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Methodology for the waste quantity and quality measurement. Case study: 6 sites in Hanoi

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Abstract. To research the volume and components of solid waste, we surveyed household waste with three different incomes (high, middle and low incomes). Then waste is separated into 34 waste components and 9 main waste groups containing organic waste (easily decomposed waste such as vegetable, root, fruit, left food.. to make the compost and difficultly decomposed waste), paper, plastic, metal, glass, rubber and leather, cloth, dangerous substance, and other waste. Besides, definition of all groups of waste is also discussed. The result shows that the ratio of easily decomposed waste is 48.5% and the different sources of waste have the different ratios. The investigative survey chose accidentally 35 households of low, middle and high incomes of each wards, Phan Chu Trinh and Nguyen Du wards. Each survey is implemented continuously during 8 days. Based on the quantity survey, the survey results are 0.572 kg/person/day in Phan Chu Trinh and Nguyen Du wards and 0.545 kg/person/day in Me Tri, Kim Giang, Dong Anh and Nghia Tan wards where are far from the city center.

Keywords: solid waste, waste quantity and quality measurement.

1. Introduction

From March, 1st 2008, total area of Hanoi expansion is 334.427ha, total population is 6,232,940 people. Hanoi economy has highly developed; gross domestic product in 2008 is 12.5% [1]. Each day, Hanoi discharged more than 3,300 tons of waste from households, offices, restaurants, hotels, markets, food shops [2]. The Project for the Implementation Support for 3R Initiative in Hanoi City to Contribute to the Development of a Sound Material-Cycle Society was launched in 2006, have implemented source separation at four pilot wards: Nguyen Du (ND:0.45km^2, 11,315 people), Phan Chu Trinh (PCT:0.41km^2, 8,306 people), Thanh Cong and Lang Ha wards. The estimation for expansion this model in whole Hanoi started with the survey on waste quantity and quality in four location: Kim Giang ward (KG:0.22 km^2, 10,118 people), Nghia Tan ward (NT: 0.57km^2, 22,790 people), Me Tri ward (MT:7.06km^2, 22,406 people), and Dong Anh town (DA:4.57km^2, 28,899 people). We have applied and gradually completed the methodology for determining the waste quantity

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and quality under the controlling and guiding of JICA experts. This method has considered an effective one and easy to apply in surveying household waste generation rate. This methodology has applied in many countries in the world: Japan, Indonesia, Singapore, and Malaysia, India, Philippines, Uruguay, Vienna-Austria, New Zealand, Hong Kong, Paris-France, Caracas- Venezuela, Uruguay, Rio de Janeiro – Brazil…[3]

2. Methodology

2.1. Preparation

1) Make the boundary, collect the economy and social information, and unify the sample size and household's income level. 2) Make the guiding document is clearer and more detail then organizing training class for surveyors. 3) Make the survey plan with residential group and households, disseminating the survey methodologies. 4) Distributing tools (waste basket or nylon) fixed waste label. Residents are guided to separate waste (inorganic waste (InOW), organic waste (OW) and recycle waste (Re) in the pilot wards) or recycle waste and other waste at four locations which haven't participated in source separation. 5) Drawing the survey map and marking the sampling position

Make the survey table- survey form: Form for surveying waste quantity is displayed in the table 1

Table 1. Surveying the waste quantity in households.

Code	Add	No of HHs member (including charwoman, grand parents)	Income (Million dong)	Waste quantity, kg			Time
				OW	InOW	Re	
1							
2…							

Waste sample of each kind of waste type is corresponding to income level. It is typically sample to separate waste into 33 components, 9 main groups: I. Organic (1, left food, vegetable, root, fruit, soybean. 2, animal bone, shell. 3, Grass, flower, leaf. 4, coconut skin, wood, bagasse); II Paper (5, paper, magazine. 6, cigarette box, carton. 7, milk box. 8, book, notebook. 9, photocopy paper. 10, used paper. 11, other papers); III. Plastic (12, PET. 13, other bottles. 14, nylon. 15, tray, plastic cup. 16, polystyrene foam. 17, household plastic. 18, other plastics); IV, metal (19, metal can. 20, Steel, aluminum scraps. 21, Aluminum can. 22, other metals); V. Glass (23, glass bottles. 24, glass, pottery); VI. Leather, rubber (25, rubber. 26, leather); VII. Cloth (27, used textiles); VIII. Dangerous substance (28. Battery. 29, lamps); IX. Others (30. Briquette coal, 31, diapers, 32, old electrics

