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Development of Solid Waste Management Plan to Solve the Transport Routes Problem in Baghdad City

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Abstract

The transportation cost problem of solid waste presents the biggest part of the budget allocated by municipalities for SWM. So, there is no comprehensive plan to address transport routes optimization problems in SWM that including the transfer of solid waste from transfer stations to final landfill sites. Therefore, the aim of the study finding a scientific method to solve the transportation problem of solid waste transport suitable Baghdad city that tries to find feasible solutions that ensure reducing total transport costs and leads to an effective solid waste management system. In this research, a new methodology has been developed to select the optimal transport routs of SWM in Baghdad city which involves determining the best-supposed scenario. the proposed methodology includes integration of Global Positioning System (GPS) technologies with Network Analysis model (NA). Therefore, this work provides an advanced framework of decision-makers for analysis and simulation of the optimal transport routs problem related to SWM. Applying these modeling tools to select the scenario that can provide economic benefits by minimizing travel time, travel distance and reduction of total transportation costs. The Results of work implementation show that all solutions that include current state S1 and suggested scenarios have been evaluated. The scenarios generated include (S2, S3) by applying the proposed technique for analyzed and identified the optimal routes. The solutions of scenario S2, specified with two landfill sites while scenarios S3 specified with four landfill sites. Finally, this work shows the Scenario S3 is the best scenario of the solution, that include applied GPS and Network Analysis for four landfill sites.

Keywords: Solid Waste Management, GPS, Network Analysis, Transportation Route.

الخلاصة

تمثل مشكلة تكلفة نقل النفايات الصلبة الجزء الأكبر من الميزانية المخصصة من قبل البلديات لإدارة النفايات الصلبة. لذلك ، لا توجد خطة شاملة لمعالجة مشاكل تحسين طرق النقل في إدارة النفايات الصلبة والتي تشمل نقل النفايات الصلبة من محطات النقل إلى مواقع المكب النهائية. لذلك ، تهدف الدراسة إلى إيجاد طريقة علمية لحل مشكلة نقل النفايات الصلبة المناسبة لمدينة بغداد التي تحاول إيجاد حلول مجدية تضمن خفض إجمالي تكاليف النقل وتؤدي إلى نظام فعال لإدارة النفايات الصلبة.

في هذا البحث ، تم تطوير منهجية جديدة لاختيار مسارات النقل المثالية لإدارة النفايات الصلبة في مدينةبغداد والتي تنطوي على تحديد السيناريو الأفضل. تتضمن المنهجية المقترحة دمج تقنيات النظام العالمي لتحديد المواقع (GPS) مع نموذج تحليل الشبكة (NA). لذلك ، يوفر هذا العمل إطارًا متطورًا من صانعي القرار لتحليل ومحاكاة مشكلة مسارات النقل المثالية المتعلقة بإدارة النفايات الصلبة. تطبيق أدوات النمذجة هذه لتحديد السيناريو الذي يمكن أن يوفر فوائد اقتصادية عن طريق تقليل وقت السفر ومسافة السفر وتقليل إجمالي تكاليف النقل. توضح نتائج تنفيذ العمل أن جميع الحلول التي تتضمن الحالة الحالية S1 والسيناريوهات المقترحة تم تقييمها. تشمل السيناريوهات التي تم إنشاؤها (S2، S3) من خلال تطبيق التقنية المقترحة لتحليل وتحديد الطرق المثلى. حلول السيناريو S2 ، المحددة مع موقعي مكب النفايات ، بينما السيناريوهات S3 المحددة مع أربعة مواقع مكب نفايات. أخيرًا ، يوضح هذا العمل أن السيناريو S3 هو أفضل سيناريو للحل ، والذي يتضمن تطبيق GPS وتحليل الشبكة المطبق لأربعة مواقع لطمر النفايات.

