

2-10 GPS/GIS Application for Data Collection of Segregate Waste Collection in Hanoi Vietnam

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ABSTRACT

This manuscript describes a new approach for monitoring and managing municipal solid waste collection, which using GIS/GPS application, other field observations and mapping. A case study was conducted to evaluate the current status and operational efficiency of municipal solid waste collection, especially segregate collection by dustbin in Hanoi city. A tracking survey of waste collection vehicles to collect the data on position, tracking, operation time, speed, and distance of each worker by GPS logger was conducted; besides, collection data on waste quantity was also carried out. The results identified existing problems, weak-points, and improper activities. Moreover, the interesting results from this study are expected to provide a support tool for monitoring and managing municipal solid waste collection and transfer systems by using GIS application for waste managers and policy decision makers.

KEYWORDS

Municipal Solid Waste (MSW), Waste Collection and Transport, GPS, GIS, Time Motion Study

INTRODUCTION

The population growth and urbanization expanse in urban cities of developing countries have led to a dramatic increase in municipal solid waste production and a complex changes in its composition. In general, an effective municipal solid waste system should include the following options: waste collection, transportation, transfer, intermediate treatment, reduce - reuse - recycle (3Rs) facilities and disposal. In which, the waste collection and transfer are the first and the most important components in whole system. These depended on the site situation, waste generation, distribution road network, manpower, vehicles, treatment methods, etc. Hence, evaluation and optimization of these factors are the important works for the effective municipal solid waste system.

This report describes a new approach for monitoring and managing municipal solid waste collection, which using GIS/GPS application, other field observations and mapping. A case study was conducted to evaluate the current status and operational efficiency of municipal solid waste collection, especially segregate collection by dustbin in Hanoi city.

METHODOLOGY

1. Current status of MSW collection activities in Hanoi city

At present, the MSW collection system in Hanoi city includes three kinds: door-to-door collection (traditional method), segregate bin collection (for 3R-HN project areas), and combination of bin collection and door-to-door collection. The operational mechanism of these systems illustrated and presented in Figure 1.

Hanoi city had been chosen as target city for 3R project which received great support from the Japan Government. This project conducted for the implementation support of the 3R initiative in Hanoi city to contribute to the development of a “Sound Material – Cycle Society” (named 3R-HN project), for 3 years from November 2006. This project conducted in four wards of Hanoi, including Nguyen Du ward (Hai Ba Trung District), Phan Chu Trinh ward (Hoan Kiem District), Thanh Cong ward (Ba Dinh District), and Lang Ha ward (Dong Da District).

After three years of the preliminary and implementation activities, Hanoi government have been keeping and improving the project’s activities in those wards. Among wards, Nguyen Du ward is the most successful and efficient case, this ward was chosen as target area for this study.

