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# Commercial and institutional solid waste generation and relevant factors: Case study in tourism city - Hue, Vietnam

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## ABSTRACT

*This study was undertaken to evaluate the waste generation rate and composition generated from commercial and institutional sectors to identify the potential for recycling, discharge, and treatment in a tourism city—Hue city, central of Vietnam. Waste generation rate (kg/unit/day) was calculated and discussed in various units of dischargers. The waste compositions were analyzed in 10 physical categories for each component of institutional and commercial sectors. The relevant factors influencing generation rates were analyzed. The authors also explored the putative correlations between the waste generation rate and the examined factors. The outcomes of this study clarified the total and detail figures of waste generation and composition and relevant factors influencing waste generation rates from commercial and institutional sectors. These are indispensable to develop reliable predictive models and master plans towards integrated waste management and sustainable development.*

**Keywords:** Commercial waste, institutional waste, waste generation rate, waste composition, ANOVA, Correlation analysis

## INTRODUCTION

To develop an effective solid waste management (SWM) strategy for a given region, it is important to know the amount of waste generated and the composition of the waste stream. The waste generation rate (*kg/unit/day*) is essential to estimate future waste generation and to evaluate the waste generation trend <sup>[1]</sup>. Data on waste composition is required for the planning of collection, transportation, and treatment of municipal solid waste (MSW). Reliable data is the foundation of effective integrated waste management system <sup>[2]</sup>. Furthermore, the evaluation on waste generation for disposal habit, changes and trends are indispensable <sup>[3]</sup>. However, it must be noted that cities in Vietnam lack reliable database on SWM.

Many studies have examined waste generation and physical waste composition for MSW or different sectors of MSW in Vietnam. Among them, Thanh *et al.* <sup>[4]</sup> analyzed household (HH) solid waste to assess the waste generation rate and the detailed waste composition separated into 83 sub-categories in order to identify the potential for recyclables and mitigating greenhouse gas emissions; and developed predictive models for waste generation. Trung and Kumar <sup>[5]</sup> assessed the resource use and management in the hotel industry in Vietnam; in which, the energy and water use, as well as the waste generated in the various hotel categories have been estimated. Byer *et al.* <sup>[6]</sup> conducted surveys on waste generation rate and waste composition for households, hotels and markets to identify the possibility of composting of organic solid waste in Vietnam and Laos.

Annually, Vietnam publishes a report on the current status of environment situation focusing on the year's prominent issue. In 2004, SWM became the main topic. However, the report <sup>[7]</sup> presented the information on physical composition of MSW around Vietnam, and didn't introduce in-depth data of waste stream and various sources of MSW.

The rapid economic growth and expanding urbanization in cities in Vietnam have caused the increase of the waste generation and the diversification of waste composition. Commercial and institutional solid waste accounted for high proportion of total MSW, especially in tourism cities. Therefore, the evaluation and understanding for waste generation and characteristic from these sources are indispensable for the effective SWM planning.

In this paper, the authors intended to evaluate the waste generation rate and the detailed waste composition on commercial and institutional sectors in a tourism city—Hue city, located in the central of Vietnam. The authors also explored the interrelationships between the waste generation rate and the examined relevant factors such as business scale indicators.

## METHODOLOGY

### Research area

In this study, Hue city was selected as the research area. Hue is located in the Central of Vietnam (see Fig. 1); it was also the capital of Vietnam in the old times. Hue city is the capital city of Thua Thien Hue province with an area of 83.3 km<sup>2</sup> and a population of 337,506 persons (by 31 December 2009) [8]. Hue city has been known as one of World Heritage sites in Vietnam. Nowadays, Hue is becoming famous for visitors around the world.

The collected MSW amount in Hue city was approximately 200 tons/day, and the waste collection efficiency was estimated about 90–95%, collected by the Hue Urban Environment and Public Works State Company (HEPCO) [9].

### Sampling method

The major components (main categories and sub-categories) of commercial and institutional sectors in this study were presented in Table 2. This table also presented the total number in Hue city, sample size in this study, and sample selection method of each category and sub-category applied in this study.

