glass, plastic, natural fertilizers, food residues, etc., and finally iron). Its sanitary landfill area has international standard specifications. However, the lack of legal legislation for the compactors efficiency of solid waste and due to its importance in the field of solid waste management, as well as the lack of a structure for managing the factory, the lack of daily and continuous supply of solid waste , the lack of cooperation of the Municipality of Baghdad with the project management led to delay in the work of the factory instead of providing support. the capabilities for the purpose of expanding sorting lines and gradually reducing solid waste as well as spoilage of sorted materials(see map 1). (1) It consists of five main treatment stations: This project was planned to cover solid waste recycling in the Mahmoudiya and Yusufiya districts only. There is no project similar to this project in Iraq except the solid waste recycling project in Sulaymaniyah Governorate. The project stopped working in 2014 and was partially restarted in 2015. The General Directorate's proposal for industrial development of a solid waste compactors efficiency and recycling project in Baghdad Governorate is due to the rapid increase in the amount of solid waste in Baghdad Governorate and the negative environmental effects of its accumulation in many sites not designated for that purpose. This can be explained by calculating the following:¹9016091 (Number of population in Baghdad Governorate in 2022) * 1.3 kg (The rate of solid waste solid generated per person) = 11,720,918 kg (per year)²While the solid waste recycling project in Mahmoudiyah only produces 44,000 tons annually if it operates at full production capacity in the first place. see Table (1

Map (1) Distribution of solid waste compactors and landfills in Baghdad

Governorate in 2022



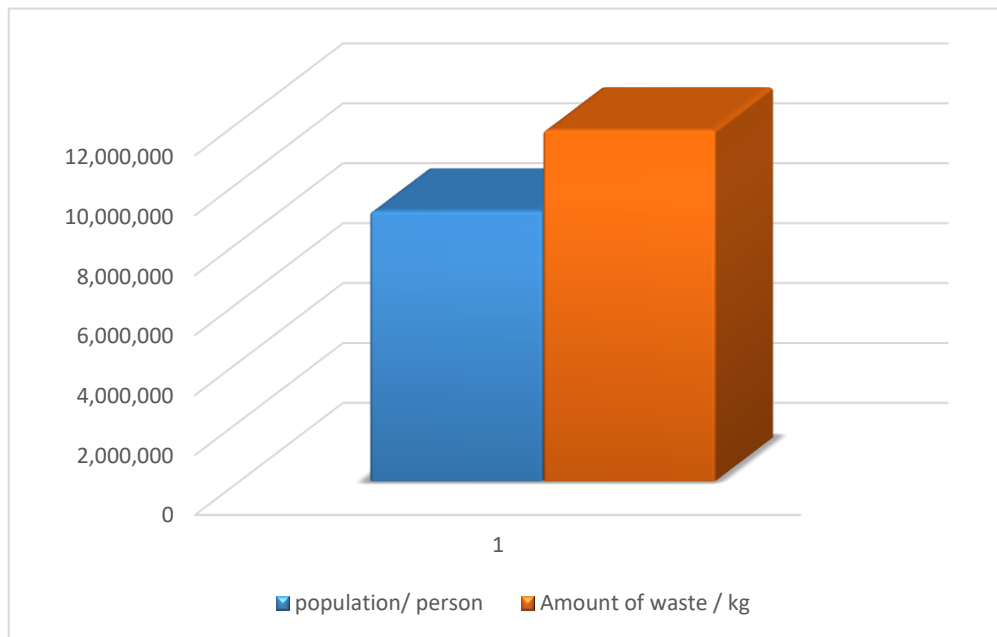
Source: From the researcher's work based on:

1. Republic of Iraq, Ministry of Water Resources, General Authority for Survey, Baghdad Table (1) The amount of solid waste generated and removed from the city of Baghdad and its Suburbs compared to Iraq in 2022 Administrative Map, in 2022.