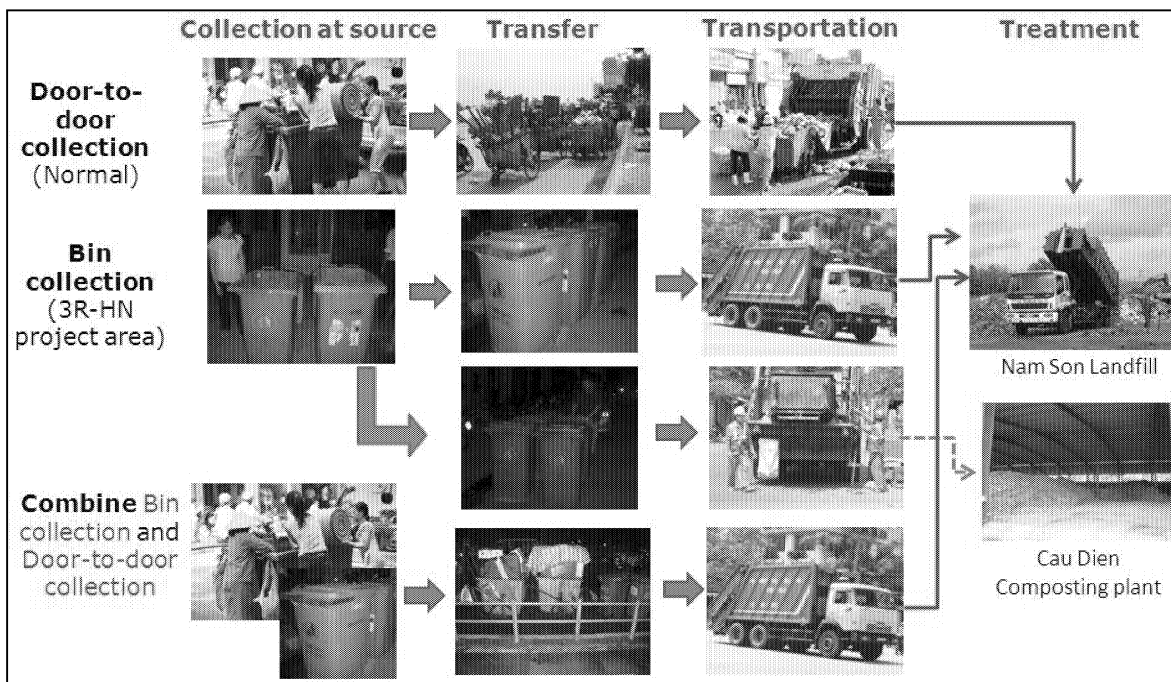


Figure 1. Schematic diagram of waste management system in Hanoi

2. Research area and target sample

Nguyen Du ward was chosen as target area for segregate collection by dustbin in Hanoi city. Nguyen Du ward estimated population of 6,682 people with 1,988 households (2010)¹. The amount of solid waste collected in Nguyen Du ward was approximately 9.0 ton/day for domestic solid waste.

¹ People committee (2010). Report on current status of economic and social in 2010. People committee of Nguyen Du Ward, Hanoi, Vietnam. (In Vietnamese)

In this ward, segregate bin collection is the major method; however every worker has one or two handcarts for collecting waste discharged from small business sectors or public areas (waste on the road).

Regarding 3R-HN project areas, each worker manage one area with a number of designed putting points, where worker put two dustbins (01 green color bin for biodegradable waste which will be treated by composting and 01 orange color bin for remaining waste which will be treated by landfill). The segregate waste collection system was illustrated in Figure 2.

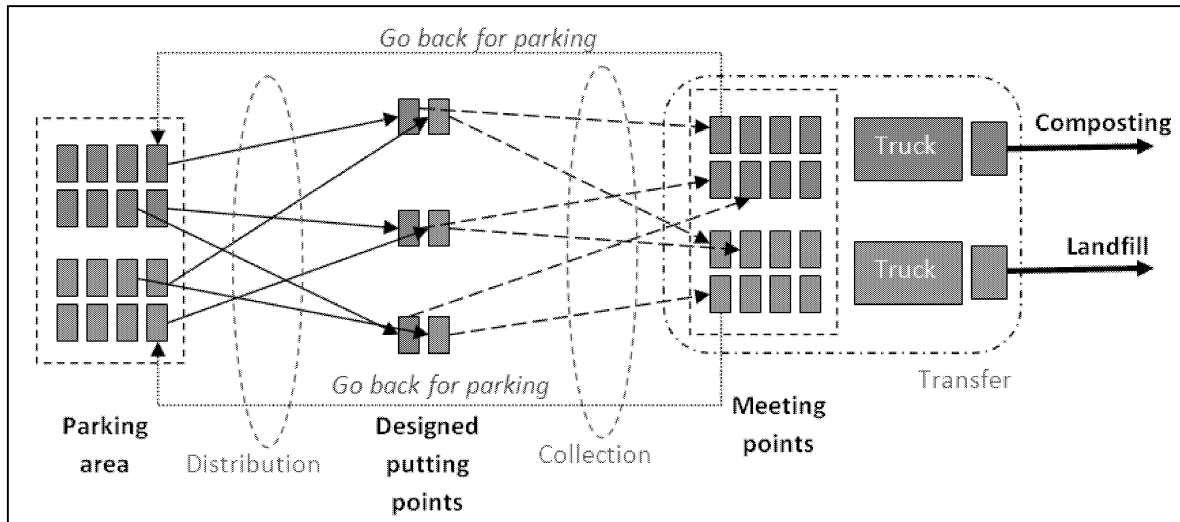


Figure 2. Schematic diagram of segregate waste collection system by dustbin in Hanoi

3. Outline of survey

A tracking survey of waste collection vehicles by tracking and GPS logger was conducted; besides, collection data on operation time, distance and waste quantity were also carried out.

For tracking data collection, survey was conducted on waste collection vehicles as dustbins and handcarts by using GPS logger application. GPS logger was attached on the shoulder of worker, so that data as position, tracking, operation time, speed, and distance of each worker was collected by GPS logger. Besides, each worker was followed by one measurement person who recorded any operation activities of collection system; especially for special position (e.g., dustbin/handcart parking, transfer station, place for putting dustbins) and operation time of each worker by manual measurements as timer, paper local map, designed form, etc.