Generally, the sample selection in this study was mainly based on the total list according to the system of economic branches of Vietnam, which was accumulated by the statistical office of Hue city.

According to “*The System of Economic Branches of Vietnam*” (Decision No. 10/2007/QĐ-TTĐ dated January 23, 2007) issued by Prime Minister of the Government of Vietnam [10], This system comprises five levels as follows: Level 1 comprises 21 branches coded by the letters of the alphabet in alphabetical order from A to U; Level 2 comprises 88 branches; Level 3 comprises 242 branches; Level 4 comprises 437 branches; and Level 5 comprises 642 branches. The structure and components were presented in Table 1. Table 1 also presented the target categories in this study.



**Fig. 1 Map of location of the target research area**

**Table 1 The system of economic branches of Vietnam [10]**

Level					BRANCH	Target category
1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>		
A	1-3	242 branches, each branch coded by three numbers after those of the corresponding Level 2	437 branches, each branch coded by four numbers after those of the corresponding Level 3	642 branches, each branch coded by five numbers after those of the corresponding Level 4	<i>Agriculture, Forestry and Aquaculture</i>	
B	5-9				<i>Mining Minerals</i>	
C	10-33				<i>Manufacturing and Processing Industries</i>	HH with business
D	35				<i>Production and Distribution of Electricity, Natural Gas, Hot Water, Steam and Air-Conditioning</i>	
E	36-39				<i>Water Supply, Waste and Sewage Management</i>	
F	41-43				<i>Construction</i>	
G	45-47				<i>Sale and repair of automobiles, motors, motorbikes, etc. Wholesale and retail</i>	HH with business & Market & supermarket
H	49-53				<i>Transport and Warehouse</i>	Office
I	55-56				<i>Accommodation and Restaurant Services</i>	Restaurant & Hotel
J	58-63				<i>Information and Communication</i>	HH with business & Office
K	64-66				<i>Finance, Banking and Insurance</i>	Office
L	68				<i>Real-Estate Business</i>	Office
M	69-75				<i>Professional Practice, Science and Technology</i>	Office
N	77-82				<i>Administrative Services and Assistant Services</i>	HH with business & Office
O	84				<i>The Communist Party, Civil society, State administration, National defense security, etc.</i>	Office
P	85				<i>Education and Training</i>	School & education services
Q	86-88				<i>Health and social support activities</i>	Hospital & healthcare services
R	90-93				<i>Artistic, recreational activities</i>	HH with business & Office
S	94-96				<i>Other Services</i>	HH with business & Office
T	97-98				<i>Hired Labor services for Households, Producing Home Consumption Material Products</i>	HH with business
U	99				<i>Operation of International Organizations and Agencies</i>	Office
21	88	242	437	642		

