บทความวิจัย

ศึกษาขยะมูลฝอยของกรุงเทพมหานครในการประยุกต์ใช้เทคนิค Vogel's Approximation method

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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาขยะมูลฝอยข องกรุงเทพมหานครในการประยุกต์ใช้เทคนิค Vogel's Approximation method เพื่อแก้ปัญหาการขนส่งที่ซับซ้อนเพื่อหาทางเลือกที่ดีที่สุด โดยได้ใช้กระบวนการการวิจัยเชิงคุณภาพแบบกรณีศึกษาและการวิจัยเชิงการดำเนินงาน ทั้งนี้ได้ศึกษาต้นทุนการขนส่งของกรุงเทพมหานคร เพื่อระบุต้นทุนการขนส่งปัจจุบัน และได้ประยุกต์ใช้ VAM เพื่อแก้ไขปัญหาด้านการขนส่งให้ได้ต้นทุนและทางเลือกที่ดีที่สุดในการแก้ไขปัญหา กรณีศึกษานี้พบว่ากรุงเทพมหานครไม่ได้มีการออกแบบกระบวนการขนส่งของเสียอย่างถูกต้องตั้งแต่แรกดังนั้นต้นทุนการขนส่งจึงมีราคาแพง การคำนวณ VAM จึงถูกนำใช้ในการศึกษาครั้งนี้เพื่อแก้ปัญหาการขนส่งที่ไม่ได้รับการออกแบบอย่างชัดเจน ผลการศึกษาแสดงให้เห็นว่าการคำนวณ VAM สามารถพิสูจน์ได้ว่าเป็นเทคนิคที่แก้ไขปัญหาและนำเสนอทางออกที่ดีที่สุดสำหรับรูปแบบการขนส่งที่ซับซ้อน

คำสำคัญ : ขยะมูลฝอย

Research

AGGREGATE PLANNING USING TRANSPORTATION METHOD: A CASE STUDY OF BANGKOK MUNICIPAL SOLID WASTE

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Abstract

This paper aimed to study the Bangkok municipal solid waste to applying the Vogel's approximation method (VAM) technique for solving the complex transportation problem and provided the optimal solution. The qualitative research was used in this study with the case study and operation research approach. First part, study the transportation cost of BMA to provide the present transportation cost. Second part of the study aimed at optimizing the transportation model by the principal of VAM to cost savings and best solution of transportation model. In this case, BMA does not properly design the waste transport process. Therefore, transport costs are expensive. The VAM's calculation was used in this study to solving the transportation problems that are not clearly designed. The result indicated that VAM calculation that proved the VAM technique can provide an optimal solution for transportation model and solve the complex transportation problem.

Keywords: Solid Waste

Introduction

Bangkok Metropolis was established in 1782 as the civilization capital of Thailand. It has become the center of Thai's government administration, commerce, mix culture, and domestic and international transportation hub. After World War II, the city received population surge as well as heavy investment in infrastructures and public utilities. The metropolis has totally 50 districts covering area of 1,568.737 square kilometers with registered population of 5.6 million (as of 2005). But the total population live in Bangkok is more than 10 million. The biggest problems were traffic, infrastructure, and municipal waste management to support the totally Bangkok citizen. The major companies, government institute and office, court, hospital, and University located in heart of Bangkok metropolis.

Bangkok is located on low-lying flat plain of Chao Phraya river extended to the Gulf of Thailand (13.7563° N, 100.5018° E). The climate is dominated by monsoon with high temperature and humidity. There are three main seasons; rainy (May-October), winter (November-January), and summer (February-April). The average low temperature is mid-20 degree Celsius and high temperature is mid-30 degree Celsius. The government sector, financial institutions, and hospitality industries are significant employers. Bangkok's work force includes; employees, government officials, entrepreneurs, private retailers, and truck drivers who transport goods to and from each province. Agricultural product processing, e.g. rice mill, was once located in Bangkok, but it has been displaced by textiles and electronics business.

