

Comparison of operational efficiency among waste collection systems in Da Nang city, Vietnam

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ABSTRACT

The objectives of this study were to get the basic data on waste collection operation on different collection systems by GPS and GIS applications, and to estimate the collection resources and compare the operational efficiency by collection system. The authors collected data on operation times, distances and waste quantities on some collection systems applied in Da Nang city, Vietnam. The operation of waste collection would be classified as follows; 1) Moving between parking/meeting point and collection area, 2) Collection, 3) Transfer, and 4) Others, and recorded operation times by the defined classification. Travel distances and velocities were analyzed by the classification of operation mentioned above. The authors also measured the amount of collected waste by actual measurement on site or a platform scale at landfill site. The authors analyzed the detail breakdown of collection activities, and compared among different collection systems by the collection efficiency indicators, e.g. person-hours/t, average collection velocity (km/h).

Keywords: Municipal solid waste, Collection and transport, GPS, Time Motion Study, Operational efficiency

INTRODUCTION

In Vietnam, the waste collection is a labor intensive task in MSW management, and the improvement of collection efficiency would be one of the important problems. Da Nang city has a good practice in waste collection system and various collection systems, e.g. dustbin collection, tricycle collection, truck collection, and waste transfer stations.

The objectives of this study were to get the basic data on waste collection operation on different collection systems as the basis of planning good waste collection system by GPS and GIS applications, and to estimate the collection resources and compare the operational efficiency by collection system.

The authors conducted tracking survey of waste collection by tracing and GPS logger, and collected data on operation times, distances and waste quantities on some collection systems applied in Da Nang city, Vietnam; tricycle door-to-door collection, dump truck dustbin collection, forklift truck dustbin collection, etc.

The operation of waste collection would be classified as follows; 1) Moving between parking/meeting point and collection area, 2) Collection, 3) Transfer, and 4) Others. The authors recorded operation times by the defined classification. The authors also collected tracking data by attaching GPS loggers. Travel distances and velocities were analyzed by the classification of operation mentioned above. The authors also measured the amount of collected waste by actual measurement on site or a platform scale at landfill site.

The authors analyzed the detail breakdown of collection activities, and compared among different collection systems by the collection efficiency indicators, e.g. person-hours/t, average collection velocity (km/h).

METHODOLOGY

The authors focused on the collection systems applied in the following target areas in Da Nang city, Vietnam:

- 1) Tricycle door-to-door collection (Traditional) in Area 4 of Cam Le District: A tricycle worker collects waste by door-to-door collection and carried to a meeting point, then forklift truck workers (1 driver and 2 workers) transferred the waste at the meeting point and carried to the landfill site.
- 2) Lift truck dustbin collection (Newly proposed) in Area 3 of Cam Le District: Lift truck workers (1 driver and 1 worker) distribute dustbins in the evening, collect waste by dustbin collection and carry to a transfer station on the following morning, then a container truck (1 worker) transferred the container at the transfer station and carried to the landfill site.

The authors conducted tracking surveys of waste collection and transport by video camera recordings and GPS loggers, and collected data on working hours and tracks. The operation category of waste collection was classified and recorded as follows; 1) Moving between parking/meeting point and collection area, 2) Collection, 3) Transfer, and 4) Others. The authors recorded operation times by the defined classification. The amount of collected waste was also measured by 100kg/1000kg scales on site or a platform scale at the landfill site. The surveys were conducted from April 29th to May 7th, 2012.

The authors intended to compare the operational efficiency among the waste collection systems by working hours needed for waste collection and transport; i.e. “person-hours for 1t of waste collection and transport (person-hours/t).” The system boundary included “waste collection by a tricycle, waste transport by a forklift truck” for Area 4, and “waste collection and dustbin distribution by a Lift truck, waste transport by a container truck” for Area 3.



Photo 1 Tricycle collection in Cam Le District



Photo 2 Dump truck collection by dustbin in Cam Le District

RESULTS AND DISCUSSION

The authors analyzed the detail breakdown of collection activities, and compared among different collection systems.

1. Current operational status of waste collection

Both of target areas are residential area, and the numbers of households (excluding house for rent) were 903 in Area 4 and 656 in Area 3. The total collection amounts were 2,440-2,715kg in Area 4, and 1,512-1,828kg during the survey period. The results of total and breakdown of collection activities by person-hours per ton were shown in Table 1. Regarding the total person-hours per ton, the tricycle door-to-door collection spent 2.76 person-hours/t and the lift truck collection spent 2.13 person-hours/t.

