PHƯƠNG PHÁP NGHIÊN CỨU THU GOM VÀ VẬN CHUYỂN RÁC NGHIÊN CỨU TẠI 6 ĐỊA BÀN CỦA HÀ NỘI

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1. INTRODUCTION

Ha Noi is in the strong urbanization process, the recent population increases 3.45% per year. Living standard of Hanoi citizen increases resulting to domestic waste generation rate increase too with the rate of 0.545 – 0.572 kg/person/day [1]. Hanoi discharged more than 3300 tons/day of household and business waste. Although the waste collection ratio is gradually increasing in recent years but the waste volume is non stop increasing and improving transportation and collection effectiveness is always most important and difficult problem for Hanoi city.

Researching waste collection and transportation will contribute to understand the existing situation and then give the effectively proper proposals as well as supervising and assessing tools of waste collection and transportation system [2]. Waste collection and transportation takes the cost of worker, equipment and financial investment for urban solid waste management. Applying the method on time and motion study can assess source separation effectiveness at Nguyen Du ward (0.38 km^2, 11315 people, Urban Environmental Company Number 3 with 23 workers are responsible for), Phan Chu Trinh ward (0.41 km^2, 8306 people, Urban Environmental Company Number 2 and 23 workers are responsible for), in which organic wastes are transpoted to Cau Dien composting plant, household inorganic waste is discharged into the 240l waste container then dumped at Nam Son landfill site. An expansion in whole Hanoi had launched by the survey at Kim Giang ward (0.22 km^2, 10118 people, Thanh Cong cooperative is responsible), Nghia Tan ward (0.57 km^2, 22790 people, Tay Do Comopany is responsible) Me Tri (7.06 km^2, 22406 people, Thanh Cong cooperative is responsible for) and Dong Anh town (4.57 km^2, 28899 people, Dong Anh Urban Environmental Company is responsible for this) [3]. Besides, study was also implemented in said above collection environmental companies to discover the existing status, makes comparison and proposals on solid waste collection and transportation not only for themselves but for other urban environmental companies in Hanoi.

2. METHODOLOGY

2.1. Procedure

Waste collection and transportation method was used surveyed forms from making the survey plan of hand push cart/ container and shifting at the loading points (making up the map of loading points, handcart routes, collection shifts, the movement from a loading point to an other, number of loading points and waste amount, working time, start time and the last loading point). The collection and transportation process contains followed stages: 1) Studying the selected areas- making the area map of collection line, table 1) loading point, handcart/collection bin,

collection workers (CWs) (collection frequency, number of collection worker, and estimation the waste quantity) ; 2) Unify the sample size: there is twelve lines of hand cart, six lines of lorry at Phan Chu Trinh and Nguyen Du; 3) Traning staff, surveyor and organizing survey; 4) Analysing data; 5) Result- conclusion and proposals.

Table 1. Collection shedudle at 6 surveyrd site in Hanoi

No	Distric	Wards	Time	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2
				Number collection works, trucks, handcarts on day working																							
1	Hai Ba Trung	Nguyen Du	Morning shift						2 CW: 6 handcarts																		
			Afternoon shift														2 CW: 6 handcarts										
			Night shift																8 CW: 18-20 handcarts								
							6 trucks: 6h-23h																				
2	Hoan Kiem	Phan Chu Trinh	Morning shift					1 CW: 3 handcarts																			
			Day shift				2 CW: 6 handcarts																				
			Night shift															6 CW: 12-15 handcarts									
			contract shift															1 CW: 2 handcarts									
							6 trucks: 6h-23h																				
3	Tu Liem	Me Tri	Day shift																								
			first shift	W: 60 handcarts																							
			second shift			6 CW: 25 handcarts																					
			third shift					18 CW: 20-22 handcarts																			
			Night shift																								
			first shift															2 CW: 4 handcarts									
			second shift																	2 CW: 3 handcarts							
								3 trucks: 8h-9h																			
4	Thanh Xuan	Kim Giang	Day shift																								
			Morning shift						1 CW: 2 handcarts																		
			Night shift																								
			Night shift																3 CW: 10-12 handcarts								
			second shift																4 CW: 14-18 handcarts								
									2 trucks: 18h-23h																		
5	Nghia Tan	Cau Giay	Day shift																								
			first shift		10 CW: 45 handcarts																						
			Night shift																53 CW: 260 handcarts								
								4 trucks: 6h-21h																			
6	Dong Anh	Dong Anh	Day shift																								
					32 CW: 70 handcarts												1 CW: 2 handcarts										
			Morning shift																								
							6 trucks: 6:30-9:30																				
				Note: CW: Collection workers																							

