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ANALYZING PROBLEM OF TRANSPORTING THE SOLID WASTE BY USING THE METHOD OF LINEAR PROGRAMMING 2009-2014 (CASE STUDY OF SHATT AL-ARAB DISTRICT)

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ABSTRACT

A problem of solid waste became in the present day common global problem among all countries, whether developing or developed countries and can say that no country in the world today is immuning from this dilemma which must find appropriate solutions. The problem has reached a stage that cannot ignore or delay, but has became a daily problem occupies the minds of ecologists, economists and politicians took occupies center front in the lists of priorities for the countries in terms of finding solutions to the rapid scientific and radical them. and that transport costs constitute an important component of total costs borne by the municipal districts in the process of disposal of solid waste, so any improvement in the transport system will lead to savings in transport costs, so it will use the method of Vogel approximate model of transport for access to a lower cost of transport solid waste generated from areas to landfill sites.

Keywords: Transport Solid Waste; Vogel Approximate Model; Landfill Sites.

تحليل مشكلة نقل النفايات الصلبة باستخدام أسلوب البرمجة الخطية للمدة
(2009–2014) حالة دراسية لقضاء شط العرب

الخلاصة

أصبحت مشكلة المخلفات الصلبة في وقتنا الحاضر مشكلة عالمية مشتركة بين جميع الدول ، سواء كانت دولا نامية أم متقدمة ، ويمكن القول بأنه لاتوجد دولة في عالم اليوم بمنجى من هذه المشكلة التي يجب إيجاد حلول مناسبة لها. وأن المشكلة وصلت إلى مرحلة لاتحتمل التجاهل أو التأجيل وإنما أصبحت مشكلة يومية تشغل عقول البيئيين والاقتصاديين والساسة وأخذت تحتل مركز الصدارة ضمن قوائم الأولويات للدول من ناحية إيجاد الحلول العلمية والجذرية السريعة لها. وأن تكاليف النقل تشكل عنصرا مهما من مجموع التكاليف التي تتحملها الدوائر البلدية في عملية التخلص من النفايات الصلبة ، لذلك فان أي تحسين في نظام النقل سيؤدي إلى توفير في تكاليف النقل ، لذلك سيتم استخدام طريقة فوجل التقريبية من نموذج النقل من اجل الوصول إلى أدنى كلفة نقل للنفايات الصلبة من مناطق تولدها إلى مواقع الطمر الصحي .

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1. INTRODUCTION

A Problem of solid waste and dispose of it has became one of the most prominent problems that face cities and civilized societies in the world as Basrah city in the Shatt al-Arab district , then quantities are resulting from solid waste are increase taker day after the other in comparison with passed days because increase of population , rise level of living that led to increase consumption behavior of individual ,and the problem has reached to point unbearable neglecting or delay , indeed Became a daily problem be occupied minds of environmentalists , economists and politicians ,and take occupy center of front within priorities lists to the states from the side of founding scientific and fast radicalism solutions to them.

Figure 1 Digital design map of Shatt al-Arab district

(Shatt al Arab municipal office, 2014)

Consequently increase quantity of solid waste enormously may cause pollute environment's elements as ground , water and air , also depletion of natural resources , so the process of assembling , transporting and disposing of solid waste had becoming occupy a great realm of importance these days , such as costs of transporting form a significant element of total of costs that municipality offices bear them in the process of disposing of solid waste , so any improve in the system of transportation will lead to save in costs of transporting [1&2].

Fig. 1 Show a Revive the Shatt Al-Arab District and Paths mechanisms neighborhoods to landfill, a digital map of Shatt al-Arab district is prepared by the implementation of Geographic Information System (GIS) in scale of 1: 250,000.

Shatt al-Arab district site in the Southeast of Basra Governorate and Area administrative boundaries (293150 km^2), The Basic design space (7725 km^2) with housing units number (18916 Residential unit) and Tiled Street lengths(46850 m. L). The number of mosques and government offices in the Shatt al-Arab district as shown in Fig.2.