The operation of waste collection would be classified as follows:

- 1) *Distributing each dustbin from a facility (a parking) to the designed putting point.*
- 2) *Refreshing and cleaning up public areas.*
- 3) *Collecting each dustbin from the designed putting point to the transfer station (meeting point).*
- 4) *Waiting at the meeting points.*
- 5) *Transferring collected waste (from handcarts/dustbins to truck).*
- 6) *Parking each dustbin*

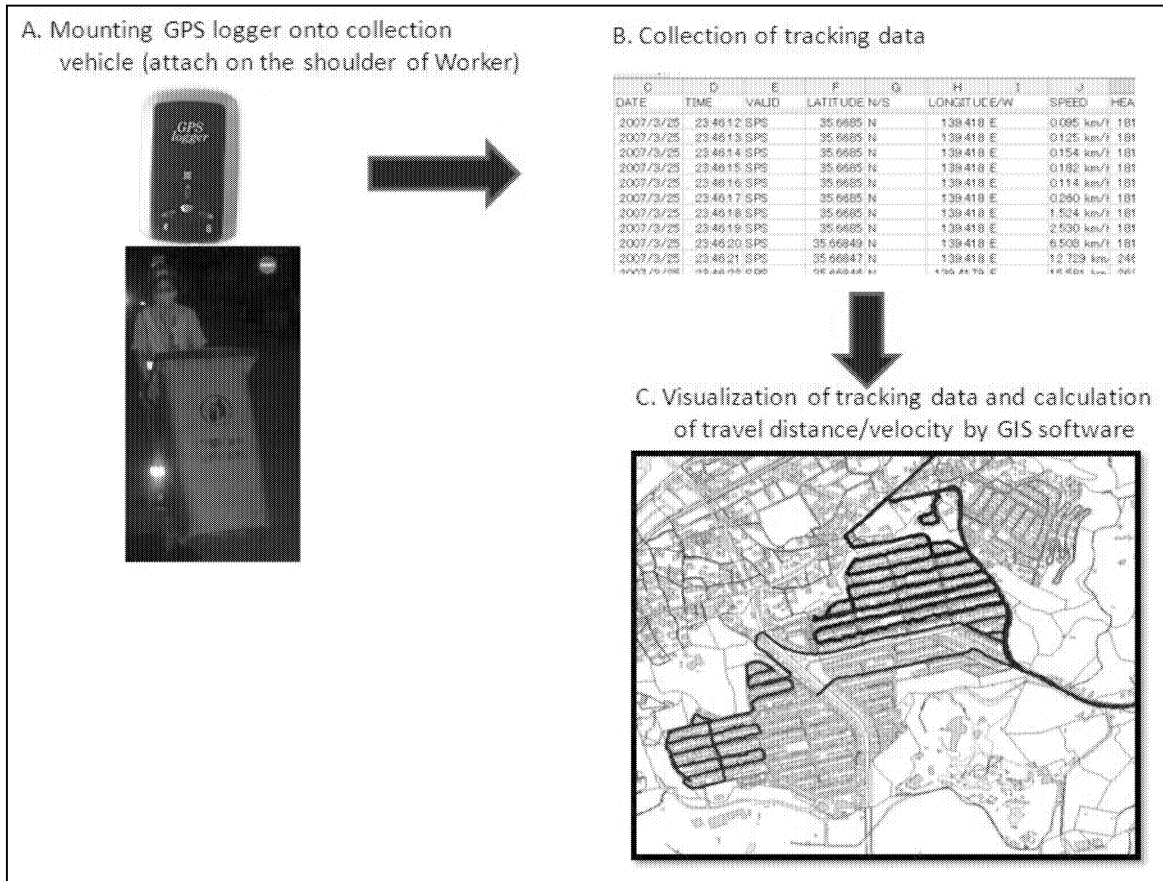


Figure 3. Framework of tracking data collection of waste collection

For data collection and analysis, the authors integrated both GPS logger data and manual measurements. By using GIS software (ArcView 9.1), spending time, travel distance and velocity were analyzed by the classification of operation mentioned above. Those data was integrated and displayed through a GIS interface (Figure 3).

As for quantities of collected waste, the authors measured the collected waste by digital scale at meeting points (see Figure 4).



Dustbin



Handcart

Figure 4. Weigh measurement of collected waste

RESULTS AND DISCUSSION

1. Efficiency of MSW collection by segregate dustbin collection

Table 1 presents the summary of operational efficiency of segregate bin collection system in Nguyen Du ward. The operation time was considered in simple classification as distribution, free (refreshing or cleaning up public areas), collection, waiting, transfer, and parking.

The collected quantity measured in many aspects as weight (kg) and height from the bottom of dustbin (cm), the authors also converted to others dimension as volume (L) and density (kg/m³); presented in Table 1. Compostable waste seemed lower density and fewer amounts than other. Table 2 also presents the frequency of dustbins' height, the survey showed that, green-bin was lower using volume and height comparing to orange-bin.