1. Introduction

Currently, SWM is considered as one of the main problems in the world. Infrastructure, residential and commercial developments are increased because of the growth in and it results in bad impact on environment. The There are several technologies that are used for solving SWM's problem and how to decrease its cost. It contains several positions to study such as a collection of waste, transfer station, recycling, processing, and landfill. Solid waste transportation and disposal is the most important problem facing cities and urban communities in the world. The quantities of solid waste are increasing day by day compared to the previous days due to the increase in population and high standard of living. Therefore, the increase in the amount of solid waste can cause pollution of the environment elements of land, water, and air, as well as the depletion of natural resources. If not calculated and submitted in recognition of true may result in serious damage and losses cannot be compensated **[1]**. Baghdad city is currently suffering from the mismanagement of thousands of tons of solid waste generated daily and the adoption of incorrect methods in the process of transporting waste from the transfer stations to the final landfill sites. This resulted in wasted costs, inefficient disposal of waste and pressure on the transport network due to multiple trips to transport these large quantities generated daily. The study aims to determine the feasibility of the proposed methodology of the current position transport of solid waste in Baghdad city and recognition on the most important problems that Baghdad honesty faces them in the process of manage solid waste, therefor in this research developing a new methodology to transport solid waste from transformer stations to final landfill sites to find the optimal Routes an to decrease distance, time and the cost of transporting solid waste.

The transportation cost of solid waste has been reduced by managing and optimizing the waste transportation route. At present work, the cost is considered as the main criterion to select the solid waste transportation route. The proposed technique is used the network model to analyze the data obtained from the GPS to select the best transfer route. A new mechanism for the distribution of municipalities around the landfill stations leads to a decrease in the cost of disposing of solid waste.

This research will deal with the previous work that takes the Solid Waste Management (SWM) as a research topic, and it will address the most important researches in the field of SMW.

M. Matotek and D. Regodic, 2013[2] demonstrated the usability of possibilities of the WinQSB software package for application in transport management in companies where is necessary to take care of the reduction of transport charges.

J. E. Santibañez-Aguilar et al, 2013[3] used a mathematical programming model for the optimal planning of the supply chain associated with the MSW management system to maximize the economic benefit. The problem was formulated as a multi-objective linear programming problem, where the results are shown through Pareto curves that tradeoff economic and environmental aspect.

O. I. Amariei et at, 2015[4] used sub-modules of Network Modeling from WinQSB software to Minimizing transport distances, costs, and study of the effect which have a certain transport unit cost over the transport optimal program to realizing an optimal distribution of products to final beneficiaries.

N. Sh. Hadi (2015) [5] utilized the strategy for Vogel estimated model of transport for access to a lower cost of transport strong waste created from regions to landfill locales, so any improvement in the vehicle framework will prompt reserve funds in transport costs.

T. P. B. Vecchi et al, 2016 [6] The main objective of this paper present a sequential approach involving three phases for solving the optimization problem of truck routes for the collection of solid waste. The proposed methodology was tested using real data and efficiently solved the problem. The results led to a reduction in the distances traveled by trucks, which could promote money savings for the public coffers, as well as a reduction in carbon dioxide emissions.

M. Rabbani et al, 2016 [7] proposed a various leveled structure to limit the all-out cost of waste assortment directing issues. In addition, the ruinous ecological impacts of waste transportation are limited simultaneously by exploiting a street, squander packs are moved to the last goal while travel time and environmental threatening are minimized. Proved that RIPv2 routing protocol can be deployed inside a medium range network infrastructure.

F. Posso, et al. 2017[8] focused on the Ecuadorian provinces with the most significant potential for diesel fuel-to-H2 replacement. To this end, the specific purpose of this work will be to create a preliminary technical overview to identify specific scenarios to be developed in future research and assessments.

K. Pardini, et al. 2019[9] advanced techniques for waste collection, and the use of technologies based on IoT and big data. There is also a vision of strengthening waste management based on public initiatives aimed at building more correct and safer environments, as well as reducing greenhouse gas emissions.

2. Proposed Methodology:

As mentioned early, the solid waste management is one of the costly urban services which require most of the municipal budgets, therefore the transportation cost of solid waste is considered as the main criterion to select the solid waste transportation route which can be reduced by managing and optimizing the waste transportation route. In this paper, a new proposed methodology has been introduced as shown in figure (1). This methodology used network analysis model to analyze the data obtained from the GPS technique to select the best transfer route. Developing of a new solid waste management method that will lead to investigate the aim and solving the problem by find the optimal transport routes to transport solid waste from transformer stations to final landfill sites through minimizing the distance, the time and the cost of transporting solid waste

2.1 Data Collection

In this, study data on different types of waste management facilities collected includes the following components. These real-time data allow to plan and optimize waste collection routes that can reduce the traveling distances of the waste transport vehicles.