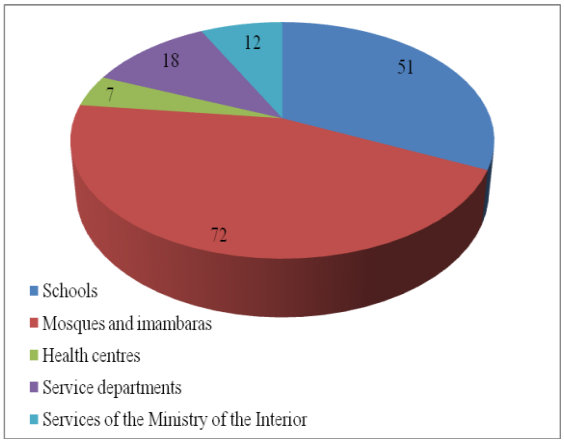

Figure 2 Number of mosques and government offices in the Shatt al-Arab district

According to this digital map produced of Shatt al-Arab area. Its three region obtained from the prepared digital map, and some of district neighborhoods named are presented in Table 1.

Table1 Shatt al-Arab district neighborhoods [Houses, Stores and Streets]

Region	Number	Neighborhood
Algahtt (16900m.L)	Residential units(6154)	Street (from 32 to 35), Secretion 57 + Street (from 41 to 43), Street (from 36 to 40), Street (from 44 to 50), Aljhamaa, Alhianeia + Almothfen, Alsuhada + Hor salean, Krdlan, River hassen, Shalamjah border port.
Alandlas (12150m.L)	Residential units(4604)	Street(from 1 to 8) , Street(from 9 to 15) , Street(from 16 to 17) , Street(from 18 to 28) , Street 29 + Dayhgn + Agriculture role, Pete zair + Apostle street + Catarrh halaf, Alparis(Area with narrow streets) , Alsalhaa , Alkahder + Albatran.
Main Street (10800m.L)	Stores (716)	Martyr canaan bridge , Main justice entrance , Main street from al-falkaa to the mosque al tanuma , Main street of al tanuma (market) to rasheed bank , From rasheed bank to clinic , From clinic to water project , From water project to army regiment , From army regiment to falkaa , Justice entrance from shalamjah , Justice entrance from alfayhaa.

This study attempt to stand on the current position to process of assemble, transport and handling of solid waste in Shatt al-Arab district and recognition on the most important problems that Shatt al-Arab district honesty faces them in process of manage waste, also try for designing model to transport solid waste as participate to decrease costs of transporting solid waste from assembling areas to areas of healthy embedding [3].

2. SOLID WASTE GENERATION

Municipal solid waste collection (MSWC) has about 85% proportion of the total cost for solid waste management system [4]. MSWC is the beginning of the process of solid waste management which consists of generation, collection, transfer, treatment and final disposal. Integrated solid waste management involves a variety of programs and facilities, and incorporates source reduction, reuse, recycling, composting, incineration and land filling [5&6]. Reliable estimate of the quantity of solid waste generated in the Shatt al-Arab district is very important in the planning for proper solid waste management. The official estimated Shatt al-Arab district population in 2009 is 120640 according to statistic department 2009. Table2 shows the quantity of waste generation in Shatt al-Arab district alone is projected to increase from 27375 tons in 2009 up to 60264 tons in 2014.

Table2 Status of Municipal Solid Waste Management in Shatt al-Arab district,

(Shatt al Arab municipal office, 2014)

Year	Population	MSW generation (tones/year)	MSW generation (tones/day)	MSW generation rate (kg/capita/day)
2009	120640	27535	75	0.62
2010	124000	38454	105	0.85
2011	124000	38875	107	0.86
2012	129000	40958	112	0.87
2013	132870	42480	116	0.87
2014	141680	60260	165	1.16

2.1 Primary Collection System of Solid Waste

The management of solid waste in Shatt al-Arab district is neither community based nor community participated .The household, commercial and industrial wastes are deposited from the source to the collection bins (concrete/C.I. sheet) located on the streets. In some areas demountable containers are used for onsite storage of municipal solid waste. All parts of the district are not provided with these bins and there are no specific rules and criteria of placing the dustbins. In cases where there are no bins, waste is simply dumped on the ground [7].

