

Determination of MSW Collection and Transportation Routes by Using GIS

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Abstract: Solid waste collection and transportation costs are most of the total cost in municipal solid waste (MSW) management systems. Therefore, shortest path for solid waste collection routes should be determined and time and cost for the waste collection should be minimized. In this study, MSW collection route problem for the Eskisehir/Turkey was effectively solved in a shorter period by using Geographic Information Systems (GIS). For this purpose, factors such as daily working period and not to exceed vehicle capacity of collected solid waste were considered, while shortest path was determined for solving this problem by using Geomedia 6.0 Professional and Transportation Manager. In the result of this model, optimization of MSW collection systems for Eskisehir was provided and weekly shortest MSW routes were determined. As a result, averagely 14 % of reduction in distances of Eskisehir MSW routes was obtained.

Keywords: Municipal Solid Waste Management, Waste Collection Route, Recycle, Geographic Information Systems

1 Introduction

The collection of MSW is one of the most difficult operational problems faced by local authorities in any city. In recent years, due to a number of cost, health, and environmental concerns, many municipalities, particularly in industrialized nations, have been forced to assess their MSW management and examine its cost-effectiveness and environmental impacts, e.g. in terms of designing collection routes [1].

The MSW collection consists of three stages: gathering manually, picking by vehicles, and transporting to dumping at the landfill. In the first stage, waste is gathered from household or industrial units and taken to the pre-decided gather sites at the beginning of specific time periods (time windows). There are also several (up to six) time windows at each site with different waste volumes in different windows. In the second stage, a tipper (a specialized truck with a hydraulic loading/unloading device) departing from the depot arrives at the site during the time window. The waste is, then, loaded onto the tipper. After a pick-up, the tipper leaves for the next gather sites following a predetermined sequence twice until

having a full or almost full load. In the last stage, the full-loaded truck shall go to dump the garbage at landfill outside the city, completing a route. After unloading, the truck returns to its gather sites to make the next round again in the same sequence as the previous one [2].

During the past 15 years, there have been numerous technological advances, new developments and mergers and acquisitions in the waste industry. The result is that both private and municipal haulers are giving serious consideration to new technologies such as computerized vehicle routing software [1].

In the literature, especially, Capacitated Arc Routing Problem (CARP) [3, 4, 5, 6]; path-scanning procedure [7, 8]; Capacitated Chinese Postman Problem (CCPP) [9, 10]; Travelling Salesman Problem (TSP) [11] and hybrid insertion heuristic and Guided Variable Neighborhood Thresholding (GVNT) [12] and GIS [13, 14, 15, 2, 16, 17] approaches with this subject were used.

In this study, MSW collection route problem for Eskisehir/Turkey was effectively solved in a shorter period by using Geographic Information Systems (GIS) which allows us to create and store as many layers of data or maps and provides

analyzed in these layers. For this purpose, factors such as daily working period and not to exceed vehicle capacity of collected solid waste were considered, while shortest path was determined for solving this problem by using Geomedia 6.0 Professional and Transportation Manager.

The rest of the paper is organized as follows. Section 2 briefly reviews the current status of MSW in Eskisehir. Next, we explain to material and method in Section 3. In Section 4, results of this study are given. Finally, we provide some conclusions in Section 5.

2 Current status of MSW in Eskisehir

Eskisehir is located in the northwest of the Central Anatolia region in Turkey. The city has an area of 13,652 km² and population of 557,028 according to the census of 2000. The average daily MSW (Municipal MSW) production rate in Eskisehir is 750 ton.

At present, Eskisehir MSWs are landfilling in unregulated dumping site that belongs to the Metropolitan Municipality of Eskisehir. Vehicles of two sub municipalities (Tepebaşı and Odunpazarı) and two private companies are working for the collect to MSW in Eskisehir. Following data were obtained with personal communication:

MSW in Tepebaşı Municipality (TM) are collecting by 21 compacting vehicles, daily. Three persons that are one driver and two waste collection people are working in a vehicle. Vehicles haven't regulated waste collection programs and routes and are consumed 85-90 liters of diesel per day. MSW generation is ca. 300-350 ton/day for this municipality.

MSW in Odunpazarı Municipality (OM) are collecting by 4 tank handler, 14 compacting vehicles every other day. Three persons that are one driver and two waste collection people are working in a vehicle. Vehicles haven't regulated waste collection programs and routes and are consumed 70-80 liters of diesel per day. MSW generation is ca. 350-400 ton/day for this municipality.

3 Material and Methods

In this study, waste collection programs for night and daytime were realized according to personal communication in TM and OM and its private companies.

In general, three objectives can be considered for collection vehicle routing and scheduling (1) minimization of total collection distance; (2) minimization of total collection costs; and (3) minimization of total collection time. For that reason, considered factors in this study are following:

- Start of the route is private company's garage and the finish of the route is unregulated dumping site.
- Finish collection point is near of the unregulated dumping site.
- Working time is 8 hour per shift (total 16 h/day).
- Average vehicle speed is 30 km/hr
- Collection vehicles capacities are 15 m³.
- Route is determined by weekly and available collection days are based on.
- Vehicles are entered to all roads in districts.