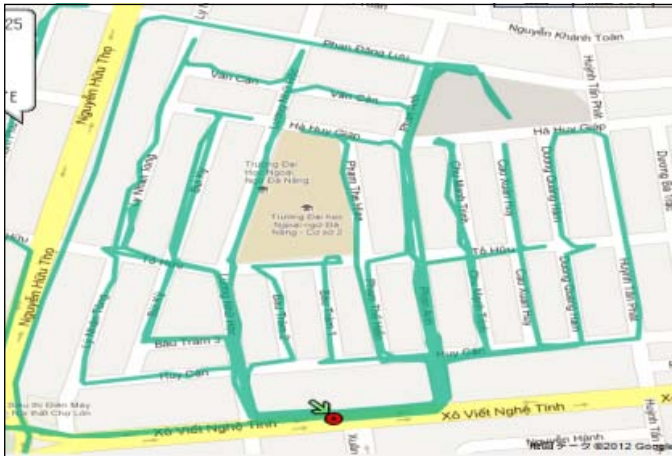
The tracking image and operation distance for each collection system was shown in Figure 1 and Table 2. The tricycle door-to-door collection covered most of the streets in Area 4; the collection distance was 7.32km per day, corresponding to 92% of the total road length. The collection route of dustbin collection was rather simplified than the door-to-door collection, and the collection distance was shortened to 3.46km, corresponding to 46% of the total road length, about half of door-to-door collection.

The result of average operation velocity (km/h) by collection system was also shown in Table 2. Regarding the tricycle door-to-door collection, the velocity for moving forward was 6.04km/h, slightly faster than the normal walking speed, and that for moving backward was 3.91km/h because of the heavy load of waste for the back way. For the lift truck dustbin collection, all the velocities were more than 4 times faster than the tricycle door-to-door collection. The dustbin collection has the potential of improving collection efficiency in combination with the advantage in operation distance.

The result of average operation velocity by collection system was shown in Table 3. Regarding the tricycle door-to-door collection, the velocity for moving forward was 6.04km/h, slightly faster than the normal walking speed, and that for moving backward was 3.91km/h because of the heavy load of waste for the back way. For the lift truck dustbin collection, all the velocities were more than 4 times faster than the tricycle door-to-door collection. The lift truck dustbin collection has the potential of improving collection efficiency in combination with the advantage in operation distance.

Table 1 Summary of operation time by collection system on May 7th, 2012

	No. of workers	Collected amount (kg)	Collection				Distribution			Others		Total
			Moving	Collection	Unloading	Others	Moving	Distribution	Loading	Transfer from dustbins to container	Clean up dustbins	
Tricycle door-to-door collection	1	2,715	1:18:54	4:12:58	0:56:05	1:01:44						7:29:41
Lift truck dustbin collection	2	1,828	0:11:21	0:27:23	0:06:47		0:13:14	0:25:32	0:08:07	0:28:35	0:19:44	3:53:07



Door-to-door collection in Area 4

(Operation distance: 7.32km=92% of total road length)



Dustbin collection in Area 3

(Operation distance: 3.46km=46% of total road length)

Figure 1 Tracking image of two collection systems

Table 2 Operation distance and velocity by collection system on May 7th, 2012

Area	Collection system	Total road length (km)	Destination of waste	Operation distance (km/day)				Average velocity (km/h)		
				Collection	Distribution	Moving	Total	Moving forward	Collection	Moving backward
Area 4	Tricycle door-to-door collection	7.93	Meeting point (Very near)	7.32km (92% of total)		6.58	13.90	6.04	1.74	3.91
Area 3	Lift truck dustbin collection	7.60	Transfer station (far)	3.46km (46% of total)	3.63	10.13	17.22	26.45	7.49	28.75

Table 3 Average operation velocity by collection system (unit: km/h)

Area	Collection system	Moving forward	Collection	Moving backward
Area 4	Tricycle door-to-door collection	6.04	1.74	3.91
Area 3	Lift truck dustbin collection	26.45	7.49	28.75

2. Current operational status of waste transfer

The authors also surveyed the waste transfer activities relevant to the waste collection systems by GPSs and video recordings in target areas; a forklift truck transfer in Area 4, and a container truck transfer in Area 3. The average unit transfer time (person-hours/t) for forklift truck was 1.64 person-hours/t, and that for container truck was 0.146 person-hours/t, less than one tenth of forklift truck because the container truck doesn't spend time for rounding many points, and the number of workers is one for a container truck and 3 for a forklift truck.

