Iran. J. Environ. Health. Sci. Eng., 2005, Vol. 2, No. 4, pp. 267-272

EVALUATION OF CHRONOLOGICAL ASPECTS OF COLLECTION AND TRANSPORTATION OF MUNICIPAL SOLID WASTE SYSTEM IN URMIA

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Received 16 October 2004; revised 6 March 2005; accepted 13 June 2005

ABSTRACT

Municipal solid waste (MSW) is a serious environmental hazard and social problem in Iran. Currently a high volume of solid waste is generated every day in the district towns of Iran and unfortunately solid waste management is being deteriorated due to the limited resources to handle the increasing rate of generated waste. Due to this fact that more than 60% of solid waste management cost is usually alocated for purpose collection and transportation of generated solid waste in the city. Analysis of this section and understanding of its effect on the management system could have a great role in reduction the costs and solving many of exist problems. This study illustrate the effectiveness of timing managing an MSW economy and that has been carried out as a case study in Urmia. Results of this research illustrsate that 58.3% in Neisan, 68.7% in Khavar, 61.5% in Benz, 81.3% in Compactor and 59.3% in FAUN 0f each cycle time is pickup time. Mean of traveling speed for *Van*, *Mini-truck*, *Truck*, *FAUN* and *Compactor* was 35,46,41,38 and 42 kilometer per hour respectively. Total spent time for collection and transportation of solid waste were 1:21 hour with *Van*, 1:23 hour with *Mini-truck*, 1:29 hour with *Truck*, 17 minutes with *FAUN* and 57 minutes with *Compactor*. Result of this study illustrated *Van* is the most economic vehicle for solid waste collection system in Urmia city. Generally, priority to usage of solid waste collection vehicles illustrate in below: Truck < Mini-truck < Compactor < Van < FAUN

Key words: Municipal, solid waste, transportation, collection, timing components

INTRODUCTION

Urmia City "west Azarbayjan province" is located in the west north of Iran and its area is 74 km^2 (Arseh Co., 2001 and Moshrefi, 1993). Its latitude is 37º 32´ and 45º 5´ E and its altitude is about 1330 meters above free seas level (Arseh Co., 2001 and Moshrefi, 1993). Urmia population is equal to 550,000 capita. This city is divided to 4 districts and 6 sub districts (Fasih, 1998 and Ghanbari, 2003). Solid waste collection costs depend on various parameters such as: recycling rate, collection scheme, time consumed for collection and transportation to landfill site. It is determined that the average collection cost per ton of collection waste equal to 114-120 $. (Miller,1993). Identifying efficient collection time will help engineers minimize program costs and introduce the best collection method.

Everett W. and Maratha S. were investigated about pickup time in Village city in U.S.A on 1998 (Everett *et.al.,* 1998).

Five types of *vehicles* include *Vans*, *Trucks*,*Mini trucks* ,compactors and FAUN is used in solid waste collection system of Urmia. All vehicles except *Van* haule collected solid waste to landfill that is place in 17 km north of city. *Vans* haule collected solid waste to transfer staion that is place approximately in 8 km south of city; Urmia has just one lanfill and one transfer station. Unfortunately some of them are not suitable for solid waste collection and based on economic and health reasons its application isn't acceptable.

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The objectives of this research are to:

- Determination of timing component for each type of vehicles.
- Comparison of timing and economic component for each type of vehicles.
- Selection the most suitable vehicles.
- Create a logical relation between the traveling time per collection service and distance between collection zone and landfill site by using a mathematical model.

MATERIALS AND METHODS

Data were collected by observing and calculation the collection of solid waste in Urmia during 3 months in May to July 2005. These months approximately have a equal solid waste generation coafficient with annual average in Urmia (Table1), therefore they select for this research.

The spent time per component of collection operation measured by two chronometer. Number of repetitions determined according to Fig.1.