In the business competition or business activity, the cost of transportation was the heavy cost that would be address by solution (Christopher, 2016). In many cases, the organizations confronted the transportation problem to finding the way of minimize the product distribution cost from the origin to place of destination (Goldsby, Iyengar, Rao, 2016). Some organization outsourced the transportation activity to logistics service provider (Alkhatib, 2016). On the other hand, some organization can't to outsourcing the transportation activity because that was primary activity (Porter, 1979) to protect the service level or performance. The transportation method was the linear programming that applied to the problems related to the study of the efficient transportation routes (Jeihani & Ardeshiri, 2017). Transportation method can be minimized the total transportation cost in many methods such as Northwest Corner method or Minimum Cell Cost method (Render *et al.,* 2015). But both of them was the initial method to address the transportation problem in basic case. The improved version was Vogel's Approximation method (VAM) that the important technique (Render *et al.,* 2017). VAM can be solved the complex transportation problem and provided the optimal solution.

Objective

To apply the Vogel's Approximation method (VAM) technique for solving the complex transportation problem and provided the optimal solution.

Literature Review

The originally method was conducted in literature review by researcher then to introduction a case study of Bangkok municipal waste management in the following:

Situation of the Bangkok municipal waste management

According to daily waste data base gathered from three transfer stations of BMA as Saimai, Onnut and Nongkham site, recording from 1st March 2014 to 7th March 2014 which demonstrated the amount of daily waste from Bangkok's each fifty districts by averages as below.

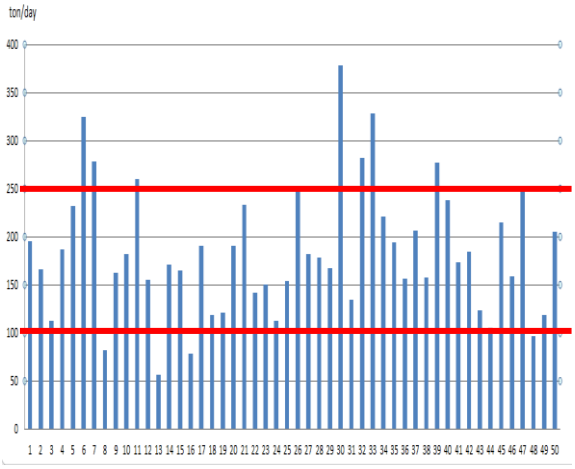


Figure 1 averages of daily waste from all fifty districts of Bangkok

Daily amount of municipal waste data was collected from transfer sites directly, from figure above clearly separate as three ranges, first range from waste collected amount 100 tons a day or under. In this range declared those areas had low waste generate rate, second range from 100 tons reached to 250 tons a day. Districts in this range are representing as the middle rate of waste generation, Third range from 250 tons a day to above. For members of this range they delegate as a highest waste generate group. On the other hand, grouping data by transfer sites member should made visible clearly as follow.

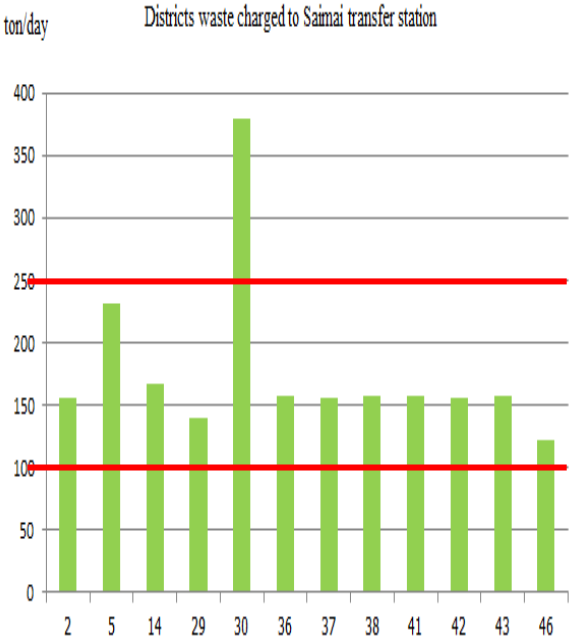


Figure 2 Districts waste charge to Saimai transfer station

Districts that contain waste to this the Saimai transfer station was 12 districts as 2 (Dusit) 155.38 t/d, 5 (BangKhen) 231.85 t/d,14 (PayaThai) 166.84 t/d, 29 (BangSue) 140.23 t/d, 30 (Jatujak) 378.58 t/d, 36 (DonMueang) 156.51 t/d, 37 (Ratchathewi) 155.85 t/d, 38 (LatPrao) 157.74 t/d, 41 (LakSi) 156.51 t/d, 42 (Saimai) 155.85 t/d, 43 (KannaYao) 157.74 t/d, 46 (KlongSamwa) 122.12 t/d, thus total amount by averages of this Saimai transfer station is 2,135.20 t/d. For this site, the data gathered was demonstrated that almost in the middle range just Jatujak the districts number 30 was in high range.