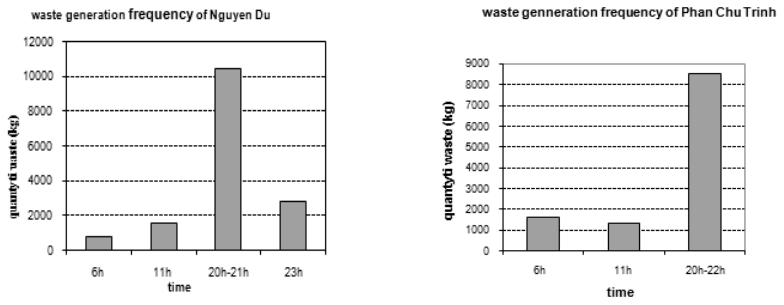

Figure 1.2. Waste generation frequency of Phan Chu Trinh and Nguyen Du wards

2.2 Making the survey form

Principal activities need to survey consist of loading point, kind of mobilize waste barrel, lorry, waste level in the barrel and all kinds of waste are encoded to being convenient the date treatment. Survey forms for handcart and waste loading turcks are displayed in the table 2 and table 3.

Table 2. Survey form for handcarts

Ward: Worker code: Mission: Working time: Survey day : Survey timetable :						
Weather: Working attitude: Work burden:						
No	Activity	Other (note)	Start time	Finish time	Location	Note
1						
2 …						

Table 3.Survey form for waste loading trucks

Ward: Worker code: Mission: Working time : Survey day : Survey timetable											
Weather: Working attitude: Work burden											
No	Start time , loading point, finish time	Meter	Coming time	Arriving time	Number of barrel at the loading point	Hand push cart size	Waste level in the barrel	Waste : household waste/ business/Other	Started time of loading waste	Finish time of loading waste	Waste
1											
2...											

2.3 Training of the surveyors, organizing of the implementation, fulfill of the forms

2.4 Creating the summary table and analyzing data

2.4.1 General table

Table 4. General form for handcart

	Working shift	Worker code	1	2	3	4	5	6	7	8	9	10	11	12	Total
Time (t_i), h:m:s	A, : - : $\sum_{i=} C_k \cdot t_i$														
		Total time													
Ratio, %	A, : - : $C_k.t_i/\sum_{i=1-12} C_k \cdot t_i$														100%
		Total time													*100%*

Table 5. General form for loading truck

Organic or Inorganic:			Weekdays:			Worker code 1_D_1				Shifts day: shift 1	
Route numbers of one trip	Ward cord	Code of loading points (LP)/ Destination, etc.	Arrival time	Departure time	Loading time (depature time-arrival time) inc. waiting time	Waiting time at the loading point	Travel time (arrival time-depature time)	Distance of Collection / Trans-portation	Number of Collection Containers	Estimated amount of waste	Type of Sources
			h:m:s	h:m:s	h:m:s	h:m:s	h:m:s	met		kg	
1.Start		1		6:16:02		-		-	-	-	-
2	1	4	6:30:40	6:32:52	0:02:12		0:14:38	6100	2	294	1
3	1	5	6:34:00	6:36:35	0:02:35		0:01:08	300	3	492	1
4		6	6:38:04	6:41:14	0:03:10		0:01:29	700	3		1+2
5		7	6:42:15	6:46:03	0:03:48		0:01:01	200	4		1+2
6		8	6:47:36	7:01:22	0:03:20	0:10:26	0:01:33	400	3		3
7		9	7:04:10	7:10:20	0:06:10		0:02:48	700	8		1
8		10	7:13:50	7:22:54	0:09:04		0:03:30	800	7		1+2
9		11	7:28:32	7:32:35	0:04:03		0:05:38	1300	5		3
10		12	7:35:48	7:46:24	0:10:36		0:03:13	800	11		1
11		13	7:49:06	7:56:20	0:07:14		0:02:42	500	7		1
12. Finish		3	9:28:24	9:42:17	0:13:53		1:32:04	50900	0		

