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GIS SUPPORTED OPTIMIZATION OF SOLID WASTE COLLECTION IN TRABZON

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ABSTRACT

In the municipal solid waste management systems, collection and hauling efforts cover 85 percent of total system expenditures that make quite huge amount of money for societies. In order to get reduction on those and to save resources, searching for optimization possibilities gains importance. In case of not using an optimization on collection, total cost of the disposal management of the solid waste is getting increased because of "empty mile negativeness. In this study, to minimize the route and collection cost was objected. For that purpose, as an optimization tool, RouteView Pro™ software was used. Comparison with present collection routes and optimized routes was pointed out a success as average 20% percent route length in decrease of entire collection job. The numbers of turns on the route and time spends also can be decreased as 30%.
Keywords: Solid waste collection, route optimization, turns, GIS, Trabzon.

TRABZON'DA KATI ATIK TOPLAMA İŞLEMİNİN CBS DESTEKLİ OPTİMİZASYONU

ÖZET

Katı atık bertaraf işlemlerinde toplama/taşıma maliyetleri toplam maliyetin %85'lik kısmını teşkil eder. Bu maliyetin azaltılması ve kaynak koruma amacıyla optimizasyon işlemlerinin araştırılması önem arz etmektedir. Toplama işlemlerinin optimize edilmemesi durumunda "boşa kat edilen yollar" yüzünden katı atık toplam bertaraf maliyetleri artmaktadır. Yapılan çalışmada en kısa güzergahın belirlemesinde Route View Pro programı kullanılmıştır. Mevcut güzergah ile optimize edilen güzergah kıyaslandığında aracın kat edeceği yol %20 oranında azalmaktadır. Katı atık toplama aracının sağa/sola dönüş sayısı da %30 oranında azalmaktadır.
Anahtar Sözcükler: Katı atık toplama, güzergah optimizasyonu, dönüşler, CBS, Trabzon.

1. INTRODUCTION

In the optimization of a solid waste management system, collection and hauling facilities that constitute for the most part of total disposal payment should be taken into consideration previously.

In literature, there are several models dealing with collection of waste in broad sense. One group of the models has an operational research approach, and they minimize costs or total driving distance by using different numerical methods [1].

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Turkey takes place in the group of medium income level economically. Kinaci et al. [2] emphasize that yearly collection expenses will be able to drop about 50% when it is used an optimization research for Istanbul.

In the research, the optimization of present truck routes being used for collection of solid wastes in Trabzon City is objected.

Trabzon City is located at the North East Part of Turkey and has a typical Mediterranean climate features. Temperature range is from 26 to -7^{o}C. Daylight hours change from 16 hours in the summer and 12 hours in the winter. The city covers an area of 40 sq km as rounded [3]. About 57,000 households have been settled down in the area. There are 39 neighborhoods in the city.

The municipality serves with about 2,800 garbage collecting containers in different sizes (150, 300, and 400 L) in the residential area. Domestic wastes from households are dropped by inhabitants into these containers. Containers are unloaded at least twice a week by about 20 trucks (in total capacity of 154 cu m). On the other hand, waste collection through some busy streets such as Maraş Caddesi is realized 7-8 times in a day. Total daily tour number in the city reaches by 50. Collection facility is subjected for 6 days in a week.

Due to the reasons such as not being smooth topographical situation and small city size, there is not any transfer station in the city yet. Collected garbage is dumped at sea side of Black Sea by blending with soil in a ratio of about 50%. The dumping area in 2 Ha and has been prepared as surrounded by breakwater walls on the sea. This kind of dumping creates considerable sea pollution. In order to reduce the amount of wastes to be landfilled, any recycling program in charge has not been applied yet [4].

2. AN OPTIMIZATION STUDY OF WASTE COLLECTION

As a beginning study for optimization of existing routes in Trabzon City, Pazarkapı-Çarşı quarters occupying 1.5% of total area were selected as a pilot area. About 5,000 inhabitants are sited in this area shown at the map in Figure 1. Selected area for optimization study is historical part and located at inner side of the city. Selected collection route in the area is employed by a truck in $7m^3$.

At the beginning of the study, first, a geo coded road map was produced. Following that work, sub-layers composing of population density and waste amount distribution were created. By this stochastic study, minimization of total route distance and so, collection cost was objected. For that purpose, RouteView Pro^{TM} being in the basis of dynamic programming and giving visual results was operated.