For the dustbin collection in Area 3, one worker took in charge of transferring waste from dustbins to a container at the transfer station. The worker spent 56 seconds for a small dustbin (240L), and 2 minutes for a large dustbin (660L).

Table 4 Comparison of operational efficiency between two collection systems by person- hours/ton

	Waste collection									Waste transfer		Total
	Collection				Distribution			Others		Container truck transfer	Forklift truck transfer	
	Moving	Collection	Unloading	Others	Moving	Distribution	Loading	Transfer from dustbins to container	Clean up dustbins			
Tricycle door-to-door collection	0.48	1.55	0.34	0.38							1.64	4.40
	11.0%	35.3%	7.8%	8.6%								
Lift truck dustbin collection	0.21	0.50	0.12		0.24	0.47	0.15	0.26	0.18	0.15		2.27
	9.1%	22.0%	5.4%		10.6%	20.5%	6.5%	11.5%	7.9%	6.4%		

3. Comparison of operational efficiency among collection systems

Based on the abovementioned data, the authors summarized the operational efficiency between two collection systems by person-hours/t. The result was shown in Table 4. The total person-hours for the tricycle door-to-door collection was 4.40 person-hours/t; and that for the lift truck dustbin collection was 2.27 person-hours/t, corresponding to about half of the tricycle door-to-door collection. The operation efficiency of waste collection is higher for lift truck dustbin collection. The operational efficiency of waste transfer contributed larger on the difference.

CONCLUSION

The authors conducted tracking survey of waste collection/transport by tracing and GPS logger, and collected data on operation times, distances and waste quantities on 2 collection systems applied in Da Nang city, Vietnam; Tricycle door-to-door collection, and Lift truck dustbin collection. The main findings were as follows:

- 1) Regarding the total person-hours per ton, the tricycle door-to-door collection spent 2.76 person-hours/t and the lift truck collection spent 2.13 person-hours/t. The detail breakdown of operation time was also surveyed.
- 2) For the tricycle door-to-door collection, the velocity for moving forward was 6.04km/h, slightly faster than the normal walking speed, and that for moving backward was 3.91km/h because of the heavy load of waste for the back way. For the lift truck dustbin collection, all the velocities were more than 4 times faster than the tricycle door-to-door collection.
- 3) The average unit transfer time (person-hours/t) for forklift truck was 1.64 person-hours/t, and that for container truck was 0.146 person-hours/t, less than one tenth of forklift truck because the container truck doesn't spend time for rounding many points.

- 4) The total person-hours for the tricycle door-to-door collection was 4.40 person-hours/t; and that for the lift truck dustbin collection was 2.27 person-hours/t, corresponding to about half of the tricycle door-to-door collection. The operation efficiency of waste collection is higher for lift truck dustbin collection.

It is indispensable to establish the information data basis on waste collection/transport in order to improve the operational efficiency. Further data collection on various applicable collection/transport systems and the simulations of waste collection/transport scenarios based on the reliable data would be useful for planning rational and efficient waste collection/transport system.

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1. Introduction

1.1 Background

- Waste collection is a labor intensive task in MSW management, and the improvement of collection efficiency is one of important problems.

 - As the basis of planning rational waste collection, it is indispensable to
 - 1) Collect basic data on waste collection operation
 - 2) Estimate the collection resources
 - 3) Compare the operational efficiency on different collection systems.
-

1.2 Collection systems in Da Nang city

- Da Nang city has good practices in waste collection and transport system; e.g. dustbin collection system, tricycle collection system, truck collection system, and waste transfer stations.



Tricycle door-to-door collection



Mini-truck dustbin collection

1.3 Objectives

Question:

- *How much differences are there between traditional door-to-door collection system and dustbin collection system?*

 - This study aimed to
 - 1) Collect the basic data on 2 waste collection systems by GPS/GIS application
 - 2) Compare the operational efficiency of 2 representative collection systems
-

2. Methodology

2.1 Target collection systems in Da Nang and the target boundary



Door-to-door collection
(in front of each house)



Collection by Tricycle



Transfer at Meeting point by forklift truck



Dustbin collection
(put along streets)



Collection by Mini-truck
(2 trips for collection & distribution)



Transfer at transfer station by container truck



Khanh Son Landfill

Scope of study:

- **2 kinds of collection methods**
- **Collection efficiency by person-hours**

2.2 Outline of tracking survey by GPS/GIS application

Basic data collection on 1) Distance, 2) Time, and 3) Collection amount

A. Attachment of GPS logger on collection/transport vehicles



B. Collection of tracking data

C	D	E	F	G	H	I	J	
DATE	TIME	VALID	LATITUDE N/S	LONGITUDE/W	SPEED	HEA		
2007/3/25	23:46:12	SPS	35.6685 N	139.418 E	0.095 km/h	181		
2007/3/25	23:46:13	SPS	35.6685 N	139.418 E	0.125 km/h	181		
2007/3/25	23:46:14	SPS	35.6685 N	139.418 E	0.154 km/h	181		
2007/3/25	23:46:15	SPS	35.6685 N	139.418 E	0.182 km/h	181		
2007/3/25	23:46:16	SPS	35.6685 N	139.418 E	0.114 km/h	181		
2007/3/25	23:46:17	SPS	35.6685 N	139.418 E	0.260 km/h	181		
2007/3/25	23:46:18	SPS	35.6685 N	139.418 E	1.524 km/h	181		
2007/3/25	23:46:19	SPS	35.6685 N	139.418 E	2.530 km/h	181		
2007/3/25	23:46:20	SPS	35.66849 N	139.418 E	6.503 km/h	181		
2007/3/25	23:46:21	SPS	35.66847 N	139.418 E	12.729 km/h	246		
2007/3/25	23:46:22	SPS	35.66846 N	139.4179 E	15.591 km/h	267		



1. Video recording for operation time by the following category:

- 1) Waste Collection (and Dustbin Distribution)
 - a) Moving from parking to collection area
 - b) Collection (Dustbin distribution)
 - c) Moving from collection area to meeting point
 - d) Waste unloading (Dustbin loading) at MP/TS
- 2) Waste Transfer
 - a) Transfer of dustbins to container
 - b) Clean up of dustbins
 - c) Transfer by truck

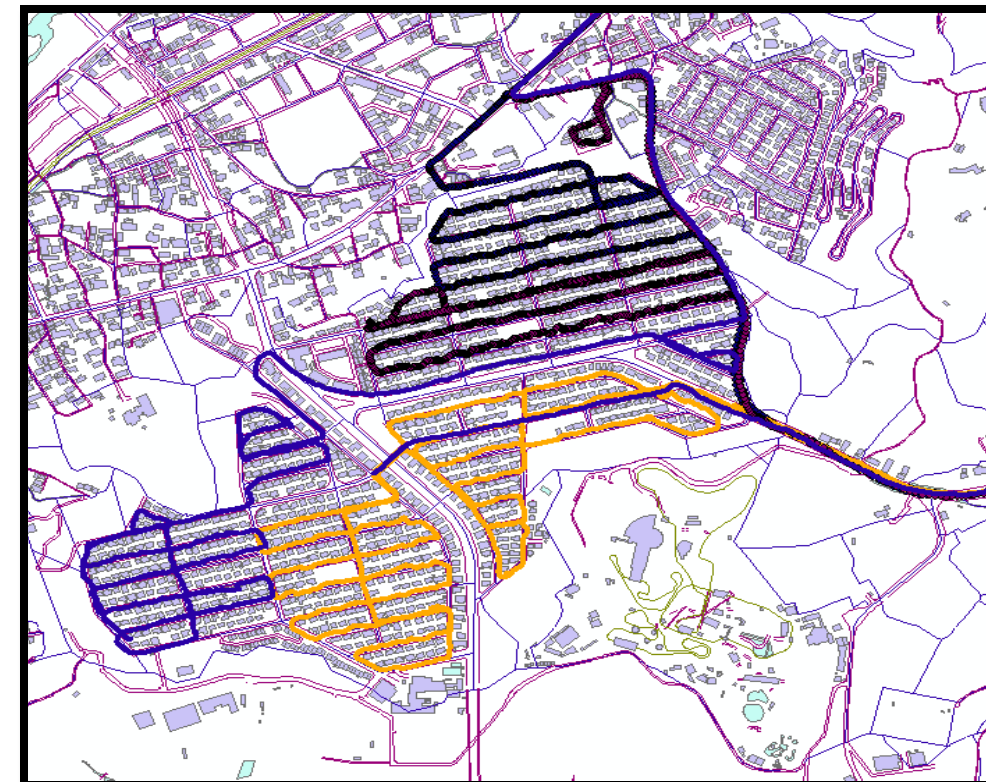


2. Data collection of collection amount

- 1) Actual measurement on site by 100/1000kg scale
- 2) Weighbridge data collection at landfill site