Minimum time to pickup and discharge a waste package into *Truck* is 0.5 minutes. According to Fig.1 minimum number of repetition for this component is equal to 60. Also, average transportation time by trucks is equal to 30 minutes (EPA, 1995). Therefore minimum number of repetition for determination the transportation time by each vehicle is equal to 10. To create a logical relation between the traveling time per each collection service and distance between collection zone and landfill site, a mathematical model was used. According to this model the duration of each traveling can be estimated as: (Abdoli, 1992 and Tchobanoglous, 1993). $Y= A+BX$ Where: y = duration time of each traveling for service, x = distance between landfill site and collection zone (for all vehicles except Vans), for *Van*s x= distance between transfer station and collection zone, A, B = empirical coefficients.

These relations correlated by using EXCEL software for various collection vehicles in Urmia.

RESULTS

Table 2 illustrates the results of total collection time for each vehicles to studied regions in Urmia. These results indicate that pickup time per each ton solid waste with FAUN is maximum and equal to 11 minutes. The ratio of pick-up time to total time of collection for *Van*, *Mini truck*, *Truck*, compactor and FAUN is respectively 3.58%, 7.68%, 5.61%, 3.81% and 3.59%. It is observed that the *Van* has the least ratio and the compactor has the highest ratio. Theorically, its efficiency must be higher than other vehicles, but the total time of collection per each ton of solid wastes for this type of vehicles is more than other, and equal to 57 minutes.

Table 1: seasonally and monthly coefficients of solid waste generation in Urmia [Ghanbari ,2003]

MONTH	1	2	3	4	5	6	7	8	9	10	11	12
Generated solid waste (tone per day)	337.4	355.4	366.1	406.2	383.7	401.2	424.9	433.5	440.8	377.3	357.2	370.9
Monthly coefficient	0.87	0.92	0.94	1.05	0.99	1.03	1.10	1.12	1.14	0.97	0.92	0.96
Seasonally coefficient		0.91			1.02			1.12			0.95	

Table 2: Total collection time for each vehicle in studied regions in Urmia

Truck type	Collected solid waste (kg/cycle)	Pickup time (hr)	Hauling time (hr)	In-site time (hr)	Weighting time (hr)	Total collection time (hr/cycle)	Total collection time (hr/cycle/ton)
Van	1251	0.99	0.58	0.05	0.08	1.71	1.36
Mini truck	2497	2.40	0.95	0.05	0.10	3.49	1.40
Truck	2241	2.04	1.09	0.05	0.14	3.32	1.48
FAUN	10174	1.73	1.00	0.06	0.14	2.92	0.29
Compactor	6645	5.17	1.01	0.05	0.13	6.36	0.96

Table 3: Total hauling time from collection region to landfill site for various vehicles in Urmia

TRUCK TYPE	Total hauling time (hour)	going distance (km)	return distance (km)	Total crossed distance (km)	hauling speed (km/hr)		
					Going	Return	Total
Van	00:31	9.4	8.3	17.7	34.8	35.7	35
Mini-truck	00:54	20.6	19.7	40.3	41.1	50.3	46
Truck	01:01	21.5	19.6	41.1	39.9	41.9	41
FAUN	00:58	19.1	17.4	36.5	35.4	41.1	38
Compactor	00:58	19.7	18.8	38.5	37.8	45.4	42

The mean total hauled time per each ton for hauled wastes per trip for *Van*, *Mini truck*, *Truck*, compactor and FAUN is respectively 27, 22, 9 and 6 minutes. Therefore the total hauled time of *Truck* and *Van* is more than others. This parameter for compactor is the least. The main reason of *this* high time for *Truck* is its incompatibility for solid waste collection and doesn't use the total vehicle capacity.

Based on measurements during this research, only 50% of *Truck* nominal capacity (approximately 2.5-3 tons) has been used for solid waste collection. This reason for *Van* comes back its small container with low volume and long distance between collection region and transfer station (approximately 8 km.).

The most time required for discharging each tons of solid waste by *Van* is equal to 4 minutes and the least of them is related to compactor that equal to 49 seconds per tons hauled solid wastes. The effective reasons of being high of discharging time for *Van* can be interpreted as follow:

- low volume of *Van* container
- Because of requirement to manual fasten and opening the container cover.