**Table 2 Target categories of commercial and institutional sectors and sample selection methods**

Category	Sub-category	Total size	Sample size	Sample selection methods	Remarks	
Institutional waste	Schools/ Education service	(1) Kindergarten	49	9	Based on the total list, excluding sub-category (4). <i>The total list of each sub-category was prepared and sorted by the number of students. The target samples were selected systematically from the list.</i>	-
		(2) Primary education	37	5		
		(3) Secondary education	36	9		
		(4) Post-graduate education	8	2		
		(5) Other education services	181	6		
		(6) Education assistant services	0	0		
	Hospital/Healthcare services	(1) Hospitals	12	3	Random selection	-
		(2) Healthcare stations	27	3	<i>The total list of each sub-category was prepared and sorted by the number of beds. The target samples were selected systematically from the list.</i>	-
		(3) General and specialized medical establishments	256	6	<i>The total list of each sub-category was prepared and sorted by the number of staff. The target samples were selected systematically from the list.</i>	50% samples is family scale
		(4) Dental establishments	92	6		50% samples is medium scale
		(5) Standby [reserve] medical	5	1	Random selection	-
		(6) Orthopedic and rehabilitation centers	2	1	Random selection	-
Offices	(1) Government offices – Professional management services – People committee (PC)	18 27+2	3 3+2	Random selection (Departments/Bureaus/Institutions/Agencies) Random selection (27 Wards' PC, 2 City/Province's PC)	-	
	(2) Other offices	365	32	Random selection from the total list	-	
Commercial waste	Hotel	(1) Guest house	101	10	Based on the total list: <i>The total list of each sub-category was prepared and sorted by the number of beds. The target samples were selected systematically from the list.</i>	Total hotels in Hue also consist of: – 45: Non-rated hotels have registered – 76: Non-rated hotels have not registered yet
		(2) 1-star hotel	29	10		
		(3) 2-star hotel	18	7		
		(4) 3-star hotel	10	6		
		(5) 4-star hotel	7	5		
		(6) 5-star hotel	4	3		
	Restaurant	(1) Restaurant (large scale)	131	15	5 target zones were selected according to the urbanization level <sup>[11]</sup>	68 restaurants in 5 zones
		(2) Family-restaurant and pub/bar – 1 worker – 2 workers – 3 workers – 4 workers or more	1068 836 212 190	30 22 7 6	Based on the total list of each target zone: <i>The total list of each sub-category was prepared and sorted by the number of workers. The target samples were selected systematically from the list.</i>	Total number in 5 zones: – 1 worker: 565 – 2 workers: 425 – 3 workers: 114 – 4 workers or more: 92
		(3) Beverage shops – 1 worker – 2 workers – 3 workers or more	921 793 211	11 7 2		Total number in 5 zones: – 1 worker: 564 – 2 workers: 416 – 3 workers or more: 149
		(4) Vendor	NA	5	Random selection	1 sample for each zone
		Market and supermarket	(1) Market (kiosks in market)	460	64	Kiosks are classified into 12 categories and 31 sub-categories based on the “ <i>The system of economic branches of Vietnam</i> ” (level 5) The total list of each sub-category was prepared. The target samples were selected systematically from the list.
	(2) Supermarket		8	1	Random selection	
Household with business	(1) Manufacturing and Processing Industries (C)*	3247	45	5 target zones were selected according to the urbanization level <sup>[11]</sup> Based on the total list of each target zone: <i>The total list of each sub-category was prepared and selected systematically from the list.</i>	17 categories from 25 total categories in the 2 <sup>nd</sup> level of the “ <i>System of Economic Branches</i> ”	
	(2) Sale, repair of automobiles, motors, motorbikes etc. Wholesale and retail (G)*	7375	82	The sub-categories with less than 5 facilities were not surveyed (only 55 in total 85 sub-categories were considered and surveyed).	31 categories from 53 total categories in the combination both 4 <sup>th</sup> and 5 <sup>th</sup> levels of the “ <i>System of Economic Branches</i> ”	
	(3) Other Services (Level 1 of the “ <i>System of Economic Branches</i> ”: J, N, R, S, T)*	2250	17		7 categories in the 2 <sup>nd</sup> level of the “ <i>System of Economic Branches</i> ”	

<sup>(\*)</sup> Industrial code according Level 1 of the “*System of Economic Branches*”

NA: Not available

## Outline of surveys

The authors surveyed the target samples for each component of commercial and institutional sectors composed of three surveys; a waste generation survey by actual measurement, a waste composition survey, and a questionnaire survey. All surveys were carried out simultaneously in rainy season (from September to December 2011).

- (1) *Waste generation survey*: a waste generation survey was conducted to acquire data on discharge amount of waste generated for 7 consecutive days. The target samples were requested to keep and separate their waste into 4 categories; “General waste,” “Recyclables,” “Food residues,” and “Garden waste.” The waste was daily collected and measured by wet weight.
- (2) *Waste composition survey*: During the waste generation survey, a waste composition survey was conducted. The representative samples were selected. The waste was classified into 10 physical categories and 54 sub-categories and recorded the weight with a digital scale measuring a minimum of one gram (g).
- (3) *Questionnaire survey*: A questionnaire survey was conducted by a face-to-face interview at the targets to obtain data on relevant factors influencing waste generation such as business scale indicators, and the current status of recycling activities.