2.2 Transportation of Solid Waste

The fleet of Shatt al-Arab district vehicles, which vary in size, age and design, carries out the collection of household, commercial and industrial wastes from collection bins and then transportation to the dumping sites as shown in Table3.

Table3 The mechanisms monthly used in the transport of waste

(Shatt al Arab municipal office, 2014)

Year	Waste Compressors	Tipper	Tipper lorries	Puller	Dnepr	Container	Shovel
2009	8	3	---	5	---	---	2
2010	8	2	1	4	1	108	1
2011	9	---	2	4	---	182	1
2012	9	---	2	4	---	182	2
2013	11	9	2	2	1	182	2
2014	24	8	---	1	1	---	2

The Shatt al-Arab district waste disposal site is at part of the piece (10) km 28 bibans, which is located 3km from an international road. The transport department, according to the requirement of the conservancy department, fixes number of trips of vehicles and schedule. Unplanned distribution of trips and under-utilization of vehicles cause reduction of collection efficiency and increases cost. It is also observed that 15%-25% trip/vehicle. Day are not executed / completed by the vehicle driver to save fuel. In case of open truck, wastes are overloaded to save trip. Most of the vehicle drivers are drawing overtime bill at an average of 250 hour/month, which is equal to additional one shift (8hr).

2.3 Final Disposal of Solid Waste

The disposes solid wastes adopting crude dumping methods, and thereby, creates environmental hazards and health risks. The dumped solid wastes are dressed irregularly by pay loaders, excavator, tyre dozer, chain dozer etc [8].

According to Shatt al-Arab district for period (2009-2014), one dumping site have already been abandoned after filling to their capacities. This site is at part of the piece (10) km 28 bibans. In period (2009-2014), almost all the wastes go to 28 bibans, and others are used when 28 bibans site is inaccessible due to rain or damage of driveways, repairing and maintenance of unloading platforms.

According to landfill estimates, the existing site would be filled up shortly and Shatt al-Arab district would have to arrange for new dumping sites for waste disposal. Accordingly, Shatt al-Arab district selected new site for dumping of solid wastes which is located 13km from an international road in year (2015).

3. TRANSPORT MODEL

To the purpose of reaching to objective was depended a hypothesis that meaning that apply quantitative methods especially transportation model for transporting solid waste from areas of assembling waste to areas of healthy embedding, on the basis of yearly will lead to decrease costs of transport to the optimal levels and participation in handling the problem of accumulation of solid waste in Shatt al-Arab district as shown in Table4.

Hypothesis Transport Model [9&10]

1) (m) = Source

   (n) = Destination

   (ai) = Quantity offered

   (bj) = Quantity required

   (xij) = Number unit of Transfer

(cij) = Cost unit of Transport

2. Minimize Z = $\sum_{i=1}^{m} \sum_{j=1}^{n} Cij \times ij$

3) $\sum_{j=1}^{n} \times ij$ = ai, i= 1, 2, 3…m , $\sum_{j=1}^{m} \times ij$ = bj, j = 1, 2, 3, n

4) $\sum_{i=1}^{m} ai = \sum_{j=1}^{n} bj$

5) Minimize Z = $\sum_{i=1}^{m} \sum_{j=1}^{n} Cij \times ij$

Subject to:

$\sum_{j=1}^{n} \times ij$ = ai, 1=1, 2, 3,…,m

$\sum_{i=1}^{m} \times ij$ = bj , j =1, 2, 3 ….n

Xij ≥ 0

Table4 General specimen transport

To / From		Destination						Supply
		D_1	D_2	….	D_j	….	D_n	
Source	S_1	C_{11} X_{11}	C_{12} X_{12}	….	C_{1j} X_{1j}	….	C_{1n} X_{1n}	a_1
	S_2	C_{21} X_{21}	C_{22} X_{22}	….	C_{2j} X_{2j}	….	C_{2n} X_{2n}	a_2
	S_i	C_{i1} X_{i1}	C_{i2} X_{i2}	….	C_{ij} X_{ij}	….	C_{in} X_{in}	a_i
	S_m	C_{m1} X_{m1}	C_{m2} X_{m2}	….	C_{mj} X_{mj}	….	C_{mn} X_{mn}	a_m
Demand		b_1	b_2	….	b_j	….	b_n	∑ai=∑bj