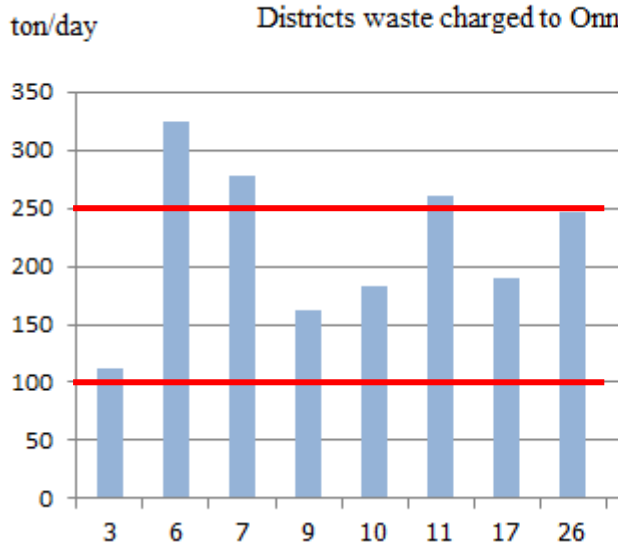


Figure 3 District waste charge to Onnut transfer station

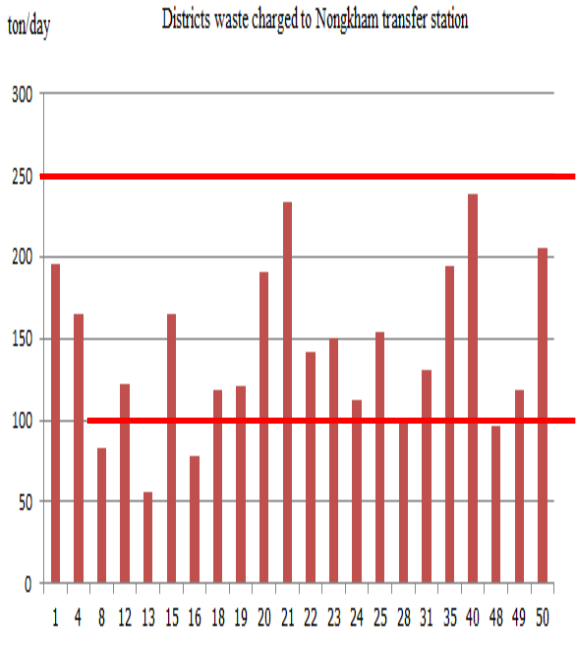


Figure 4 Districts waste charged to Nongkham transfer station

Districts that contain waste to this the Saimai transfer station was 16 districts as 3 (NongChok) 111.93 t/d, 6 (BangKapi) 324.82 t/d, 7 (PhathumWan) 278.10 t/d, 9 (PraKaNong) 162.18 t/d, 10 (MinBuri) 182.41 t/d, 11 (Latkrabang) 260.42 t/d, 17 (HuaiKwang) 189.73 t/d, 26 (Dindang) 247.42 t/d, 27 (Buengkum) 112.06 t/d, 32 (Prawet) 281.32 t/d, 33 (Klongtei) 320.33 t/d, 34 (SuanLuang) 220.79 t/d, 39 (Wattana) 276.61 t/d, 44 (SapanSung) 104.60 t/d, 45 (WangThongLang) 200.47 t/d, 47 (Bangna) 250.64 t/d, summation of this all districts disposal to Onnut transfer station as 3,523.83 t/d. Figure show nearly half of the member of this group stand at the high range, example BangKapi, PhathumWan, Latkrabang, Prawet, Klongtei, Wattana and Bangna, the others at the middle range.