## RESULTS AND DISCUSSION

### Waste generation rate

Table 3 presented the waste generation rate (*kg/unit/day*) for commercial and institutional sectors in Hue city, the average and standard deviation ( $Ave \pm SD$ ) of waste generation rate by the category of the commercial and institutional sectors were summarized. The waste generation rate was separately measured and calculated by 4 waste types; general waste, recyclable waste, food residues, and garden waste. The waste generation rate (*g/unit/day*) was calculated by dividing the waste generation amount per day (*g/day*) by business scale indicators such as the number of workers, the number of beds. The estimated waste generation rate by the category is indispensable basic data for the rational planning on waste management and 3Rs promotion.

The details and discussion are presented as follows:

*School, university, and education services*: The waste generation rate was calculated by the following 3 business scale indicators; *g/class/day*, *g/pupil (student)/day*, and *g/classroom/day*. Each category of this section was separately measured and estimated by two sources: canteen and class. Regarding waste from class activities, “Kindergarten” was identified as the highest generation category for the unit (*g/class/day* and *g/classroom/day*), while the generation rate (*g/pupil/day*) of “other education (baby-keeping house)” category was the highest.

*Healthcare services*: The waste generation rate was calculated by the following 3 business scale indicators; *g/patient/day*, *g/worker/day*, and *g/bed/day*. Among various categories of healthcare services, the waste generation rate (*g/patient/day*) of “hospital” category was the highest, followed by “dental establishment” category. While “dental establishment” was the highest category in the generation rate by worker (*g/worker/day*), followed by “hospital.” Among waste proportions, general waste accounted for the highest generation part, followed by food residues, garden waste, and recyclable waste. (Hazardous healthcare waste was not covered in this study.)

*Offices*: The waste generation rate was calculated by the following 3 business scale indicators; *g/room/day*, *g/worker/day*, and *g/m<sup>2</sup>/day*. Among three categories of office sector, the waste generation rate (*g/unit/day*) of “professional management services” category was smaller than those of others; while “other offices” category was the highest in the waste generation rates by staff (*g/worker/day*) and area (*g/m<sup>2</sup>/day*). Among 4 waste types, recyclable waste accounted for the highest part, followed by general waste and garden waste. Food residues weren’t discharged for collection by users such as pig farmers.

*Hotels*: The waste generation rate was discussed by the following 3 business scale indicators; *kg/room/day*, *kg/bed/day*, and *kg/guest/day*. Among the hotel categories, the waste generation rate (*kg/unit/day*) of “5-star hotel” category was larger than those of others; while “guesthouse” was the smallest in most cases. Among 4 waste types, general waste accounted for the highest part, followed by food residues, recyclable, and garden waste.

*Restaurants*: Waste generation rate was considered by the following 3 business scale indicators; *kg/worker/day*, *g/chair/day*, and *g/table/day*. Among the restaurant categories, the waste generation rate (*kg/unit/day*) of “vendor” category was smaller than those of others, followed by “beverage shops” category; while “restaurants” (large and family scale) was the highest in most cases. The waste generation rate (*kg/worker/day*) of “1-worker restaurant” category was the highest generation rate, while “3-workers restaurant” was the highest for the generation rates by table (*g/table/day*) and chair (*g/chair/day*). Among 4 waste types, food residues accounted for the highest part, followed by general waste, recyclable, and garden waste.

*Market and supermarket*: Kiosks in market were classified into 12 categories. The waste generation rate of kiosks in market was considered by the following 3 business scale indicators; *kg/kiosk/day*, *kg/m<sup>2</sup>/day*, and *g/m<sup>2</sup>/hour*. The waste generation rate of supermarket was considered by the following 2 business scale indicators: *g/m<sup>2</sup>/day* and *kg/worker/day*.