Source: [11]

The special structure of the transportation problem allows securing a nonartificiaI starting basic solution using one of three methods:

1. Northwest-corner method
2. Least-cost method
3. Vogel approximation method

The three methods differ in the "quality" of the starting basic solution they produce, in the sense that a better starting solution yields a smaller objective value. In

general, though not always, the Vogel method yields the best starting basic solution, and the northwest-corner method yields the worst. The tradeoff is that the northwest-corner method involves the least amount of computations [12].

Vogel approximation method

Its considered to be the most important way, for it can achieve the optimal solution on the approximate solution to the optimal solution, because it can overcome the faults of the previous method that depends on high cost cells that, it depends on calculating the payment cost for each row and column then take the highest possible payment[13&14].

The steps of finding the satisfactory basic fundamental solution in this way, after the assume that the transformation table is balanced, and as following:

- Calculate the payment costs for each row and column for transformation table, which is the difference of least two costs in each row or column, and the difference of these costs represents the increment of cost that should be eliminated, and it's called the penalty or payment costs, and it should be started on the right of row or down the column of transformation model.
- Determine the row or column of matrix with highest payment cost, and specify largest possible number of units to the least cost cell in the row or column, and that by calculating (Xij) values.
- Cut down the offer in row and the request in column with the same number of specified units for cell, then delete the row or column which all its values were specified and it equal to zero.
- Repeat the previous steps until all offered units are distributed to all requested units and reach the S.B.E.S

3.1 Methods of finding the optimal solution

1. Stepping stone method
2. Modified Distribution Method

3.1.1 Stepping stone method

This method requires evaluating each un busy cell in the basic solution table to know its effect on the total transportation costs if it was transported one by one to one of the un busy cells, it's done as the following steps[9]:

- Draw a closed path for each un busy cell. Form from set of sequent straight lines vertical and horizontal starts from the un busy cell and passes through basic variables (at the end of each line) until it goes back and ends with non basic variable that started at and with shortest ways.
- Use the closed path to close the effect of non basic variable on the value of target function by giving a positive (+)sign to the cell to be evaluated and followed with negative (-)sign for the followed cell in the path, then (+) ve sign for the next cell and so on for all cells forming the paths.
- Calculating the indirect cost by adding the cell costs within the path of the non basic variable, if the cell evaluation was (+) ve or zero, then it means the un ability to reduces the total costs of transformation, and the solution is considered the optimal solution, while if the cell evaluation was (-ve), then it means that transforming one unit to the un busy cell will lead to costs reduction with same negative value of that cell, subsequently, the solution is not optimal.

- After determining the non basic variables with negative cost, the variable with highest negative transportation cost is chosen to be a variable inside that achieves the biggest reduction in total transportation costs, and to keep the equation (m+n-1)and after new variable internal variable is inserted , the external variable should be determined among the basic variables , so its chosen by the sequent positive and negative signs for the varied internal closed path that meets the minimum equivalent negative sign(ai) the variable that reaches before others and has the smallest number of transported units.
- After determining the external variable that is the number of transported units, where a value will be added to each cell with positive sign and a value will be subtended from each cell with negative sign, this will make the new values for the internal variable path values to the basic variables, which according to total transportation cost is calculated, that forms the new satisfactory basic fundamental solution.
- Choose optimal basic solution according to the new values by repeating the previous steps.