Districts that contain waste to this the Nongkham transfer station was 22 districts as 1 (PraNakorn) 195.87 t/d, 4 (BangRak) 165.43 t/d, 8 (PomprabSattruPai) 82.53 t/d, 12 (Yannawa) 122.34 t/d, 13 (SumpanThawong) 56.39 t/d, 15 (Thonburi) 164.66 t/d, 16 (BangkokYai) 77.71 t/d, 18 (KlongSan) 118.78 t/d, 19 (TalingChan) 121.23 t/d, 20 (BangkokNoi) 190.35 t/d, 21 (BangkhunTien) 233.31 t/d, 22 (PasiChaRoen) 141.28 t/d, 23 (NongKham) 149.56 t/d, 24 (Rattburana) 112.16 t/d, 25 (Bangplat) 153.62 t/d, 28 (Sathorn) 98.30 t/d, 31 (BangKhoLaem) 130.51 t/d, 35 (JomThong) 194.49 t/d, 40 (BangKhae) 238.45 t/d, 48 (ThawiWatthana) 96.8 t/d, 49 (Thungkru) 118.55 t/d, 50 (Bangbon) 204.85 t/d, total amount of waste discharged to this Nongkham transfer station by averages as 2,135.20 t/d. In this transfer station had no high range position but some low range districts

shown as PomprabSattruPai, SumpanThawong, BangkokYai, Sathorn and ThawiWatthana, others stand in the middle range.

The level of range waste generation

The districts in Bangkok can divined by high, middle and low range waste generation as figure 5.

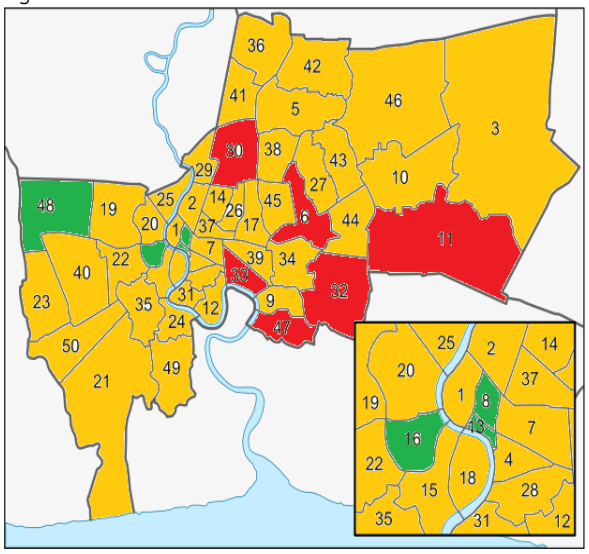


Figure 5 waste creation range by district

From the figure above demonstrated that the district number 6 (BangKapi), 11 (Latkrabang), 30 (Jatujak), 32 (Prawet), 33 (Klongtei) and 47 (Bangna) were declared as high waste creation zone (red color) by average rate more than 250 t/d waste. On the other hand, district number 8 (PomprabSattruPai), 13 (SumpanThawong), 16 (BangkokYai) and 48 (ThawiWatthana) were low range daily waste creating average by below 100 t/d (green color).

In addition, there have some districts that overlapping between two transfer stations such as district number 17 (HuaiKwang), 27 (Bungkum), 45 (WangThongLang) charged into Saimai transfer station, district number 4 (Bangrak), 12 (Yannawa), 14 (PayaThai), 28 (Sathorn), 31 (BangKhoLaem), 37 (Ratchathewi), 43 (KannaYao), 46 (KlongSamwa) charged into Onnut transfer station and district number 2 (Dusit), 29 (BangSue), 33 (Klongtei) charged into Nongkham transfer station. These numbers of districts overlapped made amount of site load went to a little higher. For the period of data that recorded (1st March 2014 to 7th March 2014) the Saimai transfer station site load was added by 84.46 t/d, Onnut transfer station load was added by 249.12 t/d and Nongkham transfer station load was added by 43.94 t/d.

Vogel's Approximation Method (VAM)

The Vogel's Approximation Method founded by Reinfeld and Vogel (1958) in the year of 1958 (Render *et al.,* 2017). The concept of VAM was mathematical programming (Voigt, 2017).

VAM or Vogel's Approximation Method solves the transportation problem that finding a good solution by taking into account the cost associated with each transportation route alternative (Gerbetz, 2017). VAM provides a best fit solution than northwest corner or least cost methods. For apply the VAM, first, computing for each row and column the penalty faced if we should ship over the second-best route instead of the least cost route. It facilitates a very good initial solution as a matter of fact, one that is often the optimal solution. Vogel's approximation method can provide a best solution for Bangkok municipal waste management. The Bangkok metropolitan has fifty districts (origins) and supplies waste to

destination in Three sites that consist On-nut, Sai Mai, and Nong Khaem. It has many transactions between origin and destination.