2.2. Sampling, number of samples

The sample number of Phan Chu Trinh wards with [35 high income households+ 35 middle income households+ 35 low income households)* 3 samples (OW, InOW, Re)]*8 days= 2520 samples, the same with Nguyen Du wards. Number of business waste samples contains 10 samples of food waste, 1 sample of market waste, 20 samples of office waste, and 5 samples of flower waste. In Nghia Tan, Me Tri, Dong Anh and Kim Giang, number of household samples are 4 sites*(20 high income households + 20 middle income households+ 20 low income households)*8 days= 1920 samples. The number of business sample are 4 sites * 20 business (food, restaurant, market and office waste)* 8 days = 640 samples. It is surveyed with 32 samples of household waste component, 80 samples of business waste and 48 samples of road waste in four days of four other sites.

2.3. Sampling method

Households of Phan Chu Trinh and Nguyen Du wards separated waste into three kinds, households of Kim Giang, Dong Anh, Nghia Tan and Me Tri separated waste into two kinds (recycle waste and dumped waste), stored waste at households until the end of day, surveyor came to weigh each kind of waste and collect it daily. (Purchased recycle waste if they required). Collecting waste sample of households, business, road waste and waste at collection points according to the sampling map.

2.4. Measuring the waste quantity and separating waste

Each kind of waste (Re, or InOW or OW) of each income level was weighed at household then filled in information in the form 1, collected all waste at one point, randomly sampled (20kg) then separated into 33 components (balance sizes are 1kg, 5kg, 10kg and 20kg). Separating procedure contains: 1) Putting waste in the big dry nylon bags. 2) Mixing and reducing the sample volume according to the standard method – the out put of this progress is 20kg of waste (Mixing, piling up to the pyramid form, dividing into 4 equal parts, taking two opposite parts) and 3) Separating 33 components like the above category.

2.5. Measuring the waste volume after separation

1) Use the volume barrel 20l -60l to measure and weigh the quantity of each component. 2) Measure the waste density. 3) Measuring the moisture from the typical samples which were measured density. [4] (To dry until the unchangeable quantity, in about 2 days at 120^0C)

2.6. Inputting date, calculating date and analyzing results

Inputting the date of 8 days, calculating date from the second day in excel: i) The average generation rate per person per day, ii) The trend of waste generation in a week iii) Waste component.

3. Survey result and discussion

The survey results are displayed in the table 2 and 3

Table 2. The survey result of waste quantity in Phan Chu Trinh and Nguyen Du wards

The average specification	PCT	ND	Average
kg/head/day	0.587	0.557	0.572
kg/week/HH	16.11	13.92	15.02

Table 3. The survey result of waste quantity in Kim Giang ward, Nghia Tan ward, Me Tri commune and Dong Anh town

Site	KG	NT	MT	DA	Ave
kg/head/day	0.53	0.59	0.57	0.48	0.55
kg/week/HH	13.25	15.68	18.7	12.44	15.0

Waste generation rate. Phan Chu Trinh and Nguyen Du has the average number of people per household is 3.572 people. The average generation quantity of household waste: **0.572** kg/person/day including recycle waste and equivalent to **2.146** kg/household/day [5]. The survey time in July, from 23 to 31, 2008, and survey result in summer is higher than in the winter **1.98** kg/household/day or **0.475** kg/person/day [5]. The quantity results are different between two wards in urban area (PCT, ND) and four locations in suburban area (KG, NT, MT, DA), with waste generation rate of **0.545** kg/person/day or **2.146** kg/household/day (table 3), and 3.938 people per household.

Relation between waste quantity and income level. The analyzing result shows that there is a different of waste quantity among high income, middle income and low income households. However, it is not considerable (example, the distance between high income and middle income is 0.06 kg/person/day, and it is 0.08 kg/person/day between middle income and low income, PCT, ND) , table 2.

The waste generation trend in a week. The result of all 6 survey wards shows that waste quantity (not included the recycle waste quantity) increases at the weekends

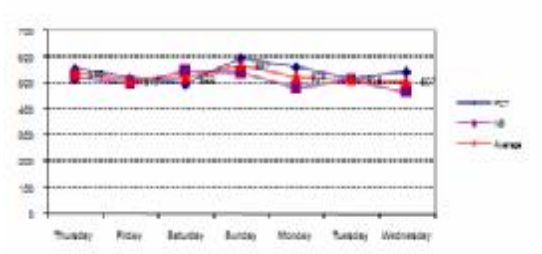

Fig. 1. Waste generation trend in a week, kg/head, Phan Chu Trinh and Nguyen Du, 23-30/7/2008.