It includes the transportation distances, waste transportation cost, duration of transfer the solid waste and quantities of generated waste number of shipments.

a. Transportation Distances (TD): Baghdad districts are varying in distances and design. Baghdad municipality's vehicles carry out the transport of households, commercial and industrial wastes from transformer stations and then transportation to the final landfill sites.

b. Transportation Time: The total time consumed to transfer one shipment of solid waste from transformer stations to the landfill stations.

c. Number of shipments (Quantity of solid waste each month): shipment is a quantity of solid waste transported from the transformer station to the fin landfill stations.

d. Transportation Cost: Is the cost incurred for the transportation of solid waste to the landfill stations performed in a given period Transportation cost including all fuel, oil and maintenance cost of transportation vehicles.

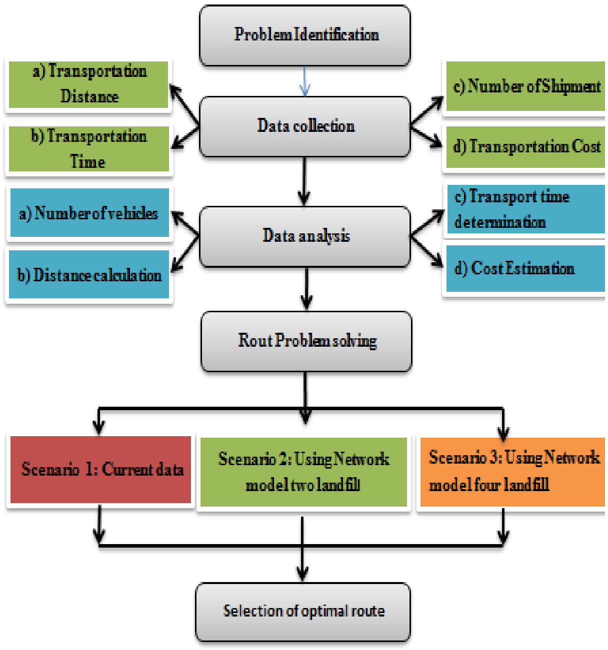

Figure 1: The Proposed Methodology

2.2 Data Analysis:

Data analysis is a procedure of reviewing, changing and demonstrating gathered information with the target of finding helpful data, the data collected can be divided into five sections (Calculate waste Quantities, Number of vehicles required, Distance Calculation, Real-time of transferring the solid waste and Cost Estimations), analyze and modeling them to obtain the required goal.

a. Calculate Waste Quantities:

In this work, we have adopted data for one season and because of the different number of shipments each month, we have calculated the rate of shipments per season for nine municipalities of Baghdad, we can calculate the number of tons per day by using equation(1).

$$\textit{Number of tons per day} = \frac{N_S * T_S}{30 \textit{ day per month}} \ldots\ldots\ldots (1)$$

N_S = Number of shipments per month.
T_S = Number of tons per shipment

b. Number of vehicles required (N_v):

To determine the number of vehicles required for each municipality, the number of shipments of solid waste in each municipality must be
Divided by the capacity of the vehicle in tons; it can be calculated by equation (2).

$$N_v = \frac{Q_w}{S_v} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Q_w: Quantity of waste generated (tons).
S_v: Number of tons per shipment.
N_v: Number of vehicles.

c. Distance Calculation (DC):

To calculate the distance traveled by the vehicle to transport waste, by monitoring the vehicle by a GPS device and connected to a particular mechanism to calculate the distance traveled to transfer one shipment from the transformer stations to the final landfill sites.

d. The real time of transferring the solid waste (T_v):

The real-time of transferring the solid waste is calculated by GPS devise for each shipment, according to the current plan of solid waste management between the transfer stations and landfill stations. There are only four sites of landfill stations Abu Ghraib, Nibaei, Nahrwan and Bueatha landfill station.