The Step of Vogel's approximation method

1. For each row and column of the transportation table, and the difference between the two lowest unit shipping costs. These numbers represent the difference between the distribution cost on the best route in the row or column and the second-best route in the row or column.
2. Identify the row or column with the greatest opportunity cost, or difference.
3. Assign as many units as possible to the lowest cost square in the row or column selected.
4. Eliminate any row or column that has just been completely satised by the assignment just made. This can be done by placing Xs in each appropriate square.
5. Recomputed the cost differences for the transportation table, omitting rows or columns crossed out in the preceding step.
6. Return to step 2 and repeat the steps until an initial feasible solution has been obtained.

Methodology

The qualitative research was used in this study with the case study and operation research approach (Hillier, 2014; Taha, 2016). First part, study the transportation cost of BMA to provide the present transportation cost. Second part of the study aimed at optimizing the transportation model by the principal of VAM to cost savings and best solution of transportation model. By the way, the primary data sources were collected from government paper or report. On the other hand, secondary data sources were collected by in-depth interview from government officer. Also, the case-base study was undertaken at Bangkok Municipal waste management. Bangkok Metropolitan Administration (BMA) is accounting for daily municipal solid waste management through the Solid Waste Disposal Division (SWDD) controlling by Department of Environment (DE). The Solid Waste Disposal Division has responsibility for controlling solid waste disposal effectively and sanitation according to technical principles, laws and related regulations, including implementing engineering works related to public cleansing and environment. SWDD control subdivisions those related directly to municipal solid waste management system as Saimai solid waste disposal center, Onnut solid waste disposal center and Nongkham solid waste disposal center. These three solid waste disposal centers were used as transfer station, they received amount waste from fifty districts of Bangkok area daily and transfer to landfill. However, all three transfer stations are in control of BMA whereas some activities are running by private sector, for example waste separation, out bound waste transportation and sanitary landfill operation.

Analysis

The amount of waste generated in each area will be collected and transported to the loading and unloading station. In some areas, the amount of waste is divided and transported to more than one loading station, such as Dusit, The amount of waste were collected and transported to the Saimai and NongKhame transfer station or Bang Rak area resulting waste was collected and transported to the On-Nut transfer station and the Nong Khaem transfer station. Table 1 shows the cost of transporting the waste to the loading stations of the 50 districts. The resulting formula is calculated as follows:

The cost of transporting the waste to the loading station = The average distance from the area to the loading station x Travel fuel loss (1.5) x Travel to and from (2) x Index of end Fuel consumption / liter / ton / ton (0.144) x Average daily amount of waste (applied from Rajavipha sub-station study report, factory department, BMA 2017)

Table 1 demonstrated distance between districts and transfer station.

	District name	Waste amount per day (tons) (2015)	Distance to .... Transfer station (k.m.)		
			Saimai	On-nut	Nong khaem
1	Pra Nakorn	197.45	30.90	28.30	27.00
2	Dusit	173.86	27.20	26.50	25.90
3	Nong Chok	119.12	34.10	30.30	85.20
4	Bang Rak	170.78	32.60	31.90	25.70
5	Bang Khen	270.45	10.60	27.70	44.30
6	Bang Kapi	313.18	20.70	14.80	44.70
7	Phathum Wan	287.27	27.50	26.70	27.30
8	Pomprab Sattru Pai	86.46	29.40	26.80	29.20
9	Pra Ka Nong	149.99	24.80	12.00	41.20
10	Min Buri	191.42	19.00	19.10	74.00
11	Ladkrabang	255.50	37.90	12.90	70.50
12	Yannawa	183.85	32.20	31.50	28.70
13	Sumpan Thawong	58.51	31.80	31.00	25.90
14	Paya Thai	161.96	22.20	24.60	33.00
15	Thonburi	164.12	37.70	37.00	16.80
16	Bangkok Yai	85.92	38.00	41.00	20.60
17	Huai Kwang	197.60	18.90	21.60	41.60
18	Klongsan	134.02	35.20	33.20	19.30
19	Taling Chan	133.33	38.50	37.80	20.80
20	Bangkok Noi	202.02	35.50	33.60	26.20
21	Bang Khun Tien	289.36	53.10	49.10	18.60
22	Pasi Charoen	167.86	42.70	42.00	11.90
23	Nong Kham	173.49	60.90	60.10	8.60
24	Ratburana	116.91	40.80	39.00	25.80
25	Bangplat	152.03	29.80	39.40	27.90
26	Dindang	268.17	24.30	21.70	37.50
27	Buengkum	187.79	17.20	16.60	55.50
28	Sathorn	180.81	34.30	33.60	26.20
29	Bang sue	158.82	24.20	28.70	32.10
30	Jatujak	377.93	22.00	31.30	40.30
31	Bang kolaem	139.17	36.60	35.90	24.80
32	Prawet	270.84	24.20	2.50	52.10
33	Klongtei	339.42	26.20	14.10	34.70