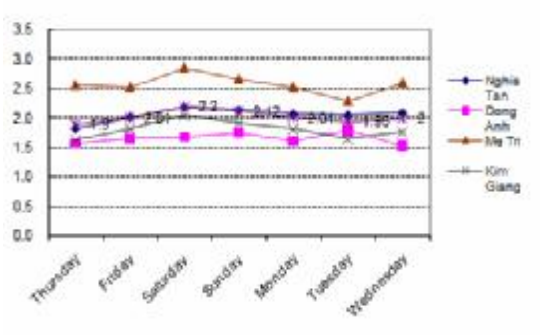

Fig. 2. Waste generation trend in a week, kg/person, Kim Giang, Nghia Tan, Me Tri and Dong Anh, 24/9 -1/10-2008.

a) Result of easily decomposed household waste

The analyzing result of household waste shows that the easily decomposed waste is 47%, difficultly decomposed waste is 6%, paper is 9%, plastic is 10%, metal is 2%, glass is 5%, leather and rubber is 1%, other waste is 18% (The average result of 6 surveyed wards). In Phan Chu Trinh and Nguyen Du, the easily decomposed waste ratio is 48.5%, this ratio is 44.6% and the total organic ratio is 49.7% in Kim Giang, Me Tri, Nghia Tan and Dong Anh).

The organic component of market, food shop, restaurant, and hotel: The total organic waste ratios of food shop and market waste are 64.65% and 63.25% respectively. Organic waste ratio of food shop and market is higher than the household waste from 10.69% to 12.10%. Organic waste ratio of office waste and road waste is lower than other with 45.65% and 47.95% respectively.

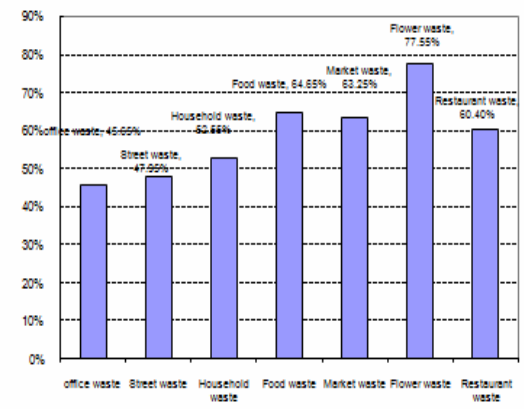

Fig. 3. Organic waste ratio in different waste type, %.

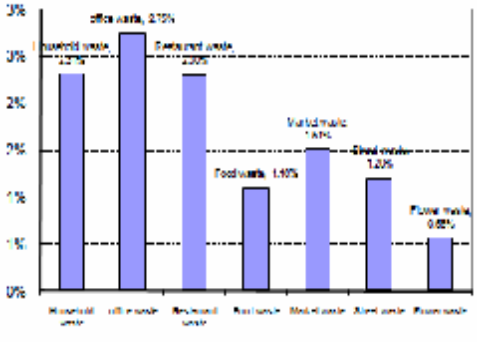

Fig. 4. Metal ratio in each different waste type, %.

b) Paper ratio is various with different waste

Office waste is the highest ratio, survey result of Kim Giang, Me Tri, Dong Anh and Nghia Tan displayed the 24% of office waste while the paper ratio in the household waste of these four wards is only 9.4%.

c) The recycle plastic

The recycle plastic in household waste of all surveyed wards had the average ratio of 4.66%; this rate was 3.6% in Phan Chu Trinh and Nguyen Du and 5.25% in Kim Giang, Nghia Tan, Me Tri and Dong Anh

d) Metal

The average surveyed result of all locations is displayed in the figure 4.

e) Hazardous substance in waste

Dangerous substance has the worrying sign. Households have the higher ratio of dangerous waste than office waste, market waste…. Most of the surveyed waste source had got the dangerous substance.

Table 4. Result on dangerous substance of 6 surveyed sites

Source	Ratio
Household waste	0.037%
Market waste	0.002%
Flower waste	0.000%
Market waste	0.003%
Food waste	0.006%
Restaurant waste	0.007%
Office waste	0.006%

Table 5 Average waste density in 6 surveyed sites

Source waste	PCT, ND (kg/m^3)	KG, MT, DA, NT (kg/m^3)	Ave (kg/m^3)
Food shop	395	336	366
Flower shop	236	228	232
Market	258	312	285
Road	265	257	261
Office	167	192	180
Restaurant	267		267

f) Density. Density result is displayed in the table 5

g) Moisture depended on the weather; the average results in the sunny day are displayed in the table 6.

