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Current Status of Solid Waste Transport in Mejayan District of Madiun

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ABSTRACT

Relocation of the capital of Madiun to Mejayan District has caused most area of this district to become a part ofthe urban area. Being occupied by 45.761 inhabitants, the District of Mejayan will be developedas a center of municipal services. Therefore, it should be supported with sufficient infrastructure and sanitation facilities, solid waste (SW) management in particular. However, the existing municipal SW management service in this district covered only 4 sub-districts from a total 14. The objective of this research was to evaluate the technical performance of the SW transport system in Mejayan District. Data on SW transportgeneration rate, transport facilities and efficiencies were collected throughdirect measurement and interviewing the Municipal Cleansing and Landscaping Agency representative. Operation mode and efficiency of SW transport activities were observed by following daily activities of each vehicle. The SW transport efficiency of each truck was calculated according to the time durations for embarking and disembarking the garage, SW loading and unloading, and transport from the transfer stations to the landfill, off-site factor, and SW dumping in the landfill. Some recommendations were made for the improvement of the SW transport performance.
KEYWORDS: efficiency, management, solid waste, transfer station, transport

INTRODUCTION

The District of Mejayan was established as a new capital of Madiun Cityin 2010 under the Goverment Regulation No. 52/2010 concerning Madiun District's Capital Relocation from the City of Madiun to Mejayan District. According to the detailed Spatial Plan of Madiun Capitalfor 2012-2032, the Mejayan District will be developed rapidly as a center of urban services. Mejayan District consists of 14 sub-districts.With an area of 5,522 hectares, this district wasoccupied by45.761inhabitants in 2015 [1].

The solid waste (SW) management services were conducted by the Municipal Cleansing and Landscaping Agency (MCLA). However, only 4 sub-districts have been served by the municipality. The low coverage of municipal SW service is typical in cities in developing countries. This is generally due to the limitation of financial support and resources, the reluctance of the inhabitants to pay for municipal services[2], the lack of technical skills among the personnel in municipal agencies[3], and the inadequacy of SW transport infrastructure [4].

Two dump trucks and twoarmroll truckswere operated to transport the SW from 8 transfer stations (TS)in Mejayan District to the landfill. The SW transport efficiency of the dump trucks wasonly 1 trip / day, whereas that of the armroll truck was 2 trips/day.This study aimed to evaluate the SW transport efficiencyand facilities in Mejayan District. Somestrategies for the improvement of the SW transport will recommended.

METHODS

The study was begun by measuring the SW generation rate in the study area using load-count analysis method [5] for 8 consecutive days. All collection vehicles or hand carts, which entered the TS's were counted and the SW volume in each hand cart was measured. The SW density

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wascalculated by dividing the weight of SW in the hand cart with its volume. The SW generation rate was the total volume or weight of the SW divided by the total number of people being served.

The daily SW transport activities of each vehicle were measured two times. Time durations which were required by each truck for daily operation (H), embarking (t_1) and disembarking (t_2) from and to the garage, SW loading (p_c) and unloading (u_c), travel between transfer stations (dbc), transport from the transfer station (TS) to the landfill (h_1) and from the landfill to TS (h_2), off-site factor (W), and SW dumping in the landfill (s) were recorded.

The SW pick up time (P), transport time (T), and transport efficiency (N_d) were calculated according to hauled container system (HCS) method [5] as the following:

$$P_{HCS} = p_c + u_c + dbc \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$T_{HCS} = (P_{HCS} + s + h) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$Nd = \frac{(H(1-w)-(t1+t2)}{Thcs} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Recommendations for the improvement of SW transport were made by considering the transport efficiency and the effective age of the vehicles, which was 5-8 years[6].

RESULTS AND DISCUSSION

The average SW generation rate was3.52 L/person.day, and the average density in the hand cartwas 152.63 kg/m^3. The SW density in the transport truck container is 235-350 kg/m^3 [7]. Using SW density value of 300 kg/m^3, acompaction ratioof1.97was obtained. This value wasused for determining the SW volumewhich should be transported to landfill. The total amount of SW which should betransported to Kaliabulandfill was57.13 m^3/day, whereas the SW generation rate in MejayanDistrict was 162.56 m^3/day. Therefore, the SW transport service coverage was only 35.14%.

The SW transport in Mejayan District appliedhauled container system (HCS)method [5], which was facilitated with two armroll trucks and two dump trucks. These vehiclestransported the SW from 8 TS's to the landfill (Figure1). Theroutes were set up by the MCLA. The daily operation time was from 07:00 am to 01: 00 pm, or 6 hours.Results of the measurement of the transport vehicleoperation timeareshown inTables 1- 4.