Spatial scale	Number of residents served by solid waste collection service	The amount of normal solid waste removed is tons/year	The normal amount of solid waste removed is tons/day	Amount of solid waste generated per person (kg/day)
Baghdad Municipality	٦,١٥١,٣٣٥	٣,٠١٩,٥٠٩	٨,٢٧٢,٦	١,٣
Suburbs of Baghdad	١,٠٥٦,٣٢٦	٥١٠,٣١٨	١,٣٩٨,١	١,٣
total	٧,٢٠٧,٦٦١	٣,٥٢٩,٨٢٧	٩,٦٧٠,٧٠	١,٣
Iraq	٢٣,٢٨١,٨٠٩	١١,١٧٣,٠٣٨	٣٠,٦١١,١	١,٣

2. ArcGIS Pro version 3.03. On a scale of 1/650000.

Hanan Jamil Ashour, Alaa Haider Kamar, Department of Parliamentary Research and Studies in the Iraqi Council of Representatives, Fifth Electoral Session, Second Legislative Year, First Legislative Semester, 2023, p. 6. The previous table shows the amount of normal solid waste removed in Baghdad Governorate, as the percentage of waste removed from the center of Baghdad Governorate was 85.54%, while the percentage of solid waste removed was 14.46% from the total solid waste removed, amounting to 3,529,827 tons annually. Despite the importance of treating solid waste in the city, some treatments include (burning) It leaves harmful environmental effects on the city's environment . see Fig (1) **Fig (1) Comparison between the quantities of solid waste generated in the city of Baghdad and population in 2022**



Republic of Iraq , Ministry of Planning, Central Statistically Organization Iraq (CSOI) "Estimation of Iraq Population" (2023).

solid waste compactors: Earlier, nine model solid waste transfer stations were established on both sides of (Al-Karkh and Al-Rusafa) in Baghdad, four of which are on the Karkh side, which are (Al-Shu'la, Al-Bayaa, Al-Mansour, and Al-Dura) stations, and five of which are on the Al-Rusafa side, which are (Al-Sadr, Al-Shaab, and Al-Rusafa, Al-Ghadeer, and Karrada) (see map (1). The project for these stations was implemented by the Turkish company (Eksim) at an amount of (26) twenty-six billion dinars. The transfer stations can be classified according to the reality of the situation that is imposed on the designer or implementer of the solid waste compactors efficiency process. For example, it can be classified based on size and the amount of solid waste arriving to it, into small stations of less than (100 tons/day) or between (100-500) tons/day, and others larger than (500) tons/day. It is noted in Table (1): In the event that there are no compactor locations in certain districts, the municipality directorate undertakes to choose a compactor in an ill-advised manner in the district in which a compactor is to be established (2). On the other hand, there are many landfill sites allocated by the Baghdad Municipality, as in Table(2) and Fig (2)³

in 2022 in Baghdad Governorate Table (2) Sanitary landfill area m²

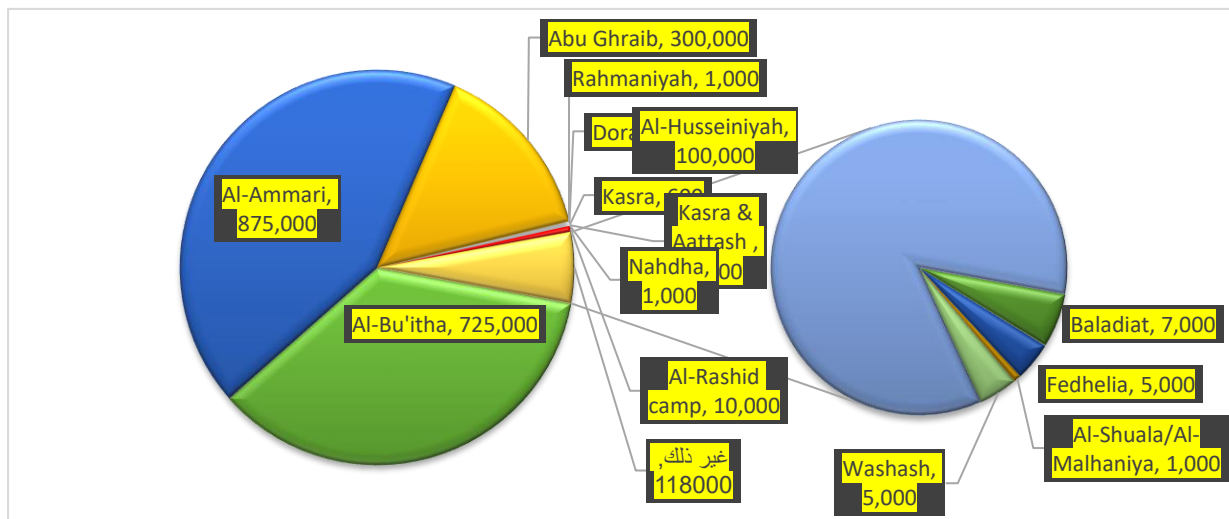
Sq	Site location	Location type	Area m ²	distance from city	distance from main road
١	Al-Bu'itha	permanent	٧٢٥,٠٠٠	Outside city ١٠ km	١,٥ km
٢	Al-Ammari	permanent	٨٧٥,٠٠٠	Outside city ١٠ km	٥٠٠ m
٣	Abu Ghraib	permanent	٣٠٠,٠٠٠	Outside city ١٠ km	١,٥ km
٤	Rahmaniyah	Temporary	١,٠٠٠	Inside city	٥٠ m
٥	Dora	Temporary	٥,٠٠٠	Inside city	١٠٠ m
٦	Kasra	Temporary	٦٠٠	Inside city	١٠٠ m
٧	Kasra & Aattash	Temporary	١,٠٠٠	Inside city	٥٠ m
٨	Nahdha	Temporary	١,٠٠٠	Inside city	٥٠ m
٩	Al-Rashid camp	Temporary	١٠,٠٠٠	Outside city ١٠ km	٢٥٠ m
١٠	Baladiat	Temporary	٧,٠٠٠	Inside city	٥٠ m
١١	Fedhelia	Temporary	٥,٠٠٠	Inside city	٥٠ m
١٢	Al-Shuala/Al-Malhaniya	Temporary	١,٠٠٠	Inside city	٥٠ m
١٣	Washash	Temporary	٥,٠٠٠	Inside city	٥٠ m