Table 6. The average results in the sunny day, Phan Chu Trinh and Nguyen Du wards

Source waste	Moisture, %			
	HH	Food shop	Market	Restaurant
Organic waste	73.23	75.8	62.33	68.77
Paper	38.68	38.67	34.67	37.33
Plastic	10.33	10.23	11.47	10.63
Metal	3.37	3.56	4.03	4
Glass	4.67	4.61	1.8	3.23
Rubber	9.35	9.52	9.93	9.73
Cloth	8.8	8.33	11.27	9.7
Wood	43	42.7	40.83	41.67
Ceramic	3.95	3.87	1.87	4
Other plastic	10.28	10.5	8.3	10.33

4. Conclusion and proposals

With the above methodology, the average generation rate of surveyed locations is 0.559 kg/person/day. The waste component are diversified, easily decomposed organic counted 47%, recycle plastic counted 4.66%, total plastic is 10%. The survey shows that each waste source has the different result, flower waste has the highest ratio of organic waste, and the food waste is in the second rank. Office waste and household waste has the high percentage of metal with 2.74% and 2.31% respectively

Appling the above methodology has been realizable in Vietnam, with the trust result. Through the survey result, it can determine the waste that needs to be dumped; the recycle waste should be reused and organic waste for

composting. If the pilot program is applied in the big size then the solution for Hanoi solid waste management will have the optimum answer.

Suggestions: Technical size: 1) It needs to carefully prepare and train surveyors following the above procedures 2) To ensure the surveyed quantity is correct, it should distribute waste store tools for household each day after weighting waste. 3) To reduce the magnitude of errors arising from moisture change and from decomposition, analysis of the samples should start within two to three hours after collection. 4) Sample size after mixing required larger enough. On the other hand, if the sample size is too small, the possibility of obtaining a representative sample is lessened. The minimum sample size after mixing should be on the order of 20kg. 5) Encouraging and reminding citizens to cooperate and weight waste every day. It should be improved source separation in the two pilot wards Phan Chu Trinh and Nguyen Du and its expansion in other areas of Hanoi: (i)3R program is suitable and need to be communicated for citizens (ii) source separation should be widen more. It needs to strongly supervise and punish citizen in the pilot wards if they freely discharge waste or do not follow the source separation program.

It is recognized that hazardous waste is count for 0.037% in the household waste so that it should be more concerned in municipal solid waste of Hanoi to find suitable separation model for households and business entireties. Separating this hazardous waste from the general stream can create the great way to reduce dangerous substances for recycling and dumping site management.

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Phương pháp nghiên cứu khối lượng và thành phần rác thải, nghiên cứu tại 6 phường và thị trấn của Hà Nội

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Phương pháp nghiên cứu lượng phát thải và thành phần rác thải trên cơ sở mức thu nhập của hộ đình và phân chia chi tiết đến trên 34 loại rác thải với 9 nhóm chất thải chính là chất hữu cơ (gồm hữu cơ dễ phân hủy như rau, củ quả, thức ăn thừa.. để làm phân compost và chất hữu cơ khó phân hủy), giấy, nhựa, kim loại, thủy tinh, da và cao su, vải, chất nguy hại và các chất khác. Bên cạnh đó đưa ra các định nghĩa và các chú thích chi tiết về các thành phần rác của các nhóm chính này. Kết quả cho thấy, tỉ lệ rác hữu cơ dễ phân hủy là 48.5% và thành phần của các loại rác khác nhau có tỉ lệ khác nhau. Kết quả điều tra tại 35 hộ lựa chọn ngẫu nhiên thu nhập cao, 35 hộ gia đình thu nhập trung bình và 35 hộ thu nhập thấp. Điều tra liên tục trong 8 ngày. Trên cơ sở thu gom mẫu đo định lượng lượng rác tại các hộ, kết quả cho thấy lượng rác của một người thải ra trong một ngày của khu vực nội thành như Nguyễn Du và Phan Chu Trinh là **0.572** kg/người/ngày tại các phường xa trung tâm thành phố như Mễ Trì, Kim Giang, Đông Anh và Nghĩa Tân có trung bình xả thải là **0.545** kg/người/ngày.