Table 1. Summary of operational efficiency of segregate bin collection for each dustbin

Activities	Items	N	Mean	Std. Deviation	Std. Error
Distribution (mi)	Orange-bin	34	2.725	2.249	0.386
	Green-bin	27	2.734	1.924	0.370
	Total	61	2.729	2.094	0.268
Free (mi)	Orange-bin	54	71.445	65.864	8.963
	Green-bin	37	89.573	63.936	10.511
	Total	91	78.816	65.345	6.8450
Collection (mi)	Orange-bin	44	2.490	2.584	0.390
	Green-bin	35	3.251	6.593	1.114
	Total	79	2.827	4.772	0.537
Waiting (mi)	Orange-bin	49	45.349	47.216	6.745
	Green-bin	39	42.838	16.865	2.701
	Total	88	44.093	32.040	4.723
Transfer (mi)	Orange-bin	69	0.719	0.364	0.044
	Green-bin	44	0.664	0.332	0.050
	Total	113	0.692	0.348	0.047
Parking (mi)	Orange-bin	20	2.332	3.478	0.778
	Green-bin	18	1.948	2.922	0.689
	Total	38	2.140	3.200	.733
Weigh (kg)	Orange-bin	73	47.805	20.932	2.450
	Green-bin	44	36.325	18.047	2.721
	Total	117	42.065	19.490	2.585
Height (cm)	Orange-bin	73	88.877	23.885	2.795
	Green-bin	44	74.341	22.567	3.402
	Total	117	81.609	23.226	3.099
Volume (L)	Orange-bin	73	206.194	55.412	6.485
	Green-bin	51	148.798	77.137	10.801
	Total	124	177.496	66.275	8.643
Density (kg/m ³)	Orange-bin	73	231.943	87.567	10.249
	Green-bin	51	177.603	94.222	13.194
	Total	124	204.773	90.895	11.721

Table 2. Histogram of height of collected waste among dustbins

Height of collected waste in dustbins		Percentage (%)	
Description	Height (cm)	Orange-bin	Green-bin
Above the dustbin's mouth level	21 – 30	9.59	-
	11 – 20	13.70	4.55
	1 – 10	10.96	2.27
At the dustbin's mouth level	0	12.33	18.18
Under the dustbin's mouth level	(-1) – (-10)	12.33	9.09
	(-11) – (-20)	13.70	20.45
	(-21) – (-30)	10.96	11.36
	(-31) – (-40)	10.96	18.18
	> - 41	5.48	15.91
		100	100

2. The distribution of activities and collection vehicles

Table 3 presents the distribution of the collection activities among workers; the result showed that, almost workers have at least one handcart for her/his daily works. However, these handcarts collected with high percentage (44.48%) in total collected waste in Nguyen Du ward; while the quantity of dustbins was larger than handcarts so much. Besides, this table also shows that compostable waste (green-bin) amount (kg/day) collected with low percentage (17.44%) of total waste in Nguyen Du ward. The remaining wastes (82.56%) were collected by orange-bin and handcart as 38.08% and 44.48%, respectively. This result also showed that household waste accounted low percentage of total, compostable waste collected with small portion and handcarts play an important role in the segregate bin collection system.

Table 3. Distribution of the collection activities among workers

Worker	No. Dustbin		No. handcart		Waste collected amount						
	Orange color	Green color	Large size (600L)	Small size (400L)	Total weight	Orange-bin		Green-bin		Handcart	
						kg	%	kg	%	kg	%
A	5	5	1		687.5	279.7	40.68	174.8	25.43	233	33.89
B	7	3	2		1095.5	391.7	35.76	137.8	12.58	566	51.67
C	8	5	2		901.4	336.7	37.35	71.7	7.95	493	54.69
D	10	6	1	1	1016.8	447.4	44.00	88.4	8.69	481	47.31
E	6	4			327.6	306.5	93.56	21.1	6.44	0	0.00
F	6	5		1	608.6	339.6	55.80	172	28.26	97	15.94
G	7	7	1		783.9	281.8	35.95	357.1	45.55	145	18.50
H	5	2		2	558	207.2	37.13	81.8	14.66	269	48.21
I	5	7	2		1035.1	230.4	22.26	281.7	27.21	523	50.53
J	8	4	3	1	1482.4	346.8	23.39	89.6	6.04	1046	70.56
K	6	3		1	667.3	322	48.25	122.3	18.33	223	33.42
Total	73	51	12	6	9164.1	3489.8	38.08	1598.3	17.44	4076	44.48

CONCLUSION AND FUTURE TASK

This study identified existing problems, weak-points, and improper activities. Moreover, the interesting results from this study are expected to provide a support tool for monitoring and managing municipal solid waste collection for waste managers and policy decision makers.

The authors will try to explore and discuss in many aspects as follows:

- 1) *To develop the predictive models for distance and working time of waste collection and transportation.*
- 2) *To improve the operational efficiency of waste collection and transport (optimization of route, combination, location of transfer facility, etc.*
- 3) *To solve the current problems for waste collection and transport*