١٤	Al-Husseiniyah	Temporary	١٠٠,٠٠٠	Outside city ١٠ km	١٠٠ m
١٥	Nahrawan	permanent	٢٥٠,٠٠٠	Outside city ١٣ km	٣٠٠ m
	Total		٢,٥٣٦,٦٠٠		

1. Republic of Iraq, Baghdad Municipality, Planning and Follow-up Division, 2022.

٢. Republic of Iraq, Baghdad Governorate, GIS Division, unpublished data, 2022

Fig ٢ areas of sanitary landfills in Baghdad Governorate in 2022



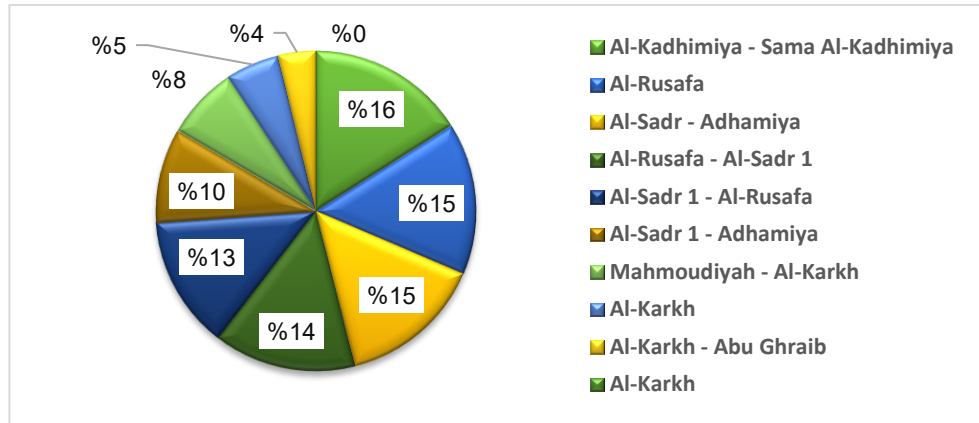
Source. Republic of Iraq, Baghdad Municipality, Planning and Follow-up Division, 2022.