34	Suanluang	237.62	25.30	10.40	50.00
35	Jom Thong	206.39	42.90	40.90	24.00
36	Don Mueang	184.60	16.00	32.90	49.10
37	Ratchathewi	202.58	24.80	23.10	31.40
38	Lat Prao	178.94	12.80	24.40	46.40
39	Wattana	287.42	21.20	17.00	42.20
40	Bangkae	271.63	47.50	52.50	11.70
41	Laksi	156.49	11.70	28.60	43.20
42	Saimai	197.01	0.45	26.30	56.60
43	Kanna Yao	130.28	15.70	13.60	60.10
44	Sapan Sung	118.16	19.20	14.10	56.50
45	Wangthong Lang	213.47	15.20	16.40	46.80
46	Klong Samwa	177.84	12.30	23.10	59.90
47	Bangna	221.44	27.60	22.30	38.60
48	Thawi Wattana	103.31	53.60	52.80	11.00
49	Thungkru	115.12	45.50	34.10	32.10
50	Bangbon	211.20	54.60	56.10	14.70
	Total amount	**9,572.91**			

Table 2 BMA's municipal waste transfer cost

	District name	Waste amount per day (tons) (2015)	Cost to .... Transfer station (Baht/Ton)			Cost of transfer (bath/day)
			Saimai	On-nut	Nong khaem	
1	Pra Nakorn	197.45	400.46	366.77	349.92	69,091.70
2	Dusit	173.86	352.51	343.44	335.66	61,108.10
3	Nong Chok	119.12	441.94	392.69	1104.19	46,777.23
4	Bang Rak	170.78	422.50	413.42	333.07	58,426.81
5	Bang Khen	270.45	137.38	358.99	574.13	37,154.42
6	Bang Kapi	313.18	268.27	191.81	579.31	60,071.06
7	Phathum Wan	287.27	356.40	346.03	353.81	99,404.04
8	Pomprab Sattru Pai	86.46	381.02	347.33	378.43	32,719.06
9	Pra Ka Nong	149.99	321.41	155.52	533.95	23,326.44
10	Min Buri	191.42	246.24	247.54	959.04	47,384.11
11	Ladkrabang	255.50	491.18	167.18	913.68	42,714.49
12	Yannawa	183.85	417.31	408.24	371.95	69,773.43
13	Sumpan Thawong	58.51	412.13	401.76	335.66	19,639.47