Waste collection program and start and finish point of collection are shown in Figure 1.

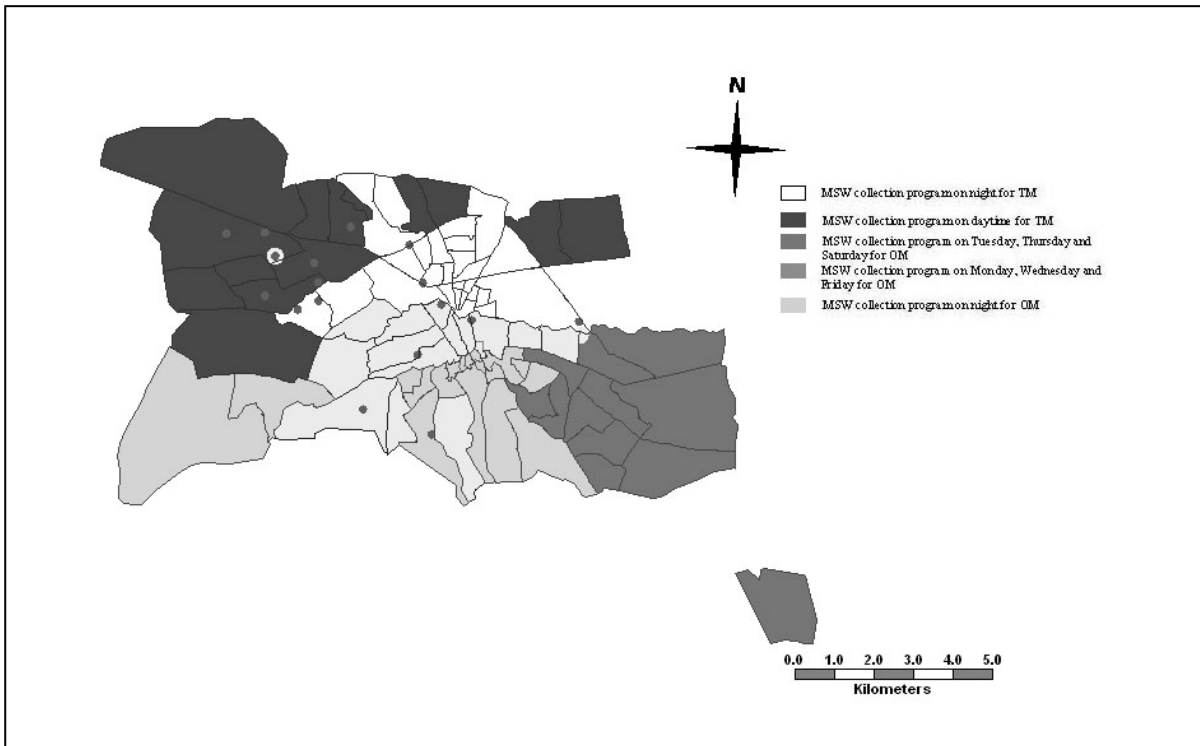


Figure 1 Waste collection program for Eskisehir

4 Results

Geomeia 6.0 and Transportation Manager were used for determination of waste collection routes. Sample of waste collection route for OM are presented in Figure 2. MSW collection routes for

all of the locations that is given in Table 1 as Figure 2. Results obtained with this study and current status were compared and are given in Table 1. Also, weekly total distances for TM and OM are given in Table 2.