The previous table shows the difference in the areas allocated for sanitary landfill. Al-Ammari landfill in Al-Zawraa District occupied the highest allocated area with an area of 875,000 square meters, followed by Al-Bu'itha landfill with an area of 725,000 square meters, and after that, Al-Nahrawan landfill with an area of 250,000 square meters, all of which are permanent landfill sites, while the smallest place allocated for sanitary landfill is located In the Kasra area in Al-Adhamiya district, with an area of 600 square meters, it is a temporary **Table (3): solid Waste compactors and their affiliated municipal department, in addition to the quantity of solid waste entering the station in tons for the year 2022:**

Sq	Station name	Location	Districts which receive it	Total solid waste entered annually	percentage
١	Al-Shuala	Al-Sabiyat - Al-Shuala	Al-Kadhimiya - Sama Al-Kadhimiya	١٠٥٢٣	١٦,٠٣٠.١٦
٢	Alzaefarania	Rustamiya- Al-Za'franiya	Al-Rusafa	١٠١٠٥	١٥,٣٩٣.٤
٣	Shaab	Al-Hamidiyah - Sadr City	Al-Sadr - Adhamiya	٩٥٩١	١٤,٦١٠.٤
٤	Al-Rusafa	April 7 - Al-Ghadir	Al-Rusafa - Al-Sadr 1	٩٤٦٤	١٤,٤١٦.٩٤
٥	Ghadeer	Al-Shamaya - Sadr City	Al-Sadr 1 - Al-Rusafa	٨٨١٧	١٣,٤٣١.٣٤
٦	Sader city 1	Al-Habibiyah - Sadr City	Al-Sadr 1 - Adhamiya	٦٢٣٧	٩,٥٠١.١٠.٤
٧	Al-Rashid camp	Industrial District - Al-Bayaa	Mahmoudiyah - Al-Karkh	٤٨٨١	٧,٤٣٥.٤٤٨
٨	Dora	Al-Sahha District - Dora	Al-Karkh	٣٥٣٥	٥,٣٨٥.٠.٢٦
٩	Amriya	Amriya	Al-Karkh - Abu Ghraib	٢٤٩٢	٣,٧٩٦.١٧٦
١٠	Mansor	Al-Mansour	Al-Karkh	0	.
	total			٦٥٦٤٥	100

Source: Baghdad Municipality, Solid Waste and Environment Department, Cleaning and Transfer Stations Department, 2022.

Percentage of quantities processed by solid waste compactors in 2022^٢ Fig



Source. Republic of Iraq, Baghdad Municipality, Planning and Follow-up Division, 2022.

In addition to the above topic The previous table (3) and(Fig 3) shows that the highest solid waste processing compactor is the Al-Shuala compactor with a production quantity of 10,523 tons annually, followed by the Al-Rustamiya compactor with a production quantity of 10,105 tons annually, then the Al-Shaab compactor located in the Al-Hamidiyah region with a production quantity of 9,591, and all of these are located on the Rusafa side, while the least productive located is the Al-Amriya compactor in The Karkh side, with the exception of the Al-Mansour compactors that stopped working .⁴

Solid Waste compactors efficiency in Baghdad :

This study showed The efficiency of processing difference solid waste types in landfill areas and the quantities processed in these presses. However, solid waste compactors efficiency in Baghdad Governorate poses a major challenge to the residents of areas close to sanitary landfills. Therefore, these sites in Baghdad are not suitable in their current locations. These sites are randomly distributed in Baghdad and their movement to and from their treatment areas is not controlled. The lack of strategic planning using modern technologies made this distribution has a negative impact on the residents of the capital. Moreover, the problem becomes more acute with the lack of logistical transportation of this solid waste which has made the municipal solid waste compactors efficiency system ineffective within the municipalities affiliated with the districts. This is coupled with the lack of machines and equipment for collecting and compressing this solid waste, in addition to the absence of strategies for the municipal solid waste system .⁵

Analysis method using GIS

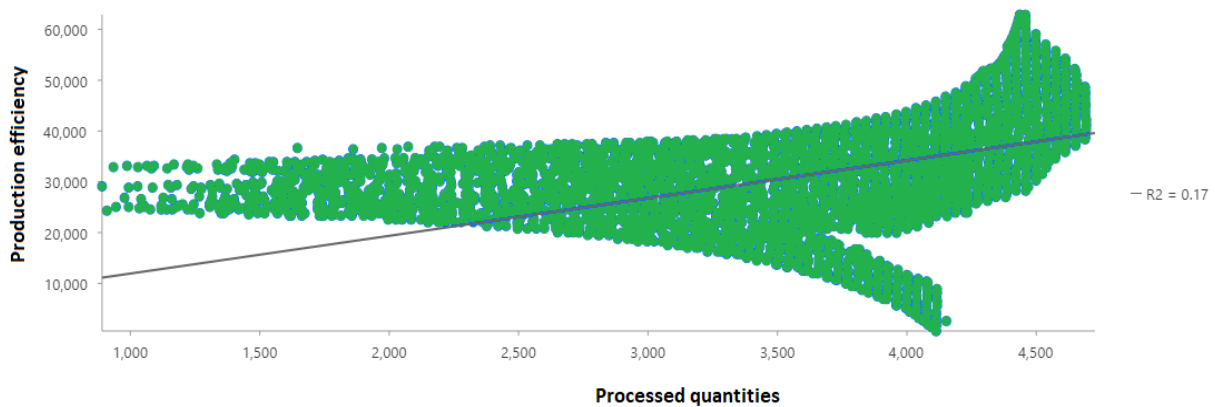
For solid waste compactors efficiency we used empirical Bayesian kriging To know the potential of these presses and which areas need to increase production to get rid of the waste problem .⁶