2.4.2 Summary table

Table 6. Analyzing table for handcart

			Activity code of worker												
	Working shift	Worker code	1	2	3	4	5	6	7	8	9	10	11	12	Total
Ratio, %	A, : - :	Total time													100
	B, : - :	Total time													100
	Total average														100

Table 7. Analyzing table for transportation truck

			code	Formular	Unit	Average			
Summary table of raw date	Distance from garage to the first loading point		a		m	17963	11319	10000	28307
	Distance in the survey area		b		m	4400	2588	3843	1445
	Distance from the survey area to dumping site		c		m	13838	55219	13400	48697
	Time from garage to the first loading point		d		h:m:s	0:51:44	0:22:13	0:29:06	0:48:19
	Collection time in the survey area	Loading time	e		h:m:s	0:37:47	0:22:58	0:44:00	0:26:17
		Movement	f	g-e	h:m:s	0:19:25	0:10:02	0:12:58	0:05:49
		Total	g		h:m:s	0:57:12	0:32:16	0:56:57	0:25:40
	Time of transporting waste		h		h:m:s	0:34:18	1:47:15	0:36:48	1:34:27
	Stopping time at the dumping site		h'		h:m:s	0:13:14	0:16:58	0:09:05	0:28:35
	Number of loading point in the survey area		i			20	7	9	5
	Number of waste container of surveyed area		j			33	22	47	26
	Number of waste in the survey area		k		kg	2213	2401	2568	3254
Date calculation	Loading time/container			e/j	s/barrel	77.6	65.1	56.3	62.4
	Loading time of 1kg (average)			e/k	s/kg	1.1	0.6	1	0.4
	Total of loading time and moving time			g/k	s/kg	1.7	0.8	1.3	0.5
	Velocity from garage to survey area			a/1000/d	km/h	21.6	25.5	20.9	32.1
	Velocity in the survey area			b/1000/f	km/h	13.9	21.1	18	17.8
	Velocity from survey area to the end			c/1000/h	km/h	24.8	31.8	22.4	33.3

III. RESULT AND DISCUSSION

3.1. Investigated results

3.1.1 Results at Phan Chu Trinh, Nguyen Du and four sites in Hanoi

Table 8. Daily collection waste quantity in Nguyen Du, Phan Chu Trinh wards

Daily waste quantity of each ward (kg)								
Day	5/8/2008 (Tus)	6/8/2008 (Wed)	7/8/2008 (Thur)	8/8/2008 (Fri)	9/8/2008 (Sat)	10/8/2008 (Sun)	11/8/2008 (Mon)	Average
Nguyen Du	16025	15833	15362	13105	15008	15690	12865	14841
Phan Chu Trinh	10990	12327	11092	11492	11658	8610	11461	11090

Table 8 shows that, daily waste was quantity collected in Nguyen Du ward is higher than in Phan Chu Trinh ward, Nguyen Du ward need 18 waste collectors for one working day without day-off collectors/shift. One waste collector in Nguyen Du and Phan Chu Trinh wards averagely collected 824.5kg waste/day and 616kg/day respectively. Collected waste in Nguyen Du ward was more effective than in Phan Chu Trinh ward. In the time from 20 pm to 23 pm, 72.9 % of generated waste and collected waste in Nguyen Du ward and 73.5% of them in Phan Chu Trinh ward, table 1, figure 1 and 2.