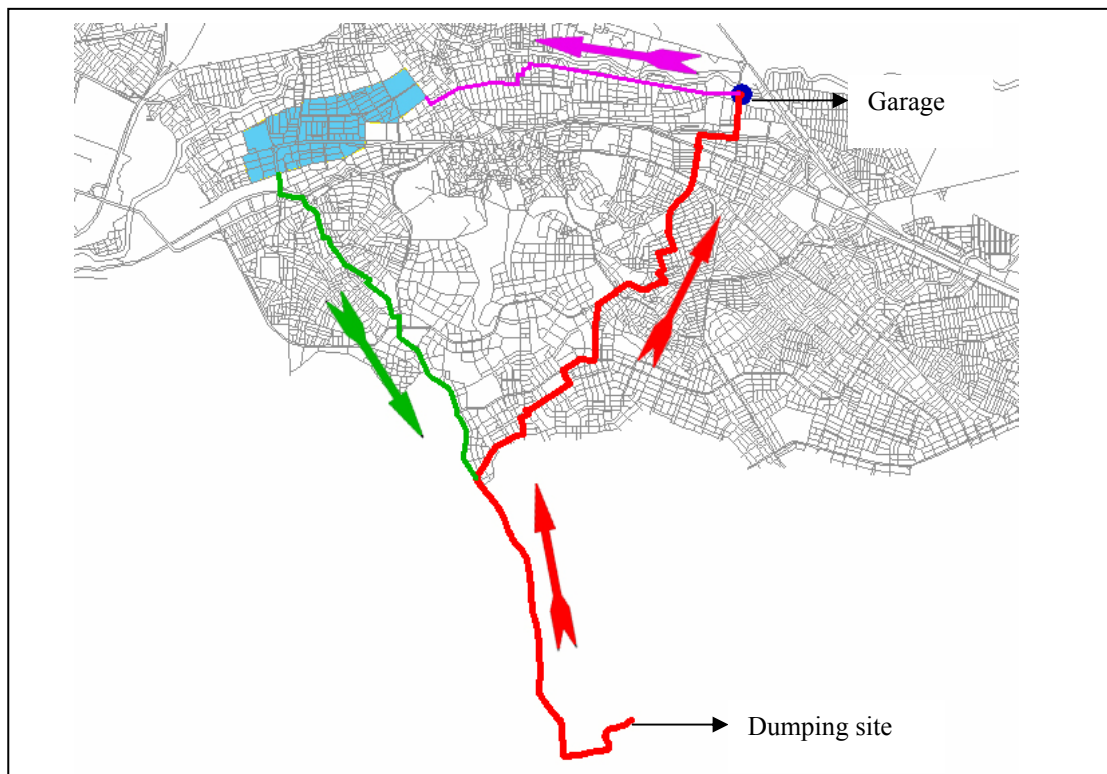


Figure 2 Sample of MSW collection route on night for Odunpazarı (Location number: O6)

Table 1 Comparison of the current status and study results

| Number of location | Current status (km) | Results obtained with this study (km) | Number of location | Current status (km) | Results obtained with this study (km) |
|---|---------------------|---------------------------------------|---|---------------------|---------------------------------------|
| MSW collection program on daytime for TM | | | MSW collection program on night for TM | | |
| T1a | 98 | 81.2 | T1a | 72 | 56.8 |
| T1b | 105 | 81.5 | T1b | 79 | 52.2 |
| T2 | 99 | 58.8 | T2 | 74 | 55.5 |
| T3a | 70 | 63.6 | T3 | 57 | 49.6 |
| T3b | 75 | 69.7 | T4 | 60 | 58.4 |
| T3c | 82 | 64.7 | T5 | 58 | 48.5 |
| T4a | 79 | 68.6 | T6 | 63 | 59.2 |
| T4b | 125 | 57.1 | T7 | 58 | 52.2 |
| T4c | 81 | 69.9 | T8 | 47 | 38.9 |
| T5 | 89 | 84.9 | T9 | 139 | 61.8 |
| T6 | 125 | 105.7 | T10 | 82 | 70 |
| T7 | 135 | 129.8 | T11a | 70 | 61.9 |
| T8 | 91 | 80.6 | T11b | 53 | 47.6 |
| MSW collection program on Monday, Wednesday and Friday for OM | | | MSW collection program on Tuesday, Thursday and Saturday for OM | | |
| O1a | 98 | 93.4 | O1a | 59 | 55.3 |
| O1b | 68 | 63.1 | O1b | 73 | 52.2 |
| O2a | 45 | 36 | O1c | 67 | 62.8 |
| O2b | 37 | 35.6 | O1d | 58 | 41.3 |
| O3 | 62 | 56.5 | O2 | 78 | 70.3 |
| O4a | 71 | 63.9 | O3a | 50 | 48.3 |
| O4b | 82 | 78.2 | O3b | 40 | 38.8 |
| O5 | 43 | 37.6 | O4a | 59 | 56 |
| O6 | 55 | 49.8 | O4b | 63 | 57.9 |
| O7 | 35 | 32.3 | O5a | 111 | 105 |
| O8a | 45 | 41.3 | O5b | 116 | 115 |
| O8b | ---* | 30.9 | O6 | --- | 41.8 |
| MSW collection program on night for OM | | | | | |
| O1a | 37 | 34.8 | O7 | 45 | 36 |
| O1b | 49 | 39.2 | O8 | 58 | 54.4 |
| O2 | 55 | 44 | O9 | 58 | 53.8 |
| O3 | 56 | 34.8 | O10 | 51 | 44 |
| O4 | 45 | 42.4 | O11 | 62 | 58.7 |
| O5 | 36 | 34 | O12a | 55 | 52.8 |
| O6 | 61 | 53.1 | O12b | 55 | 53.7 |

* These data were not obtained.

Table 2 Weekly total distances for TM and OM

| Municipality | Current status | In this study | % reduction |
|--------------|----------------|---------------|-------------|
| TM | 12996 | 10372.2 | 20.2 |
| OM | 8583 | 7904.1 | 7.9 |

As shown in Table 2, averagely 14 % of reduction in distances of Eskisehir MSW routes was obtained. TM has high distances for dumping site is more distant to this location and MSW collection is done every day in all districts. Especially, collection vehicles are working under the capacity in outskirts. Therefore, it is considered that collection operations in these locations should be realized in every other day and transfer station can be constructed in this municipality.

5 Conclusions

Collection and transportation system of MSW should be urgently rehabilitated in Eskisehir. In this study, it is clearly shown that can be done in both systematical planning of collection system and most appropriate route for MSW collection. Traffic density and road conditions will be researched in further study. Also, recycling centers in shopping centers, marketplaces and community centers that were occurred recycling waste collection routes for these centers will be determined.

Acknowledgements: This study was financially supported by Anadolu University (Project No: 050239).

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