C. Visualization of tracking data and calculation of travel distance/velocity by GIS software



3. Results and discussion

3.1 Tracking image of 2 collection systems in Da Nang city



Door-to-door collection in Area 4

Operation distance:
7.32km=92% of total road length



Dustbin collection in Area 3

Operation distance:
3.46km=46% of total road length

3.2 Summary of operation time by collection system on May 7th, 2012

	No. of workers	Collected amount (kg)	Collection				Distribution			Others		Total (person-hours)
			Moving	Collection	Unloading	Others	Moving	Distribution	Loading	Transfer from dustbins to container	Clean up dustbins	
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Regarding the total person-hours per ton, the tricycle door-to-door collection spent 2.76 person-hours/t and the lift truck collection spent 2.13 person-hours/t.

3.3 Operation distance and velocity by collection system on May 7th, 2012

Area	Collection system	Total road length (km)	Destination of waste	Operation distance (km/day)				Average velocity (km/h)		
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Area	Collection system	Moving forward	Collection	Moving backward
Area 4	Tricycle door-to-door collection	6.04	1.74	3.91
Area 3	Lift truck dustbin collection	26.45	7.49	28.75

- Regarding the tricycle door-to-door collection, the velocity for moving forward was 6.04km/h, slightly faster than the normal walking speed, and that for moving backward was 3.91km/h because of the heavy load of waste for the back way.
- For the mini truck dustbin collection, all the velocities were more than 4 times faster than the tricycle door-to-door collection. The dustbin collection has the potential of improving collection efficiency in combination with the advantage in operation distance.

3.4 Current operational status of waste transfer

	Number of workers	Average transport time (person-hours/t)	Transfer time from dustbins to container at transfer station (seconds/dustbin)
Tricycle door-to-door collection	3	1.64	-
Mini truck dustbin collection	1	0.146	56 for 240L 120 for 660L

- The average unit transfer time by container truck was less than one tenth of forklift truck because the container truck doesn't spend time for rounding many points, and the number of workers is one for a container truck and 3 for a forklift truck.
-

3.5 Comparison of operational efficiency between two collection systems by person-hours/ton

	Waste collection							Waste transfer				Total	
	Collection				Distribution			Others		Container truck transfer	Forklift truck transfer		
	Moving	Collection	Unloading	Others	Moving	Distribution	Loading	Transfer from dustbins to container	Clean up dustbins				
Tricycle door-to-door collection	0.48	1.55	0.34	0.38	/							1.64	4.40
	11.0%	35.3%	7.8%	8.6%								37.3%	100%
Mini truck dustbin collection	0.21	0.50	0.12		0.24	0.47	0.15	0.26	0.18	0.15	/		2.27
	9.1%	22.0%	5.4%		10.6%	20.5%	6.5%	11.5%	7.9%	6.4%			100%

- ❑ The total person-hours for the tricycle door-to-door collection was 4.40 person-hours/t; and that for the lift truck dustbin collection was 2.27 person-hours/t, corresponding to about half of the tricycle door-to-door collection.
- ❑ The operation efficiency of waste collection is higher for lift truck dustbin collection. The operational efficiency of waste transfer contributed larger on the difference.

Conclusions

- The dustbin collection can decrease the collection distance and operation time in comparison to the traditional door-to-door collection.
- The total person-hours for the lift-truck dustbin collection was about half of the tricycle door-to-door collection.
- Transfer system has a great impact on the total collection efficiency.

As the future tasks,

- Data collection on various collection systems, especially on separate collection for biomass, dustbin collection, collection by trucks, etc.
 - Analysis on factors relevant to collection efficiency
 - Estimation model development as the basis of rational waste collection planning
 - Analysis based on LCA, LCC, cost-effectiveness of MSW
-

Thank you very much for your attention.

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Major alternatives in Vietnam



Door-to-door commingled collection



Dustbin collection of MSW



Segregate collection of food waste



Transfer station installation

Waste collection and transportation in **Ha Noi**

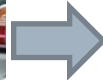
Collection at source

Transfer

Transportation

Treatment

Door-to-door collection
(Normal)

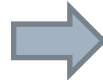


Nam Son Landfill



Cau Dien Composting plant

Bin collection
(3R-HN project area)



Combine Bin collection and Door-to-door collection