14	Paya Thai	161.96	287.71	318.82	427.68	46,704.33
15	Thonburi	164.12	488.59	479.52	217.73	35,733.85
16	Bangkok Yai	85.92	492.48	531.36	266.98	22,938.92
17	Huai Kwang	197.60	244.94	279.94	539.14	55,302.31
18	Klongsan	134.02	456.19	430.27	250.13	33,522.42
19	Taling Chan	133.33	498.96	489.89	269.57	35,941.77
20	Bangkok Noi	202.02	460.08	435.46	339.55	68,595.89
21	Bang Khun Tien	289.36	688.18	636.34	241.06	69,753.12
22	Pasi Charoen	167.86	553.39	544.32	154.22	25,887.37
23	Nong Kham	173.49	789.26	778.90	111.46	19,337.20
24	Ratburana	116.91	528.77	505.44	334.37	39,091.20
25	Bangplat	152.03	386.21	510.62	361.58	54,971.01
26	Dindang	268.17	314.93	281.23	486.00	75,417.45
27	Buengkum	187.79	222.91	215.14	719.28	40,963.93
28	Sathorn	180.81	444.53	435.46	339.55	69,175.16
29	Bang sue	158.82	313.63	371.95	416.02	52,401.19
30	Jatujak	377.93	285.12	405.65	522.29	107,755.40
31	Bang kolaem	139.17	474.34	465.26	321.41	45,285.17
32	Prawet	270.84	313.63	32.40	675.22	8,775.22
33	Klongtei	339.42	339.55	182.74	449.71	64,028.20
34	Suanluang	237.62	327.89	134.78	648.00	32,026.42
35	Jom Thong	206.39	555.98	530.06	311.04	64,195.55
36	Don Mueang	184.60	207.36	426.38	636.34	38,278.66
37	Ratchathewi	202.58	321.41	299.38	406.94	63,967.86
38	Lat Prao	178.94	165.89	316.22	601.34	29,684.36
39	Wattana	287.42	274.75	220.32	546.91	63,324.37
40	Bangkae	271.63	615. 89	680.40	151.63	41,187.26
41	Laksi	156.49	151.63	370.66	559.87	23,728.58
42	Saimai	197.01	5.83	340.85	733.54	1,148.57
43	Kanna Yao	130.28	203.47	176.26	778.90	26,074.88
44	Sapan Sung	118.16	248.83	182.74	732.24	21,592.56
45	Wangthong Lang	213.47	196.99	212.54	606.53	45,158.47
46	Klong Samwa	177.84	159.41	299.38	776.30	34,097.10
47	Bangna	221.44	357.70	289.01	500.26	63,998.37
48	Thawi Wattana	103.31	694.66	684.29	142.56	14,727.87
49	Thungkru	115.12	589.69	441.94	416.02	47,892.22
50	Bangbon	211.20	707.62	727.06	190.51	40,235.71
	Total amount	**9,572.91**				**2,290,490.27**

Table 1 and 2 describe about waste generation of each districts per day and distance from districts office to three transfer stations and cost of transfer by light yellow mean main transfer station, waste generation every will contain to this transfer station mostly and dark yellow mean support transfer station, some of waste generated contain to this the transfer station

Based on the calculations, it is estimated that Bangkok will have to pay the total cost of transporting waste to the transfer station at 2,290,490.27 baht per day or approximately 836,028,948.55 baht per year. (2015)

According to transportation model, the Vogel approximation method (VAM) used to calculate for finding transportation cost optimizing for BMA. The result as follow table 3.

From table 3, waste transportation of BMA after use VAM algorithm calculation was 2,249,663.84 baht per day, that was lower than the total cost from table 2 declared as 2,290,490.27 baht per day as 40,826.43 baht per day or 14,901,646.95 baht per year.

The table 3 indicated that the result of VAM calculation that proved the VAM technique can provide an optimal solution for transportation model and solve the complex transportation problem.

Table 3 Use VAM technique to grouping member of each transfer station on cost optimizing objective

	District name	Waste amount per day (tons) (2015)	Cost to .... Transfer station (Baht/Ton)			Cost of transfer (bath/day)
			Saimai	On-nut	Nong khaem	
1	Pra Nakorn	197.45	400.46	366.77	349.92	69,091.70
2	Dusit	173.86	352.51	343.44	335.66	59,489.84
3	Nong Chok	119.12	441.94	392.69	1104.19	46,777.23
4	Bang Rak	170.78	422.50	413.42	333.07	56,881.69
5	Bang Khen	270.45	137.38	358.99	574.13	37,154.42
6	Bang Kapi	313.18	268.27	191.81	579.31	60,071.06
7	Phathum Wan	287.27	356.40	346.03	353.81	101,639.00
8	Pomprab Sattru Pai	86.46	381.02	347.33	378.43	30,030.15
9	Pra Ka Nong	149.99	321.41	155.52	533.95	23,326.44
10	Min Buri	191.42	246.24	247.54	959.04	47,351.75
11	Ladkrabang	255.50	491.18	167.18	913.68	42,714.49
12	Yannawa	183.85	417.31	408.24	371.95	68,383.01
13	Sumpan Thawong	58.51	412.13	401.76	335.66	19,639.47