3.1.2 Modified Distribution Method

One of the used methods to choose basic fundamental solution , in order to reach the optimal solution, this method is considered to be a development for the previous method , and the solution steps are represented as follows[9]:

1. After conducting the satisfactory basic fundamental solution, and identify the variables in rows by (ui) to represent the calculated variables for row(i) where (i=1,2,….,m)and the columns are identified with (vj) where the variables calculated in column are represented where (i=1,2,….,n).
2. Find the values for variables (vj) (ui) and that's by forming equations to the busy cells as follows cij=ui+vj these equations point to that the cost is equal to doubles of columns and rows, and their number will be (m+n-1).
3. Find solution for busy cell equations and according to the formulas were mentioned in step(2), and since the number of variables as larger than equations number, then , value of zero is given tone of variables, let it be ui=0 , then values of other variables is extracted by direct atonement.
4. After finding all variable values the un busy cells are evaluated using the following law:

$$Cij = Cij - (ni + vj)$$

If all resulted values from the above law to the non basic variables are positive or zero, then stop the repeated calculation and the basic fundamental solution is the optimal solution, while, there is one or more un busy cells, the indirect cost is negative, which means there is an ability to reduce the total cost of transportation by changing the non basic variable with biggest negative cost to basic, which makes the internal variable and exclude one of the basic variable that offset least number of transported units as previously mentioned in stepping stone method.

4. RESULTS AND DISCUSSION

Applying the transportation model in waste transportation cost reduction:

1. The basic dependent objective in model:

- Quantity offered (ai): it's the generated quantity of solid waste in each region of district holes (i=1, 2,…….3) that show vertically in transportation model as shown in Table5.

Table5 Quantity offered (ai)

I	Sources of waste generation
1	Algahtt
2	Alandlas
3	Main Street

- Quantity required (bj): the quantity of waste that arrived to the landfill location for each year's (j=1, 2, 3, 4, 5, 6) which show horizontally in transportation model as shown in Table6.

Table6 Quantity required (bj)

J	Landfill
Part of the piece (10)km 28 bibans	
1	2009
2	2010
3	2011
4	2012
5	2013
6	2014

- The offered and requested quantity in transportation model with cubic meter (m^3) while the transportation costs is with dinar (dinar/m^3).
- The cost calculation of solid waste transportation from the collecting areas to the landfill locations which is transported using the district machines, was depending on the cost of machine per a day which was specified by the municipal office of Shatt al Arab district as shown in Table7.

Table 7 Cost transfer of solid waste by different mechanisms from Shatt al Arab district to landfill

No.	Type of Mechanism	Leasing Cost (2009,2010,2011) (Dinar/Day)	Leasing Cost (2012,2013,2014) (Dinar/Day)	Number of Shipments per day	Per Shipment
1	Compressors	120000	150000	3	10 (m^3)
2	Tipper	90000	100000	3	8 (m^3)
3	Tipper lorries	120000	150000	3	16 (m^3)

Source: The work of researchers relying on rental rates for workers and mechanisms for municipal departments in the Shatt al-Arab district (2009-2014)

- If the transportation model to reduce costs was solved through depending on the program in computers that is called (win QSB) quantum business system , under the title of transportation problems, and this program works on solving and testing the model, where the optimal solution is conducted, which will give use the final results for the test.
- The results will be showed yearly through the study periods for years(2009-2014), where the data were put in classified tables done by the researcher with some form that serves applying the transportation model, depending in that on the

conducted data by the municipal office of Shatt al Arab district, solid environmental waste office as shown in Table 8.

Table 8 Actual data for offered and requested quantity in transportation model with cubic meter (m^3) while the transportation costs is with dinar (dinar/m^3).

To / From	Part of the piece (10)km 28 bibans						Supply	Total cost
	2009	2010	2011	2012	2013	2014		
Algahtt	3333	3846	3965	4885	4008	4381	21312	87720000
Alandlas	3478	3824	3947	4824	3875	4347	13680	56040000
Main Street	4000	4000	4000	5000	3846	4166	3672	15120000
Demand	4608	3456	3816	3816	9720	13248	38664	158880000

2. The optimal solution for waste transportation for periods(2009-2014):

The computer results ,which are the summary of conducted solution by depending data of the municipal office of Shatt al Arab district, solid environmental waste office as shown in Tables (9,10&11).