For a given distance h, empirical Bayesian kriging supports the following semivariograms:

Power method : $y(h) = \text{Nugget} + b|h|^\alpha$

where the h = distance and the Nugget and b must be positive, α (power) must be between 0.25 and 1.75. Under these restrictions, the parameters are estimated using Restricted maximum likelihood (REML. In EBK, it's possible to analyze the empirical distribution of the parameter estimates because many semivariograms are estimated at each location. As The figure below shows the relationship between production efficiency and processed quantities. (see Fig^٤) and (map 2)⁷

The relationship between production efficiency and processed quantities)Fig(4

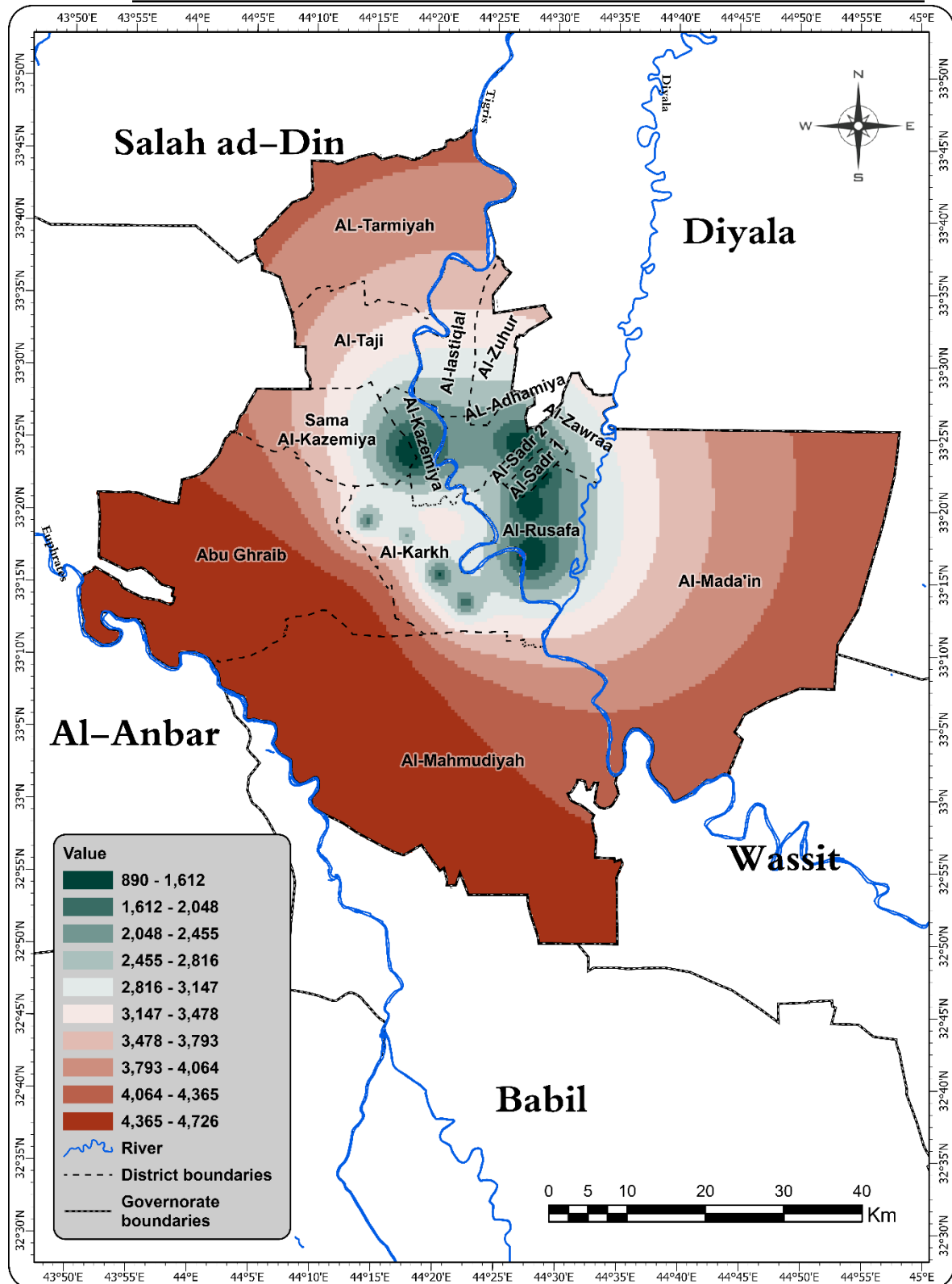


Dissection and Results

This article is based on data collected during the year 2023. Which was obtained in two ways: Information from Baghdad Municipality, Solid Waste and Environment Department, data for waste compactor and landfill area in 2022 .and Information from Ministry of Planning, Central Statistically Organization Iraq data for population , and urban zone in 2022 .

a combination of qualitative and quantitative research methodologies was selected to obtain solid waste compactors efficiency by processing quantitative data and analyzing it with a geographic information systems program and displaying the results in the form of an integrated map. These results were analyzed, processed and discussed in light of the theoretical framework, and this was done by integrating the quantitative and qualitative approaches in data analysis, using simple mathematical formulas and applying them in the geographic information systems program. the results of the study were as follows:

1. The person in Baghdad produces 1.3 kilograms of waste per day, which makes it difficult to treat all the waste In the long term , this makes increasing the efficiency and number of compactor necessary.
2. Although the production capacity of all compactor in Baghdad Governorate is equal, the efficiency of the solid waste compactor in the Rusafa side is greater than their efficiency in the Karkh side, due to the forced pressure to process the large quantities of waste in the Rusafa side.
3. The best locations for establishing solid waste compactors are near official landfills located in the suburbs of Baghdad