**Table 4** Waste composition (in percentage, %) of commercial and institutional sectors

Category	Sub-category	Plastic	Paper	Food waste	Rubber & leather	Grass & wood	Textile	Metal	Glass	Ceramic	Miscellaneous	Total	Boundary		
Institutional waste	Schools/Education service	(1) Kindergarten	14.87	20.04	51.01	1.47	4.05	1.55	0.65	0.14	0.88	5.33	100	General waste (class and canteen)	
		(2) Primary education	21.74	23.77	22.81	0.60	7.50	6.86	0.13	0.12	3.99	12.48	100		
		(3) Secondary education	22.74	28.76	32.06	0.17	8.21	0.38	0.32	1.14	0.46	5.76	100		
		(4) Post-graduate education	27.42	11.64	21.29	0.21	13.32	1.66	0.51	-	-	23.96	100		
		(5) Other education services	15.21	22.36	32.47	0.06	23.78	0.19	1.16	-	-	4.77	100		
		Garden of school	1.48	6.82	0.25	0.07	90.10	0.76	0.03	-	-	0.50	100		
	Hospital/Healthcare services	-	-	-	-	-	-	-	-	-	-	-	-		
	Offices	(1) Government offices	15.66	38.57	31.39	0.58	4.69	0.78	1.90	0.18	0.14	6.13	100	General waste	
		- Professional management	11.56	43.67	30.80	0.23	9.73	0.55	0.52	-	-	2.94	100		
		- People committee (PC)	14.07	35.61	39.45	0.01	0.20	0.26	1.75	-	-	8.64	100		
(2) Other offices		21.34	36.42	23.90	1.49	4.12	1.53	3.42	0.54	0.42	6.80	100			
Commercial waste	Hotel	(1) Guest house	11.52	10.24	28.80	0.03	3.73	0.04	1.70	31.90	0.01	12.05	100	General waste and recyclable waste	
		(2) 1-star hotel	28.29	23.39	28.75	0.14	10.29	0.05	3.01	-	-	6.09	100		
		(3) 2-star hotel	25.15	8.99	52.15	0.05	2.92	0.85	0.42	-	-	9.46	100		
		(4) 3-star hotel	9.48	9.69	63.11	0.77	7.56	1.17	2.74	-	-	5.48	100		
		(5) 4-star hotel	13.86	18.93	47.37	0.38	3.64	1.77	1.67	3.52	0.01	8.86	100		
		(6) 5-star hotel	15.52	13.84	55.81	0.09	1.46	2.89	1.50	3.77	0.18	4.95	100		
	Restaurant	(1) Restaurant (large scale)	12.80	9.04	57.63	0.08	4.69	2.82	1.18	0.99	0.17	10.61	100	General waste	
		(2) Family-restaurant and pub/bar	11.66	9.64	53.43	0.04	7.47	1.19	1.76	0.50	0.42	13.90	100		
		(3) Beverage shops	4.62	5.46	78.48	0.02	3.30	0.22	1.17	0.04	0.05	6.64	100		
		(4) Vendor	12.90	-	76.10	-	10.16	-	-	-	-	0.84	100		
	Market and supermarket	Market (kiosk in market)	(1) Market (kiosk in market)	18.19	10.50	51.76	0.67	13.13	0.28	0.19	0.40	0.20	4.68	100	General waste
			- Food (rice, cereal, etc.)	2.65	0.94	71.33	0.17	-	-	-	-	-	24.91	100	
			- Meat and meat products	26.11	15.62	55.88	0.09	-	-	-	2.29	-	-	100	
- Fish and fish products			4.74	-	95.04	-	-	-	-	-	-	0.22	100		
- Vegetables			4.80	0.69	91.15	-	3.07	-	-	-	-	0.29	100		
- Fruits			8.51	14.48	62.02	0.03	0.19	-	-	-	-	14.76	100		
- Other foodstuffs			55.14	27.09	14.94	0.15	2.19	0.25	-	-	-	0.25	100		
- Food stalls			3.67	2.98	46.61	0.03	38.45	0.02	0.03	0.43	-	7.77	100		
- Beverages			-	-	-	-	-	-	-	-	-	-	-	-	
- Cigarettes, rustic tobacco			19.87	4.10	66.56	0.95	7.26	-	1.26	-	-	-	100		
- Textiles, apparel, footwear			51.46	15.79	22.53	4.92	2.75	2.19	0.24	-	-	0.11	100		
- Fresh flowers, ornamental			6.90	4.32	5.34	0.10	83.22		0.09	-	-	0.03	100		
- Other commodities		16.27	29.49	37.94	0.93	7.28	0.62	0.41	1.69	2.23	3.14	100			
(2) Supermarket	23.58	22.15	42.42	0.08	1.77	3.48	1.06	-	-	5.48	100	General waste			
Household with business	(1) Manufacturing Industries (C)	(1) Manufacturing Industries (C)	20.88	8.21	37.13	2.63	7.64	16.84	4.15	0.31	-	2.20	100	General waste of business facilities	
		(2) Sale, repair of automobiles, etc.	17.39	25.43	18.84	20.21	0.48	10.54	1.84	-	-	5.29	100		
		Wholesale and retail (G)	20.32	11.37	48.52	0.54	10.99	3.27	0.69	2.51	0.46	1.32	100		
		(3) Other Services	17.30	13.32	40.70	6.53	1.76	0.45	2.74	1.87	0.92	14.41	100		