2.3 Cost Estimations:

It includes the cost of all services specifically incurred for transferring solid waste.The cost estimation of solid waste specifies for the vehicle type of Astra. In this study, the cost elements consist of (Fuel cost, oil cost, and maintenance cost).

- **Fuel cost (FC):** it is the price of fuel that consumed to move solid waste per kilometer. Baghdad municipality determines half a liter of fuel therefor the fuel cost calculation for each one kilometer as fallowing.

$$\textbf{Fuel cost} = \textbf{0.5 liter} * \mathbf{P_f} \ldots\ldots (3)$$

P_f = price of fuel

Price of one liter fuel = 400 Iraq dinar (ID) therefor

$$\textbf{Fuel cost of each kilometer} = \textbf{0,5 liter} * \textbf{400} = \textbf{200 ID}$$

- **Oil cost (OC):** It refers to the price of oil used in the transportation vehicle to transfer the solid waste for landfill stations. According to the exchange mechanism used in the Municipality of Baghdad

(Production Department) for vehicle oil that per 3000 kilograms 34 liters or approximately per kilo (0.011) liters so that the price is approximately 30 dinars per kilo.

- **Maintenance Cost (M_C) :** Are the cost incurred to keep a vehicle in good condition or good working order. The maintenance cost of transportation vehicle is calculated by the production department and the mechanical plant responsible for the maintenance of vehicles included the maintenance cycle and the change of some parts per month approximately 1325000, which is approximately daily 51000 thousand dinars. Therefor find the maintenance cost per kilometer determine the maintenance cost per day and divided this cost on the total distance of each municipality.

$$\textbf{Maintenance cost} = \frac{\textbf{(monthly cost/30)}}{\textbf{total distance}} \text{........ (4)}$$

Therefor the total cost per kilometer for fuel, oil and maintenance shows as follows:

$$C_t = C_f + C_o + C_m \text{ .... (5)}$$

C_t : Final cost
C_f : cost fuel per kilometer
C_o : The cost of oil per kilometer
C_m: Maintenance cost per kilometer

The total cost of transportation of solid waste per kilometer can be calculated as follow:

C_t =200 + 30 + 620 = 850 ID/km

The total cost of one day is calculated from equation (10) and the total cost per ton is calculated by equation (11)

$$T_c = C_t * T_d * N_{ov} \text{ .... (6)}$$

T_c : Total cost per day (ID)
C_t : Final cost = 850 DI
T_d: Traveled distance Km
N_{ov}: Number of vehicles required

$$T_{ct} = \frac{T_c}{Q_w} \text{.................... (7)}$$

T_{ct}: Transport cost per ton (ID)
T_c: Total cost per day (ID)
Q_w: Quantity of waste ton /day

2.4 Transportation Model

To the motivation behind coming to objective was depended a theory that implying that apply quantitative strategies particularly transportation model for moving solid waste from transformer stations to conclusive landfill locales, based on daily will prompt abatement expenses of transport to the ideal levels and interest in taking care of the issue of transportation of solid waste in Baghdad city **[11, 12]**.

1) (m) = Source (Represents display centers. in our study the sources of solid waste production).
- (n) = Destination (Represent demand centers. In our study the final landfill sites).
- (ai) = Quantity offered (The quantity supplied in each source i)
- (bj) = Quantity required (Represents landfill capacity j).
- (xij) = Number unit of Transfer (Represents the amount of waste transferred from source i to site j).
- **(Cij)** = Cost unit of yransport (represents the cost of transporting the unit from the transfer stations i to the final landfill site j)

2) Minimize Z= $\sum_{i-1}^{m} \sum_{j=1}^{n} c_{ij} \times x_{ij}$ **.. (12)**

It means that the total cost of transferring solid waste from municipalities to different demand centers should be minimal.