Present route to be optimized has been shown in Figure 2. The truck starts from Pazarkapı quarter and ends Çarşı quarter. After taking last MSW container in Çarşı quarter, the truck transports compacted contents to available landfill site. Total travel distance of present route is 4833m.

Optimized distance was 3867 m as may be observed from Figure 3. Optimization facility occupied for shortest distance was supplied a benefit of 20%. The study has been supplied a visual correction possibility on present collection route. This type of optimization trials helps to local waste managers by gaining fault correction skill.

3. RESULTS

To analysis of this visual optimization output, right and left turn numbers and distances between following containers were evaluated.

Table 1 contains of right/left turn numbers for present/optimized routes and time spends during turns. Particularly, in the right turn numbers, a substantial decrease is observed (about 50%). Depending on this state, time spends are also get decreased. On the contrary to this, only a

few benefit for left turns is contributed. Total benefit for the entire turns reaches up to roughly 30%.

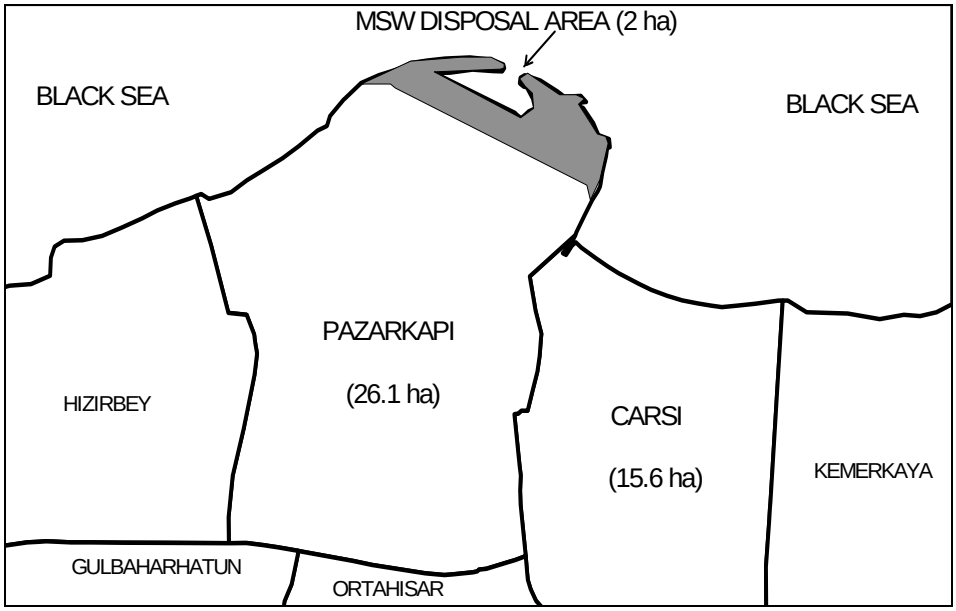

Figure 1. Quarters studied in Trabzon City

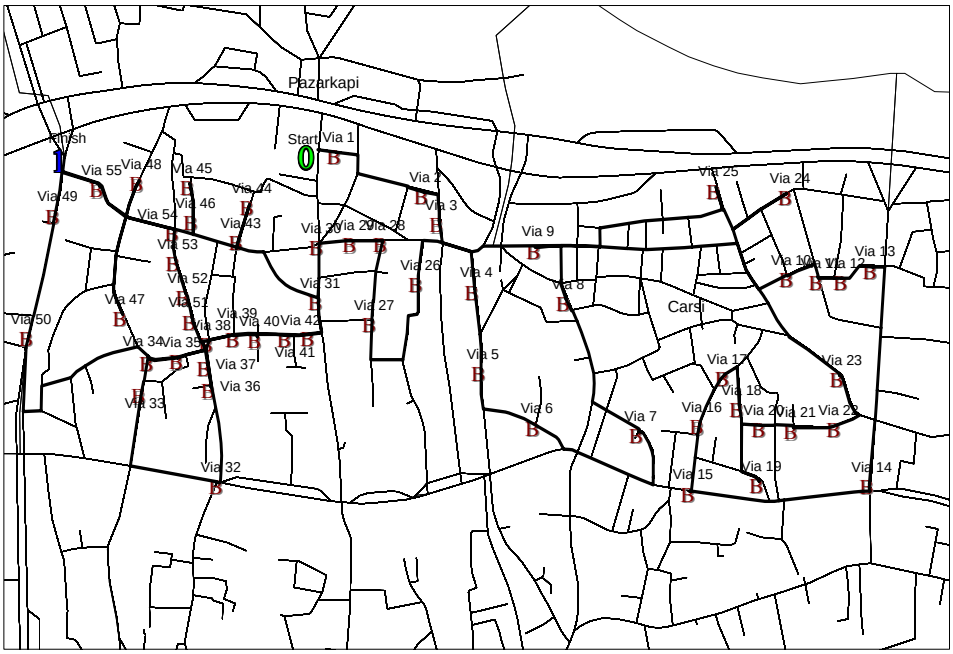

Figure 2. Çarşı Neigbourhood Present Route: **4833m**

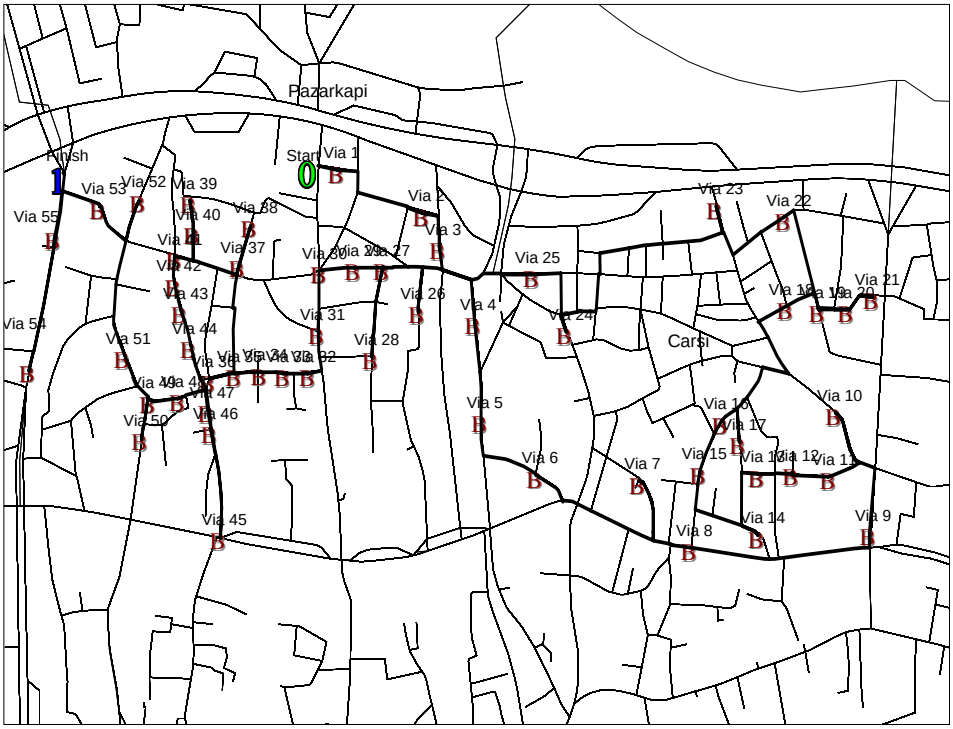

Figure 3. Çarşı Neigbourhood Optimized Route: **3867m**

Table 1. Analysis of turn numbers and time spends

	Present Route		Optimized Route	
	Number	Total Turn Time (s)	Number	Total Turn Time (s)
Right turn	32	303	17	162
Left turn	26	240	25	228
Total	58	543	42	380

As indicated from Figure 4 and Figure 5 that those state frequencies of distances between each following containers on present and optimized routes, respectively. Optimization effort causes shortenings on distances between each following containers. While 65% containers on the present route have had lower than 90m distance to following containers, 70% containers on the optimized route have had. Furthermore, distances between following containers on the optimized route are not more than 270m.