Table9 Solution for Transportation: Minimization

No	From	To	Shipment	Unit Cost	Total Cost	Reduced
1	Algahtt	2009	2880	4000	1.152E+07	0
2	Algahtt	2010	2880	4000	1.152E+07	0
3	Algahtt	2011	3240	4000	1.296E+07	0
4	Algahtt	2012	3240	5000	1.62E+07	0
5	Algahtt	2013	1440	5000	7200000	0
6	Alandlas	2013	2520	5000	1.26E+07	0
7	Alandlas	2014	6120	5000	3.06E+07	0
8	Main Street	2014	2520	5000	1.26E+07	0
	Total	Objective	Function	Value=	1.152E+08	

Source: The computer results depending on the Table8.

Table10 Distribution optimal quantities and transportation costs in accordance with the schedule the best solution for the period (2009-2014)

Transport Route	Total Quantity(m^3)	Total Cost/ Dinar
Algahtt / Landfill (2009)	2880	1.152E+07
Algahtt / Landfill (2010)	2880	1.152E+07
Algahtt / Landfill (2011)	3240	1.296E+07
Algahtt / Landfill (2012)	3240	1.62E+07
Algahtt / Landfill (2013)	1440	7200000
Alandlas / Landfill (2013)	2520	1.26E+07
Alandlas / Landfill (2014)	6120	3.06E+07
Main Street/Landfill(2014)	2520	1.26E+07
Total	24840	1.152E+08

Source: Researcher of work depending on the table 9.

Table11 Compared actual cost with best solution cost for the period (2009-2014)

Year period	Actual cost	Best solution cost	Abundance in transportation costs	The abundance ratio to the actual costs (%)
(2009-2014)	158880000	115200000	43680000	27.5

Source: The actual cost from municipal office of Shatt al Arab district, solid environmental waste office, Department of Statistics.

Through comparison between actual cost and best solution cost was reached and abundance in the solid waste transfer costs (43680000) Dinar Iraqi, An the abundance obtained through the application of transport model. Through the solution that was reached, the researcher believes that the premise of the study have been achieved, Through the achievement of an abundance of transport and the amount of cost (43680000) Million dinars and that this abundance can be used in other areas such as the provision of containers and waste collection bags, which may claim to reduce the pollution of the environment.

5. CALCULATIONS

1. The usage of transportation model achieved a reduction with solid waste transportation costs from its collection locations to the landfill locations through the optimal solution model which represents (43680000) which is the richness that achieved by using transportation model.
2. The use of uncovered machines like Tipper and Tipper lorries and others of uncovered machines leads to environmental pollution with fly waste during the transporting process, also not loading them in a complete manner because of not using the hydraulic pressure to reduce waste density.
3. Few available machines at municipal of Shatt al-Arab district like compressors and small are marking that led to hiring for waste transportation which made the costs rises.
4. Not enough landfill location in all Shatt al-Arab district, where there are only two locations, which lends to less options for district halls at transportation where some of them don’t have the alternatives and that causes high transportation costs.
5. The use of transportation stations that don’t correspond with the environmental criteria, and they are open lands where the waste is collected at, then its transported to landfill and these locations cause pollution for the nearby environment and effect the society and the general health.
6. There is no separation process for the solid waste by the source, and also , no use for the re-cycling process to use these waste, instead , the landfill is depended in order to disposal the waste , and the used landfills are open , non-systematic lands that leads to environment pollution.
7. Managing the cleaning operations in Shatt al-Arab district is a serious problem, and its shown to public, and it's a big challenge for the municipal of Shatt al-Arab district, although the big efforts that the municipal gives in this field, yet, there are few real results and they still less than the desired level, and this is for several reasons like the absence of plans and good effective machine for collecting and waste disposal also the continuous increase in the waste. In addition to the weak performance of the executive systems in the district hall office, few field pursuit, the absence of law status, the citizens small care and assiduous of district cleanliness and non cooperation with cleaning process.

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