Table 4: Mathematical modeling of vehicles hauling distance between landfill site and transportation station

TRUCK TYPE	R^2	EQUATION
Van	0.25	y=0.0011x+0.0210
Mini-truck	0.02	y=-0.0002x+0.0461
Truck	0.03	y=-0.0002x+0.0522
FAUN	0.22	y=0.0008x+0.0126
Compactor	0.32	y=0.0019x+0.0320

Note: R^2= coefficient of determination

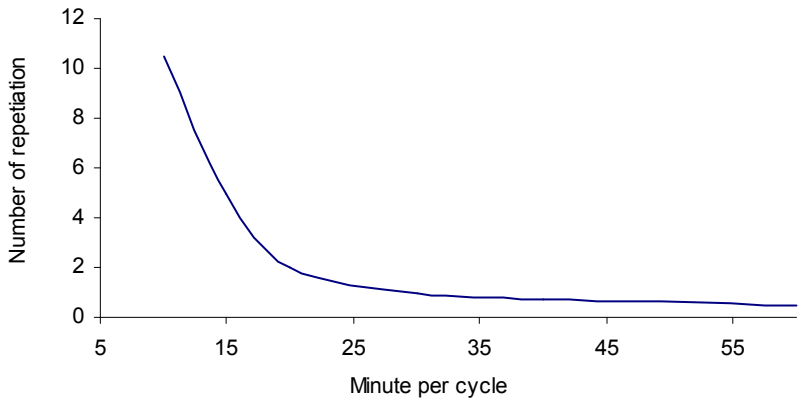

Fig. 1: The number of repetitions for each cycle of collection system

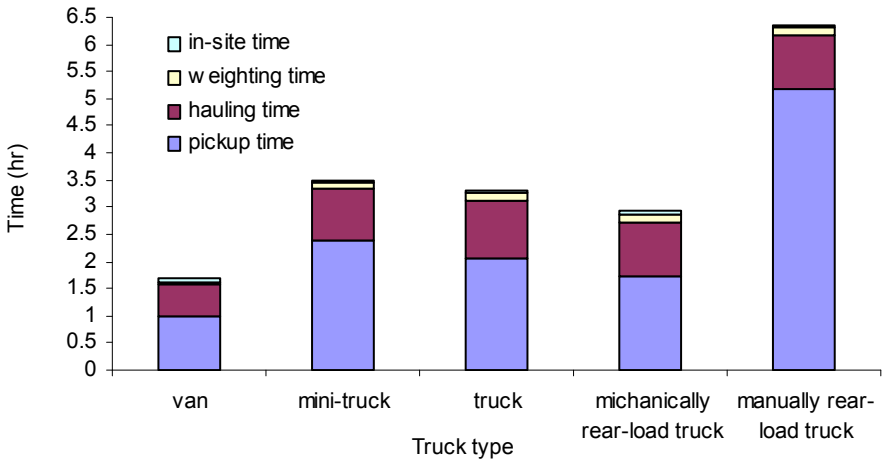

Fig. 2: Collection time for various vehicles in Urmia solid waste management system (h/cycle)

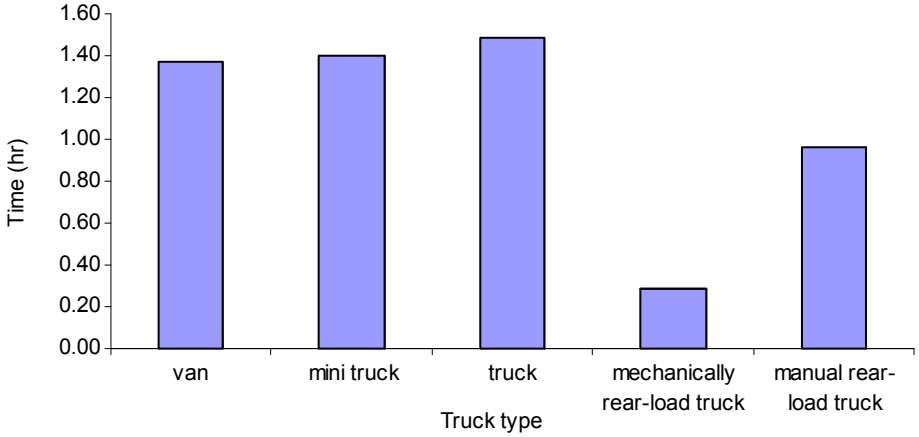

Fig. 3: Collection time for various vehicles in Urmia solid waste management system (h/cycle/tone)