The same calculation with four other areas, in average, Kim Giang ward was 782 kg/person/day, Nghia Tan ward was 847 kg/person/day, Me Tri commune was 640 kg/person/day and Dong Anh town was 503 kg/person/day. Me Tri commune and Dong Anh town has a volume of waste dumped on site then one waste collector collected averagely waste less than others.

3.1.2 Investigative result of collection by hand push cart

Surveying activity at three shifts showed that each shift has their typical activities. Although there was the time changing among shifts, main activities takes most of time such as (1)Cleaning the sewage, (2) Sweeping and picking street waste/leaf; (4) Collecting waste barallel; (10) Talking rest; (11) Being on duty at collection point to train citizen; (12) Waiting to loading waste, table 9 and 10. In which

Activity 2: This takes much more time, waste collector had to sweep and pick street waste. In fact, they some time had to turn around in one place to pick waste, because of freely discharging. This symptom is normal in the lines which is surface of the road and has business activity, the temporarily discharged places such as tension poles, small markets. **Activity 4**: Collecting and storing waste bucket at two source separation wards, waste collectors were not only sweeping and picking waste but also distributing waste bucket of 240l (organic and inorganic waste bucket) along the collection points. One worker collected and stored 8 to 10 waste buckets in the rush hour (17h30-18h) within crowded traffic. If citizen would self manage collection points then it will save money and labor of waste worker and equipment finance. **Activity 10**: In three working shifts, evening had the least rest time, they are quite strenuous, and it should to work in shifts to ensure the fair. **Activity 12**: Waiting time for loading waste is so

long, there is much insufficiency because of no strong relationship among waste collectors and truck driver.

Table 9. Ratio of main activities in Phan Chu Trinh and Nguyen Du wards

Pilot wards			Main activities				
Wards	Working shift		2	4	10	11	12
Nguyen Du	Morning, 5 h -15 h	Ratio, %	65.73%	2.83%	17.20%	0.00%	7.85%
	Afternoon, 15 h -2 h		56.01%	8.09%	7.18%	11.56%	4.03%
	Night, 17 h – 2 h		52.82%	11.10%	6.82%	4.35%	9.87%
Phan Chu Trinh	Morning, 5 h – 15 h		80.35%	0.00%	11.89%	0.00%	0.79%
	Afternoon, 15 h – 2 h		74.67%	0.26%	12.68%	0.00%	5.59%
	Night, 17 h – 2 h		39.28%	5.47%	5.87%	23.64%	9.35%

Note: (1)Cleaning the sewage, (2) sweeping and picking up waste/ leaf; (4) collecting and storing waste bucket; (10) having rest; (11) being on duty at collection point to guide citizens; (12) waiting for loading waste

Table 10. Main activities at Kim Giang, Me Tri, Nghia Tan and Dong Anh sites

Survey areas			Main activites				
Location	Working shift		1	2	4	10	12
Kim Giang	Morning, 5 h – 15 h	Ratio, %	4.00%	73.82%	1.16%	13.35%	0.00%
	Night 1, 17 h – 12 h		0.00%	45.24%	8.53%	25.39%	5.59%
	Night 2, 17 h – 2 h		1.93%	58.15%	5.16%	14.41%	7.01%
Me Tri	Morning 1, 3 h – 10 h		1.04%	48.08%	10.26%	3.87%	18.91%
	Morning 2, 5 h – 11 h		29.94%	48.82%	3.56%	12.88%	0.00%
Nghia Tan	Night time, 16 h – 24 h		1.27%	61.21%	4.25%	10.10%	13.93%
Dong Anh	Morning, 4 h – 10 h		7.22%	72.97%	2.89%	4.81%	0.49%

In four expansion sites, there was a change. The activity 1 takes most time, 29.94% in Me Tri commune. Other activities are suitable for each survey areas.