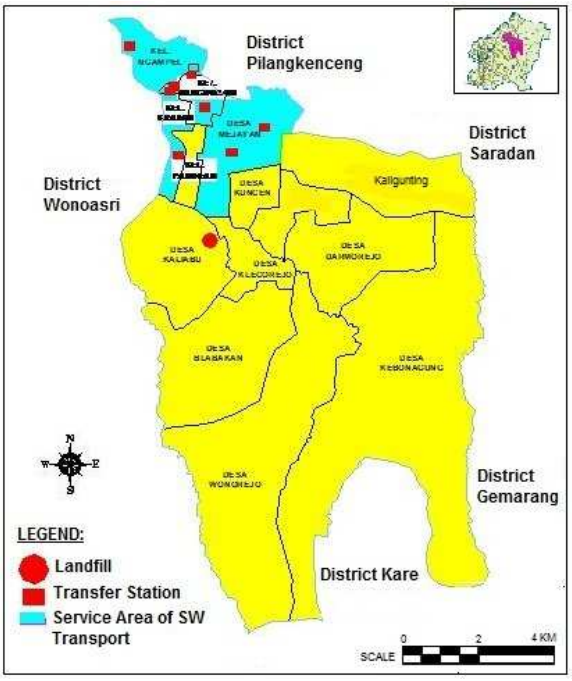

Figure 1. Orientation Map Service Area of SW Transport

Table 1. Results ofservice time measurements of the dump trucks

Vehicle number	Route	Distance (km)	Traveling time (hr)		Average traveling time (hr)	Speed (km/hr)
			1	2		
AE 8395 FP	Garage – TS	2.3	0.100	0.102	0.101	22.73
	TS– landfill	4.1	0.186	0.176	0.181	22.67
	Landfill – garage	5.8	0.193	0.203	0.198	29.29
AE 8036 EP	Garage– TS	4.6	0.188	0.205	0.196	23.17
	TS– landfill	6.9	0.291	0.298	0.294	23.44
	Landfill – garage	4.8	0.186	0.191	0.188	25.52

Table 2. Unit operation time of dump trucks

Vehicle number	p_c(hrs)	u_c(hrs)	dbc(hrs)	P_{HCS}(hrs)	s (hrs)	h (hrs/trip)	T_{HCS}(hrs/trip)
AE 8395 FP	1.315	-	-	1.315	0.08	0.36	1.76
AE 8036 EP	1.395	-	-	1.395	0.06	0.59	2.05

Table 3. Results ofservice time measurements of thearmroll trucks

Vehicle number	Route	Distance (km)	Traveling time (hrs)		Average traveling time (hrs)	Speed (km/hrs)
			1	2		
AE 8016 EP	Garage – TS	2.5	0.09	0.17	0.13	19.11
	TS – landfill	3.3	0.14	0.14	0.14	24.31
	Landfill – TS	4.0	0.22	0.22	0.22	18.22
	Landfill – garage	4.8	0.19	0.19	0.19	25.46
AE 8576 FP	Garage – TS	2.5	0.09	0.09	0.09	27.08
	TS – landfill	4.2	0.20	0.20	0.20	20.86
	Landfill – TS	4.8	0.22	0.22	0.22	21.75
	Landfill – garage	4.8	0.19	0.19	0.19	25.22

Table 4. Unit operation time of armroll trucks

Vehicle number	p_c (hrs)	u_c (hrs)	dbc (hrs)	P_{HCS} (hrs)	s (hrs)	h (hrs/trip)	T_{HCS} (hrs/trip)
AE 8016 EP	0.021	0.031	-	0.052	0.06	0.36	0.47
AE 8576 FP	0.019	0.020	-	0.039	0.06	0.39	0.49

It was observed that the existing transport efficiency (N_d) ofthe dump trucks (N_d) wasonly 1 trip/day, and that of the armroll trucks was 2trips/day. Using equation (3), which is shown in the Method Section, results of off route factor (W) calculation of the dump trucksvaried from 0.59 to 0.65, and that of the armrolltruckswas 0.80 (Tables5 and6). These values were far exceeding the criteria which are widely applied in the SW transport operations of0.10-0.15 [5].