3) $\sum_{j=1}^{n} x_{ij} = ai,\quad i = 1, 2, 3, \dots m$,
$\sum_{j=1}^{m} x_{ij} = bj,\quad j = 1, 2, 3 \dots n$**..... (8)**

4) $\sum_{i=1}^{n} ai = \sum_{j-1}^{m} bj$**………………….……(9)**

5) Minimize Z=$\sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} \times x_{ij}$ **.......(10)**

Subject to:

$\sum_{i=1}^{m} x_{ij} = bi,\quad 1 = 1, 2, 3, \dots, n$
$\sum_{j=1}^{n} x_{ij} = ai,\quad 1 = \ 1, 2, 3, \dots, m$
$x_{ij} \geq 0$

3. Case study:

In this research, Baghdad city selected as case study according to the solid waste problem. The governorate of Baghdad was the highest governorate in the population of 2018 with a population of (8,126,755) and a percentage of (21%) of the total population of the governorate. The population of urban areas in Baghdad (7,110,234) was 87% of the total population of the governorate, while the population of rural areas (1,016,521) was 13 % (central statistical organizations Iraq) **[10].** Distribution of the population of Iraq by governorate for 2018 shown in Figure (2).

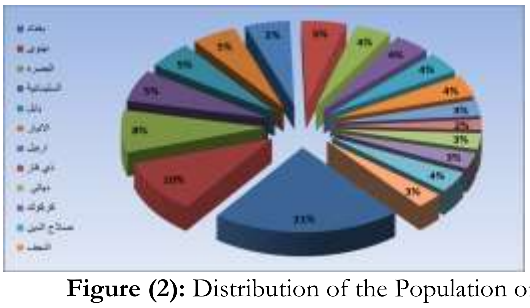

Figure (2): Distribution of the Population of Iraq by Governorate for 2018.

The Mayoralty of Baghdad is partitioned into fourteen regions (Beladiya). Baghdad mayoralties are shown in figure (3), as a map obtained from Baghdad mayoralty.

Figure (3): Map of Baghdad Municipalities

In our study we will address only municipalities that have a waste transformer station as show in figure (4)

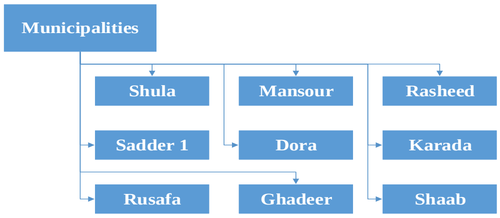

Figure (4): Municipalities That Have a Transformer Stations.

3.1 Route Problem Solving:

In this section, the solution method presented as a scenario of solution depending on the nature of the data obtained from the problem.

First, and second scenario are solved based on two landfill stations but the third scenario is solved based on four landfill stations which illustrated as follows:-

Scenario 1: Calculate the final costs according to the distribution mechanism of municipalities applied by Baghdad mayoralty based on GPS data.

Scenario 2: Optimize the route by transport model according to the distribution mechanism of municipalities applied by Baghdad mayoralty based on GPS data.

Scenario 3: Distribute municipalities for four landfill stations by using transport model based on GPS data

Scenario 1: we will clarify the mechanism of the mayoralty of Baghdad in the distribution of municipalities at the final landfill sites. According to the data obtained from the Mayoralty of Baghdad and analyzed previously, travel distance, real-time of one trip, a quantity of waste, number of vehicles required, total cost per day and transportation cost per ton in the table (1).

Table (1) Distribution of municipalities at the final landfill sites by GPS.

	Municipalities	Landfill	*Qw* ton /day	*Nov* per day	*Td* trip/km	*Td* day/ km	*Tv* trip/km	*Tv* day/km	*Tct* ton/ (ID)	*Tc* day(ID)
1	Al – Shula	Abu Ghraib	180	9	82	738	2:13:18	19:59:42	3485	627300
2	Al – Mansour	Abu Ghraib	440	22	71	1562	1:56:03	42:33:06	3017	1327480
3	Al – Rasheed	Alnibaei	404	21	142	2982	3:48:50	80:05:30	6274	2534696
4	Al – Dora	Abu Ghraib	221	12	105	1260	2:38:27	31:41:24	4846	1070966
5	Al – Rusafa	Alnibaei	120	6	123	738	3:29:28	20:56:48	5227	627240
6	Al – Sadder 1	Alnibaei	90	5	121	605	03:38:18	18:11:30	5713	514170
7	Al - karada	Alnibaei	221	12	147	1764	04:05:36	49:07:12	6784	1499264
8	Al – Ghadeer	Abu Ghraib	178	9	142	1278	03:50:25	34:33:45	6102	1086156
9	Al – Shaab	Abu Ghraib	101	6	129	774	03:36:10	21:37:00	6513	657813
Total (Distance, Time , Cost)per day (ID)						11701		318:45:57		9287272

Scenario 2:

Table (2) demonstrates the program interface and transportation costs for second scenario.