3.1.3 Investigative result of waste transportation by trucks

3.1.3.1 Collection effectiveness, quantity and velocity in Nguyen Du and Phan Chu Trinh wards

Table 11. Comparison collection effectiveness between two wards

	Unit	Comparing effectiveness between two wards , average value			
		PCT_Organic	PCT_Inorganic	ND_Organic	ND_inorganic
Loading time/container	s/ container	77.6	65.1	56.3	62.4
Loading time/1kg waste	s/kg	1.1	0.6	1	0.4
Loading time total and moving time/1kg waste	s/kg	1.7	0.8	1.3	0.5
Velocity from garage to surveyed wards	km/h	21.6	25.5	20.9	32.1
Velocity in the surveyed wards	km/h	13.9	21.1	18	17.8
Velocity from surveyed wards to Nam Son/Cau Dien	km/h	24.8	31.8	22.4	33.3

Nguyen Du ward loaded organic waste quickly (56.3 s / 77.6 s) because organic waste quantity is not much at collection point, reduction the self loading point and there is a support from waste collectors. If collect organic waste bin at the same location, loading activity will be more convenient but the waste collectors will be harder. Collection effectiveness is higher in Nguyen Du ward, waste quantity is much more, and worker is harder and is hurried. Generally, velocity of the trucks are slow and depending on out side factors such as rush hour, ward geography, traffic density and street area.

3.1.3.2. Collection effectiveness and waste quantity in Kim Giang, Me Tri, Nghia Tan and Dong Anh sites.

Table 12. Collection effectiveness at Kim Giang, Me Tri, Nghia Tan and Dong Anh

	Unit	Comparing effectiveness at four wards, average value			
		Kim Giang	Me Tri	Nghia Tan	Dong Anh
Loading time/ container	s/container	55	68.4	54.7	56.6
Loading time/1kg waste	s/kg	0.33	0.26	0.32	0.44
Loading time total and moving time/1 kg waste	s/kg	0.35	0.29	0.44	0.76
Velocity from garage to surveyed wards	km/h	15.27	22.88	25.45	23.25
Velocity in the surveyed wards	km/h	7.08	27.54	20.75	22.03
Velocity from surveyed wards to Nam Son/Cau Dien	km/h	23.01	28.73	33.78	28.76

Me Tri had the smallest collection time of one kg of waste then Me Tri commune had the largest collection effectiveness. Collection effectiveness in Dong Anh is the least. Me Tri commune has the great quantity of waste (waste are fully and highly stored) so that even loading time/1kg of waste is big but general effectiveness is still higher.

Comparison within surveyed sites according to loading time total and moving time in the surveyed area, collection effectiveness of Dong Anh town is not high because the distance between two loading points is quite far (more than 5 km) and the small loading capacity (less than 3 tons) that do not compress waste effectively so that the effectiveness is lesser than using high loading capacity truck. Me Tri commune has only two main loading points along the main and large road so that the moving time is effective, many hand push carts gathered at the loading points making the loading more effectiveness. In general, the trucks run slowly in the survey area for loading waste. Other reasons such as, traffic jam, stopping within traffic light, high traffic density in the survey area also impact working effectiveness of the truck transportation. So that, it need to arrange moving time and collection routes in the street line to reach the optimal collection effectiveness.

Average collection effectiveness of organic waste and inorganic waste are 1 s/kg and 0.5 s/kg respectively in two pilot wards. In the four expansion sites, average collection time is 0.34 s/kg. The waste container of 240l collects waste lesser and loading point per 1 kg collected waste is higher.

Table 13. Investigative result summary of waste collection at 6 survey areas in Hanoi.