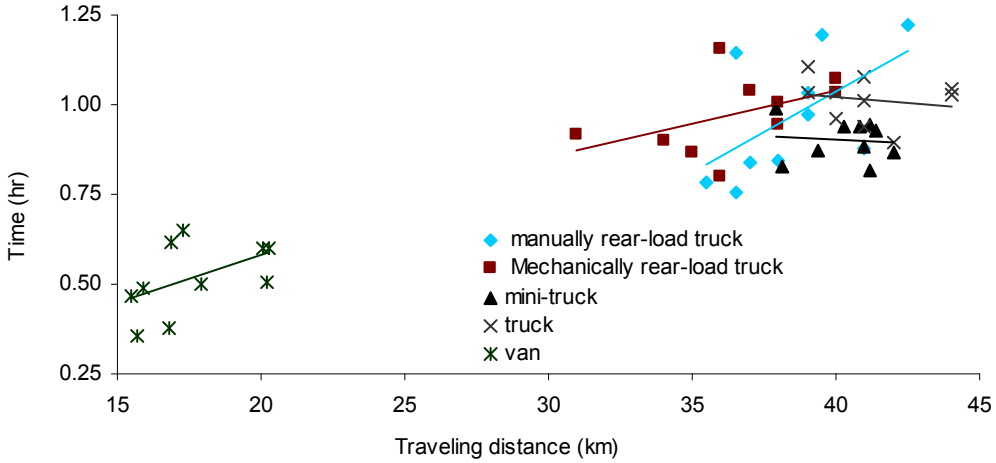

fig 4: Mathematical modeling of vehicles hauling distance between landfill site and transportation station

DISCUSSION

The timing comparison of Solid waste collection in Urmia per each ton of Solid wastes and total time of each collection cycle for various vehicles demonstrate in Fig. 2 and Fig. 3. This is resulted that the FAUN has the least time in collection and transportation solid wastes. Therefore this vehicle is the most economic vehicle in Solid waste management. Also the *Truck* need the most time for collection and transportation of Solid wastes per each ton and it is a non-economic vehicle. The reasons of this trend can be interpreted as follow:

- The internal time between pickups is high that results the dimension of vehicle container be large.
- Low number of temporary stations because using of stationary containers.
- high volume container of vehicle

Reasons of increasing pickup time per each ton of Solid waste for *Truck* in comparison with other vehicles can be interpreted as follow:

- This vehicle in not suitable for curbside collection method
- This vehicle in not suitable for passing of narrow and dead-end streets
- The vehicle doesn't have any compactor devices.

The hauled time for various vehicles in Urmia collection system is illustrated in table 3. The *Mini truck* has the most speed and *Van* is slowest vehicle. The main reason is that the *Van* most passes though crowded streets and faces with traffic.

Solid waste collection operation starts at morning therefore the *Vans* must pass through crowded streets for hauling the waste to transfer station and face with the morning traffic. Therefore the *Vans* speed become slow. However, for following reasons, transfer station don't need for this system:

- Transfer station is place on south of city, however landfill is place on north.
- Distance of landfill of city in not high to select a transfer atation for solid waste collection; therfore using of transfer station in this system is not economic.

The results of mathematical correlation of vehicles hauling speed between landfill site and transfer station demonstarted in Fig. 4 and Table 4. There is observed a logical relation between the hauling time per each tripe and crossed distance from collection zone to landfill site. The slope of all curve's for vehicles except *Truck* and *Mini-truck* is positive that this factor affect directly on this vehicles amortization.

The results of this research can be summarized as follows:

- The collection and disposal of Urmia Solid waste is operated with a traditional management system, therefore it is essential to assessment on systematic management system based on scientific principals.
- There is no compatibility between vehicles, containers and physical structure of city that was affect on collection operations efficiency.
- There is no compliance between number and type of vehicles with curbside method.
- The well designed operational plans are essential and must be closely followed to ensure an efficient and environmentally sound operation.

ACKNOWLEDGEMENTS

The authors are greatly indebted to recycle and recovery organization of Urmia especially Eng. Mortaz, for their honestly corporation during this research.

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