Table (3) from the solution obtained from WINQSB software, we discovered a change in some municipal trajectories for the landfill sites specified by the municipality of Baghdad.

In this scenario, the best transferring route is selected by using WINQSB software (network technique). Explains the distribution mechanism of Baghdad municipalities' to the final landfill sites, we note that a clear decrease in the time and final costs of transferring and landing of the solid waste as shown in the table (4).

Table (2) illustrating the program's interfaced and transport costs

From \ To	Abu Ghraib	ALnibaei	Supply
AL- Shula	3485	3910	180
AL- Mansour	3017	5015	440
AL- Rasheed	3932	6274	404
AL- Dora	4846	5723	221
AL- Rusafa	5610	5227	120
AL- Sadder 1	6138	5713	90
AL- Karada	5630	6784	221
AL- Ghadeer	6102	5973	178
AL- Shaab	6513	6160	101
Demand	1500	1500	

Table (3) Solution of Transport Model for second scenario

02-07-2020	From	To	Shipment	Unit Cost	Total Cost	Reduced Cost
1	AL- Shula	Abu Ghraib	180	3485	627300	0
2	AL- Mansour	Abu Ghraib	440	3017	1327480	0
3	AL- Rasheed	Abu Ghraib	404	3932	1588528	0
4	AL- Dora	Abu Ghraib	221	4846	1070966	0
5	AL- Rusafa	ALnibaei	120	5227	627240	0
6	AL- Sadder 1	ALnibaei	90	5713	514170	0
7	AL- Karada	Abu Ghraib	221	5630	1244230	0
8	AL- Ghadeer	ALnibaei	178	5973	1063194	0
9	AL- Shaab	ALnibaei	101	6160	622160	0
10	Unfilled_Demand	Abu Ghraib	34	0	0	0
11	Unfilled_Demand	ALnibaei	1011	0	0	0
	Total	Objective	Function	Value =	8685268	

Table (4): Final Solution of the second Scenario

	Municipalities	Landfill	*Qw* ton /day	*Nov* per day	*Td* trip/km	*Td* day/ km	*Tv* trip/ km	*Tv* day/ km	*Tct* ton/ (ID)	*Tc* day(ID)
1	Al – Shula	Abu Ghraib	180	9	82	738	2:13:18	19:59:42	3485	627300
2	Al – Mansour	Abu Ghraib	440	22	71	1562	1:56:03	42:33:06	3017	1327480
3	Al – Rasheed	Abu Ghraib	404	21	89	1869	2:23:22	50:10:42	3932	1588528
4	Al – Dora	Abu Ghraib	221	12	105	1260	2:38:27	31:41:24	4846	1070966
5	Al – Rusafa	Alnibaei	120	6	123	738	3:29:28	20:56:48	5227	627240
6	Al – Sadder 1	Alnibaei	90	5	121	605	03:38:18	18:11:30	5713	514170
7	Al - karada	Abu Ghraib	221	12	122	1464	03:23:33	40:42:36	5630	1244230
8	Al – Ghadeer	Alnibaei	178	9	139	1251	3:45:59	33:53:53	5973	1063194
9	Al – Shaab	Alnibaei	101	6	122	732	3:24:34	20:27:26	6160	622160
Total (Distance, Time , Cost)per day (ID)						10219		278:37:07		8685268

Scenario 3: Optimization of transport routes for four landfill sites can be obtained by GPS. (Al-buaitha, Nahrwan, Abu Ghraib and Al_Nibaie) according to the data approved by the Baghdad mayoralty (GPS) distribution are shown in table (5).

We notice that using the distribution of municipalities to the four landfill sites and the use of GPS data significantly reduced cost and time compared to the previous scenario as shown in Table (6).

It is noted that the Distribution of municipalities to the four landfill sites data significantly reduces cost and time compared to the previous scenarios, as shown in Table (7).