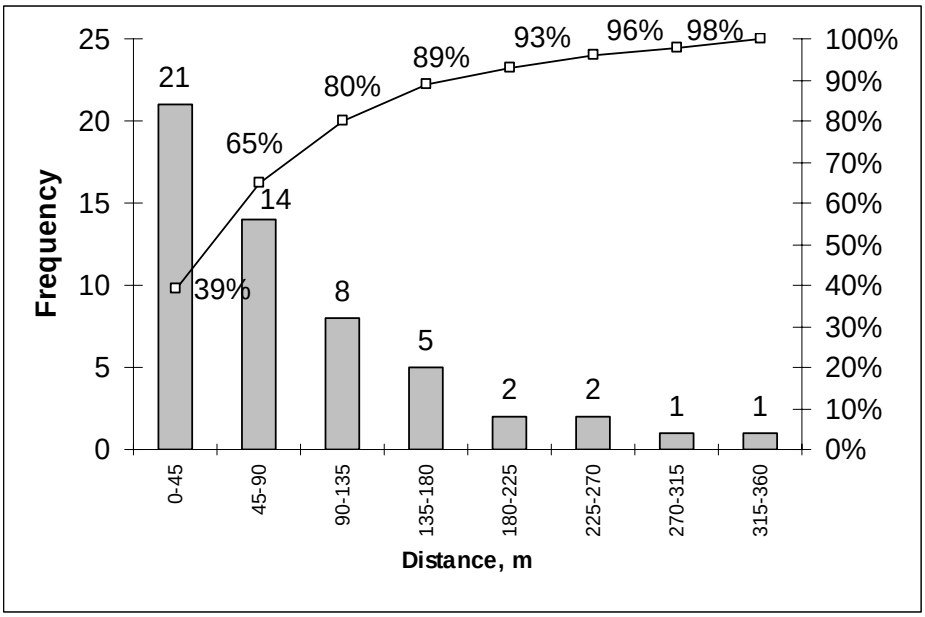

Figure 4. Intervals between container distances on present route

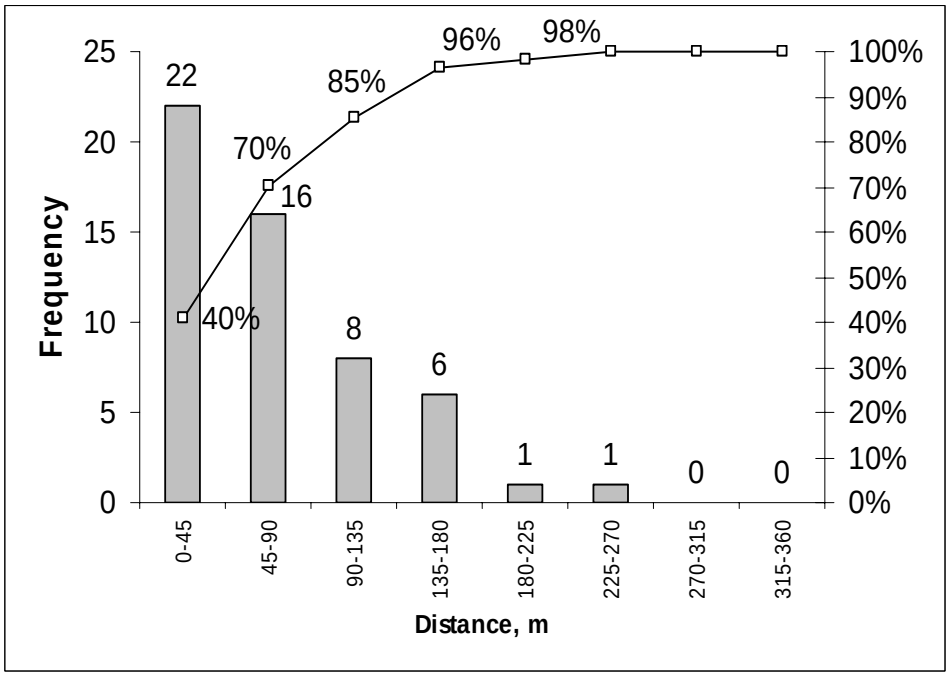

Figure 5. Histogram intervals between container distances for optimized route

4. CONCLUSION

This preliminary study made for a limited area to optimize Waste Collection facility in Trabzon City put forward that optimization conducted for shortest collection route provides 20% benefit from total distance.

The numbers of turns on the route and time spends also can be decreased as 30%. Travel distances between each following containers decrease, i.e. they close to each other.

Unit collecting cost in Trabzon city was determined as 0,05$/km*ton. It is determined that the longer road traveled the more expensive cost on collecting/hauling system. When it is used the optimized route, approximately 200,000$/year economy will be obtained in Trabzon city where 150ton/day solid waste is collected. Another gain of the optimized route is vehicle is being less time in traffic.

Turning of right, and left of vehicle causes decreasing average speed of the vehicle, so wasting time at route is getting increased. By the optimization route, number of the right turning undesirable in collecting process will decrease and vehicle speed increase.

ACKNOWLEDGEMENTS

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