14	Paya Thai	161.96	287.71	318.82	427.68	46,597.51
15	Thonburi	164.12	488.59	479.52	217.73	35,733.85
16	Bangkok Yai	85.92	492.48	531.36	266.98	22,938.92
17	Huai Kwang	197.60	244.94	279.94	539.14	48,400.14
18	Klongsan	134.02	456.19	430.27	250.13	33,522.42
19	Taling Chan	133.33	498.96	489.89	269.57	35,941.77
20	Bangkok Noi	202.02	460.08	435.46	339.55	68,595.89
21	Bang Khun Tien	289.36	688.18	636.34	241.06	69,753.12
22	Pasi Charoen	167.86	553.39	544.32	154.22	25,887.37
23	Nong Kham	173.49	789.26	778.90	111.46	19,337.20
24	Ratburana	116.91	528.77	505.44	334.37	39,091.20

Table 3 Use VAM technique to grouping member of each transfer station on cost optimizing objective

	District name	Waste amount per day (tons) (2015)	Cost to .... Transfer station (Baht/Ton)			Cost of transfer (bath/day)
			Saimai	On-nut	Nong khaem	
25	Bangplat	152.03	386.21	510.62	361.58	54,971.01
26	Dindang	268.17	314.93	281.23	486.00	75,417.45
27	Buengkum	187.79	222.91	215.14	719.28	40,401.14
28	Sathorn	180.81	444.53	435.46	339.55	61,394.04
29	Bang sue	158.82	313.63	371.95	416.02	49,810.72
30	Jatujak	377.93	285.12	405.65	522.29	107,755.40
31	Bang kolaem	139.17	474.34	465.26	321.41	44,730.63
32	Prawet	270.84	313.63	32.40	675.22	8,775.22
33	Klongtei	339.42	339.55	182.74	449.71	62,025.61
34	Suanluang	237.62	327.89	134.78	648.00	32,026.42
35	Jom Thong	206.39	555.98	530.06	311.04	64,195.55
36	Don Mueang	184.60	207.36	426.38	636.34	38,278.66
37	Ratchathewi	202.58	321.41	299.38	406.94	60,648.40
38	Lat Prao	178.94	165.89	316.22	601.34	29,684.36
39	Wattana	287.42	274.75	220.32	546.91	63,324.37
40	Bangkae	271.63	615.89	680.40	151.63	41,187.26
41	Laksi	156.49	151.63	370.66	559.87	23,728.58
42	Saimai	197.01	5.83	340.85	733.54	1,148.57
43	Kanna Yao	130.28	203.47	176.26	778.90	22,963.15
44	Sapan Sung	118.16	248.83	182.74	732.24	21,592.56
45	Wangthong Lang	213.47	196.99	212.54	606.53	42,051.46

46	Klong Samwa	177.84	159.41	299.38	776.30	28,349.47
47	Bangna	221.44	357.70	289.01	500.26	63,998.37
48	Thawi Wattana	103.31	694.66	684.29	142.56	14,727.87
49	Thungkru	115.12	589.69	441.94	416.02	47,892.22
50	Bangbon	211.20	707.62	727.06	190.51	40,235.71
	Total	9,572.91				2,249,663.84

Discussion

The result indicated that the VAM's calculation provided a best solution than others method such as northwest or lower-cost method. The VAM is a way to find the minimum and minimum cost variance in the next order of rows and columns. In this case, BMA does not properly design the waste transport process. Therefore, transport costs are expensive. The VAM's calculation was used in this study to solving the transportation problems that are not clearly designed. The results of the study are consistent with the VAM was appropriate when applied to large amounts of data. Second, VAM was the best used when the transport network was large. Soomro, Junaid & Tularam (2015) founded that the VAM calculation method outperformed other methods such as the northwest or lower-cost method. Also, Soomro, Junaid & Tularam (2015) tested the VAM modified by finding that the results were not different. By the way, The VAM is most appropriate with this case (BMA). Because, the BMA was a large transportation network and complex in routes.

Acknowledge

This paper is partial fulfillment of a dissertation for environment management, concept or research result of Uddin *et al.,* (2016). They found that when transportation costs were calculated from one point to another, the northwest approach would yield the highest cost. But, the concept of northwest is easy to used. And another method such as the lower-cost or Least Cost method is a better alternative than the first method with cost efficiency. In addition, the study of Korukoğlu & Balli (2011) founded that the VAM is a model that can allocate transportation appropriately, with particular emphasis on cost. While, Ullah, Uddin & Kawser (2015) discovered the interesting research results. First, National Institute of Development Administration (NIDA)

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