Source: From the researcher's work based on:

1. Republic of Iraq, Ministry of Water Resources, General Authority for Survey, Baghdad Administrative Map, in 2022.
2. ArcGIS Pro version 3.03. On a scale of 1/650000.

Conclusion : Solid Waste compactor's efficiency using GIS requires accurate data on solid waste generation in urban areas. a study was conducted to identify the positions of solid waste compactors and sanitary landfill sites, evaluate the solid waste compactors' work efficiency system in all parts of Baghdad Governorate, and suggest the best districts to establish new compactors . the study showed that there are 10 solid waste compactors corresponding to 15 solid waste landfill sites, all of these sites treat solid waste at an amount of 50 tons per day

at a rate Generating 1.3 kilograms of solid waste per capita per day. In Baghdad Governorate, which has a population of more than 10 million people according to the statistics of the Iraqi Ministry of Planning, the per capita production rate of this solid waste is estimated at 1.3 kilograms per day, as solid waste represents the highest percentage of food solid waste (54.8%), followed by plastic solid waste (25). (2%) and then paper solid waste (7%). The study also showed that Al-Sadr District 1 and Al-Sadr 2 represent the highest rates of solid waste production, while Abu Ghraib District is the least solid waste-producing district. After using statistical methods in GIS, the study concluded that solid waste compactors should be established outside the borders of Baghdad city , specifically in the districts of Mahmoudiyah and Abu Ghraib, which are not included in the scope of the compactors' work.

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هوامش البحث

¹ Abbas , Muhammad ,(2020) p 17.

² Ashour , Kamar , (2023) p 6

³ Republic of Iraq , Ministry of Planning, Central Statistically Organization Iraq (CSOI) "Estimation of Iraq Population" (2023).

⁴ Solid Waste and Environment Department, Cleaning and Transformation Stations Division, (2021).

⁵ Chang, Breeden, (2008) p139

⁶ <https://pro.arcgis.com/en/pro-app/latest/help/analysis/geostatistical-analyst/what-is-empirical-bayesian-kriging-.html>

⁷ Krivoruchko, K. (2011).p 928