Area	Area km^2	Population (people)	Waste quantity (ton/day)	Waste quantity (kg/person/day)	Number of waste collector (people)	Waste quantity of waste collector (kg/person)
Nguyen Du	0.38	11315	14.8	1.31	18	824
Phan Chu Trinh	0.41	8306	11.1	1.34	18	616
Nghia Tan	0.57	28899	53.4	1.85	63	847
Kim Giang	0.22	10118	6.3	0.62	8	782
Me Tri commune	7.06	22790	25.6	1.12	40	640
Dong Anh town	4.57	22406	16.1	0.72	32	503

3.2 Conclusion

Use the above study methodology allows determining the collection effectiveness and the result show the existing situation. This is one suitable method to survey the waste collection and movement. In two pilot wards, organic waste were separated and dumped at site with the rate of 20% in Nguyen Du ward and 25% in Phan Chu Trinh ward. Activity of freely discharging waste into pavement is still popular. It needs to communicate and remind citizen to over this situation, it will reduce the collection time, it not only increase waste collection effectiveness but also create nice urban lifestyle. Besides, it needs to: 1) Reducing the waiting time for loading waste, loading waste lately to reduce traffic jam, arranging again the collection time of hand push cart. 2) Maintenance sour separation at the collection point, discharging waste properly. 3) Arranging optimal collection routs, manpower of working shifts.

4. CONCLUSION, PROPOSAL

Method of researching waste collection and transportation is the basic tool for quantitative decription of time and motion of waste and will be an effective tool to survey the solid waste management. This methodology need to supported and documented to do the technical method and tools for determining solid waste collection effectiveness while this method is still lack of technical guide and insufficiency in Vietnam.

Acknowledgement: Studied results were based on the survey on time and motion in Phan Chu Trinh and Nguyen Du wards and four sites in Hanoi (Kim Giang, Me Tri, Nghia Tan and Dong Anh) carried out in 2008, with finance supported by JICA-3R Hanoi project, JICA experts guided and discussed detailly of methodology and survey forms. We would like to thank the enthusiastic guides of Mr Hirata, Ms Nguyen Huong Giang and staff of Urban Environmental Company Number 2, 3 and Thanh Cong Cooperative, Tay Do Environmental Company, Dong Anh Environmental Company for suppoting the method and supervising during the implementing all surveys in 2008.

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SUMMARY

STUDY METHOD ON TIME AND MOTION OF SOLID WASTE COLLECTION AND TRANSPORTATION CASE STUDY IN 6 SITES OF HANOI

One method of time and motion study on solid waste collection and transportation was used in 6 investigated sites in Hanoi. Survey sheets have been designed and trained to carrying out study waste collection by hand push cart/waste bins along assigned routes and the load by trucks at the loading point in the streets, volume of collected waste, time of loading and transportation, time of each activity of waste collection. The results showed that; sweeping and picking up waste discharged in to the pavements was the most time consuming accounting for 60% of the total time. One waste collector collected an average of about 824kg/person/day, an average volume of 14.8tons/day colleted in Nguyen Du ward; average of 616kg/person/day and the amount of 11 tons/day collected in Phan Chu Trinh ward. The organic waste with about 20-25% of the total generated waste was separated from the normal – landfilled waste going to the Cau Dien composting plant by waste separation at source (WSS) in Phan Chu Trinh and Nguyen Du wards. In other sites without WSS such as Kim Giang, Me Tri, Nghi Tan, Dong Anh town, the volume of waste is 6,3 tons/day, 25,6 tons/day, 53,4 tons/day, 16,1 tons/day respectfully. One waste collector collected an average of 782, 640, 847, 503kg/person/day in Kim Giang, Me Tri, Nghia Tan, Đong Anh town.

The results showed that the good habitude of discharging waste at regulated place and time should be maintained and encouraged in order to increase the effectiveness of the waste collection and transportation. The distribution of manpower as well as optimal the collection route and schedule should be done to increase the productivity of waste collection and transportation. The mentioned study method on time and motion of waste collection and transportation as well as its use will create an effective tool and permit to carry out quantitatively the solid waste collection and transportation in Hanoi with the specific characteristics of narrow routes. It is need to detailed and technical document this study method in order to create one useful tool and technical method to investigate municipal solid waste management in Vietnam.

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