Table (5) illustrating the program's interfaced and transport costs

From \ To	Abu Ghraib	AL nibaei	AL bueatha	AL nahrwan	Supply
AL Shula	3485	3910	3060	6885	180
AL Mansour	3017	5015	2125	6205	440
AL Rasheed	3932	6274	1678	5567	404
AL Dora	4846	5723	1476	5353	221
AL Rusafa	5610	5227	2380	3910	120
AL Sadder	6138	5713	2833	4722	90
AL Karada	5630	6784	1569	4153	221
AL Ghadeer	6102	5973	2320	3438	178
AL SHaab	6513	6160	3282	4241	101
Demand	1500	1500	1000	1000	

Table (6) Solution of transport model for the third scenario.

10-27-2019	From	To	Shipment	Unit Cost	Total Cost	Reduced Cost
1	AL Shula	Abu Ghraib	180	3485	627300	0
2	AL Mansour	Abu Ghraib	440	3017	1327480	0
3	AL Rasheed	AL bueatha	404	1678	677912	0
4	AL Dora	AL bueatha	221	1476	326196	0
5	AL Rusafa	AL bueatha	64	2380	152320	0
6	AL Rusafa	AL nahrwan	56	3910	218960	0
7	AL Sadder	AL bueatha	90	2833	254970	0
8	AL Karada	AL bueatha	221	1569	346749	0
9	AL Ghadeer	AL nahrwan	178	3438	611964	0
10	AL SHaab	AL nahrwan	101	4241	428341	0
11	Unfilled_Demand	Abu Ghraib	380	0	0	0
12	Unfilled_Demand	AL nibaei	1000	0	0	0
13	Unfilled_Demand	AL nahrwan	665	0	0	0
	Total	Objective	Function	Value =	4972192	

Table (7): Final Solution of the third Scenario

	Municipalities	Landfill	*Qw* ton /day	*Nov* per day	*Td* trip/Km	*Td* day/Km	*Tv* trip/Km	*Tv* day/Km	*Tct* ton/ (ID)	*Tc* day(ID)
1	Al – Shula	Abu Ghraib	180	9	82	738	2:13:18	19:59:07	3485	627300
2	Al – Mansour	Abu Ghraib	440	22	71	1562	1:56:03	42;54:06	3017	1327480
3	Al – Rasheed	albueatha	404	21	38	798	01:01:01	21:35:21	1678	677912
4	Al – Dora	albueatha	221	12	32	384	00:51:17	10:23:24	1476	326196
5	Al – Rusafa	albueatha	64	3	56	168	01:35:28	05:17:48	2380	152320
5	Al – Rusafa	Nahrwan	56	3	92	276	02:36:04	08:48:12	3910	218960
6	Al – Sadder 1	albueatha	90	5	60	300	01:48:18	14:01:30	2833	254970
7	Al - karada	albueatha	221	12	34	408	00:57:14	11:26:48	1569	346749
8	Al – Ghadeer	Nahrwan	178	9	80	720	02:10:13	19:31:57	3438	611964
9	Al – Shaab	Nahrwan	101	6	84	504	02:21:09	14:31:34	4241	428341
Total (Distance, Time , Cost)per day (ID)						5858		125:35:41		4972192

4. Results and Discussion:

This research first intended to identify the most suitable scenarios to solve the transportation problem of SWM from transfer stations into landfill sites in Baghdad city which chosen as a case study. An optimization of transport route selection has been carried out by employing the GPS and network analysis method.

Therefore, selection of an optimal transport route is based on the obtained results of actual real state of initial scenario (S1) and compared it along with two other suggested scenarios (S2, S3,). These final results of all supposed scenarios have been analyzing and represented that as shown in Table (8).

As explained in the table, the final results of scenarios will allow better service and contribute to significant gains for the transportation operation with reductions of total transport distance, transport time, and estimation costs respectively without mentioning the extra benefits related to fuel consumption, CO_2 emissions maintenance of the vehicle, etc

Table (8): Final Results of all Supposed Scenarios.