Table 5. Results ofoff route factor (W) calculation of dumptrucks

Vehicle number	N_d (trip/day)	H (hrs)	t_1(hrs)	t_2 (hrs)	T_{HCS}(hrs/trip)	W
AE 8395 FP	1	6	0.10	0.20	1.76	0.66
AE 8036 EP	1	6	0.20	0.19	2.05	0.59

Table 6. Results ofoff route factor (W) calculation ofarmroll trucks

Vehicle number	N_d (trip/day)	H (hrs)	t_1(hrs)	t_2(hrs)	T_{HCS} (hrs/trip)	W
AE 8016 EP	2	6	0.13	0.19	0.44	0.80
AE 8576 FP	2	6	0.09	0.19	0.47	0.80

The transport efficiency can be optimized by lowering theoff routefactor to a maximum 0.15 [5]. This means that the transport crew should reduce the unnecessary activities, such asexcessive lunch time, taking unauthorized personal breaks, talking to friends, and the like.This working ineffectiveness occurred mainly because of the inavailability of clear SW transport planning and standard operation procedure. This situation reflects the weakness in organization structure and management, and the improper application of SW transportmethod [9].

Using off route factor value of 0.15, the dump truck transport efficiency could be increased to 2 trips/day, and that of the armroll truck became 10 trips/day (Tables7 and8).

Table 7. Transport efficiency values of dump trucks using W = 0.15.

Vehicle number	W (hrs)	H (hrs)	t_1(hrs)	t_2(hrs)	T_{HCS} (hrs/trip)	(1-W)*H	N_d(trip/day)
AE 8395 FP	0.15	6	0.10	0.20	1.76	5.10	2
AE 8036 EP	0.15	6	0.20	0.19	2.05	5.10	2

Table 8. Transport efficiency values of armroll trucks using W = 0.15

Vehicle number	W (hrs)	H (hrs)	t_1(hrs)	t_2(hrs)	T_{HCS} (hrs/trip)	(1-W)*H	N_d(trip/day)
AE 8016 EP	0.15	6	0.13	0.19	0.44	5.10	10
AE 8576 FP	0.15	6	0.09	0.19	0.47	5.10	10

Based on the SW transport efficiencies of the trucksand the number of TS (8 units), one armroll truckwith N_d = 10 trips/day was considered to be sufficient for serving the SW transport in Mejayan District. The dump trucks can be used for serving other MCLA duties. An addition of one reserved armroll truckwould be necessary in order to avoid the absence of SW transport activity when the operating truck do not work. In order to provide good operation of these armroll trucks, additional 3 containers of 6 m^3 capacity were required, as only 5 TS's were facilitated with SW containers.

The truck agesare shown in Table 9. Two of the truck ages(50%) exceeded the maximum lifetime of 8 years [6, 8]. These trucks, namely armrolltruck AE 8016 EP (10 years of age) and dump truck AE 8036 EP (22 years of age) required replacements for better SW transport service. The aging problem of SW transport vehicles is typical in developing countries [10][11], and needs proper budgetary planning solution.

Table 9. Transport vehicle lifetime

Vehicle number	Type of vehicle	Capacity (m^3)	Procurement year	Age (year)	Lifetime criteria (year)
AE 8016 EP	**Armroll truck**	6	2006	10	8
AE 8576 FP	**Armroll truck**	6	2015	1	
AE 8395 FP	**Dumptruck**	7.5	2014	2	
AE 8036 EP	**Dumptruck**	7.5	1994	22	

Based on the above description on the SW transport condition in Mejayan District, the following recommendations were made for improving the operation performance:

1. Performing technical training for the SW transport crew for proper service implementation .
2. Improving the management performance of SW transport activity, and inclusion of regular monitoring and evaluation on the SW transport activities.
3. Replacementof one armroll truck of which lifetime has exceeded the criteria of 8 year operation.
4. Procurement of 3 containers of 6 m^3 capacity for 3 TS's, which have not been prepared for armroll truck operation.

CONCLUSION

The SW transport in Mejayan District was operated with very limited efficiency. The transport efficiencies of the dump trucks and armroll trucks were only 1 trip/day for and 2 trips/day respectively. The low efficiencies were caused by the high values of off route factors. Optimization of the transport service whichused off route factor of 0.15 resulted in the improvement of transport efficiency of the dump trucks to 2 trips/day, and those of the armroll trucks to 10 trips/ day. Based on these results, only two armroll trucks were needed to serve 8 TS's. Three additional containers of 6 m3 capacity were required to facilitate 3 TS's to support armroll truck operation. Recommendations for improving the SW transport activities were conducting technical training for the SW transport crew, improving the SW transport management performance, replacing the aging trucks, and providing 3 containers for armroll truck operation in 3 TS's.

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