Total (Distance, Time ,Cost) Per One year						
No	Data	Software	Landfill	Total Distance/Km	Total Time/Hour	Total Cost/ID
Scenario 1	GPS	…….	(AbuGhraib & Nibaei)	4212360	114755	3343417920
Scenario 2	GPS	WinQsb	(AbuGhraib & Nibaei)	3678840	100302	2902718880
Scenario 3	GPS	WinQsb	(AbuGhraib, Nibaei , Nahrwan, Bueatha)	2108880	45214	1789989120

The results obtained of supposed scenarios (S2, S3,) as shown in the previous table indicate that reduction of all input parameters studied (Distance, Time and Cost) compared with the initial state of scenario (S1). Therefore, we can see the final results of all assumed scenarios have a feasible solution that illustrates more accurate in the following figures (5, 6 and 7).

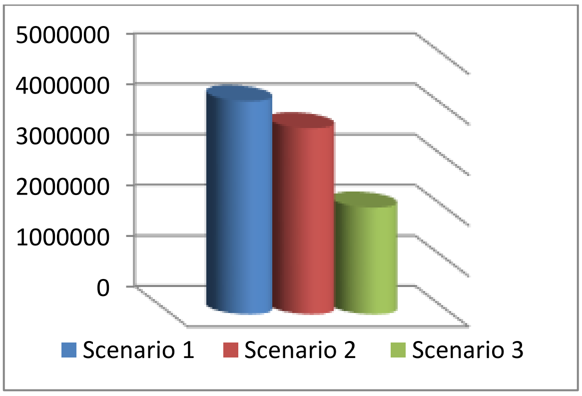

Figure (5): Final Results Distance of all Assumed Scenarios.

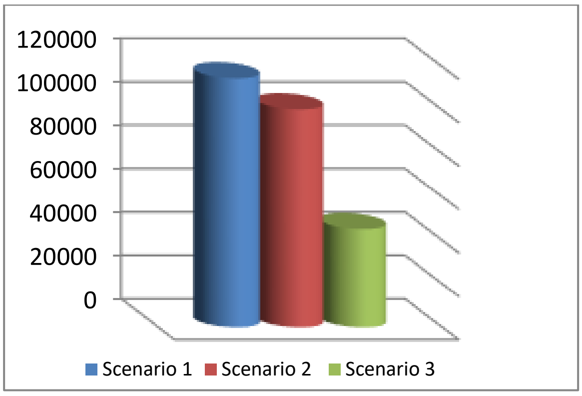

Figure (6): Final Results Distance of all Assumed Scenarios.

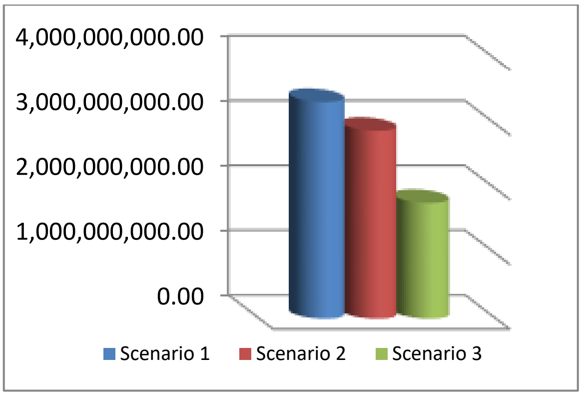

Figure (7): Final Results cost of all Assumed Scenarios.

5. Conclusions

Here are some future investigation proposals which can be received as a subsequent stage to the proposed model for the study zone.

1. Based on the data obtained from GPS and with the using of two landfill stations and solving the data by using Network transportation model, We note a decrease in the final cost (440699040ID) of transporting solid waste.

2. The use of the transportation model using four landfills resulted accomplished a decrease with solid waste transportation costs from its transformer stations to the final landfill sites where the interest has reached (1553428800ID)

3. Insufficient landfill sites in Baghdad, where there are only two regions (Abu Ghraib, AL Nibeai) which offer fewer options in transportation routes as some of them do not have other options that cause higher transportation costs.

4. The route of waste transport vehicles is random, and the best and economical route is not chosen, but the path is determined by the vehicle driver or staff.

5. Lack of paved roads for easy movement of vehicles transporting solid waste to final landfill sites and lack of a sufficient number of vehicles in landfill sites.

6. Finally, conclude the Scenario S3 is the best scenario of solution in this work, that include applied GPS and Network Analysis for four landfill sites.

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