*Household with business:* Households with business facilities were classified in four types of business: manufacturing industries, sale/repair of automobiles, wholesale/retail, and other services. The waste generation rate of business facilities was calculated by *g/worker/day*, and the waste generation rate of household was separately estimated by *g/capita/day*. Besides, garden waste was calculated by 2 indicators for households and business scales.

ANOVA results showed that the significant average differences were found among the generation rates of categories and sub-categories of the commercial and institutional sectors by business category. The business category was identified as the appropriate factor influencing waste generation for “Hotel” category, “Education” category and “Market” category.

### Waste composition

Table 4 presented the average proportion of waste composition of commercial and institutional waste by 10 physical categories.

*School, university, and education services:* The waste compositions of education service were calculated by 5 categories of education service and garden waste. Food waste accounted for the largest part in the total

general waste, followed by paper and plastic (excluding “post-graduate education” category). Regarding “post-graduate education” category, plastic accounted for the largest part in the total general waste (27.42%), followed by miscellaneous (23.96%), food waste (21.29%), grass and wood (13.32%), and paper (11.64%).

*Offices:* Paper and food waste accounted for the largest parts, followed by plastic, miscellaneous, grass and wood, metals, textile, rubber and leather, ceramic, and glass. The large generation rate of food waste was partly caused by the discharge from residents (security staff, drivers) living in the office. Paper and plastic have high potential for recycling and reducing of total waste generated from these sources.

*Hotels:* Food waste accounted for the largest part in the total general waste and recyclable waste, followed by plastic and paper (excluding “guest house” category). These large components have high potential for recycling and reducing by composting and recycling options for paper and plastic waste.

*Restaurants:* Food waste accounted for high proportion in total general waste (more than 50%), especially more than 75% in “beverage” and “vendor” categories. Paper and plastic were the second largest components. However, miscellaneous accounted for large part in “restaurants” (for large scale and family scale); the possible reason was the fossil coal used for cooking in these restaurants; this coal caused large discharge amount by coal ash with high density.

*Market and supermarket:* Kiosks in market were also classified into 12 categories. The average composition of market showed that food waste accounted for the largest part in the total general waste, followed by paper, plastic, grass and wood.

*Household with business:* The waste compositions in various business categories of households with business sector were considered by 4 types of business: manufacturing industries, sale/repair of automobiles, wholesale/retail, and other services; the physical composition varied greatly among four types as presented in Table 4.

**Table 5 Correlation analysis of waste generation (kg/day) and relevant factors<sup>(★)</sup>**

Category	Sub-category	General	Recyclable	Food residues	Garden	Total	
Institutional waste	Schools/ University/ Education service	(1) School/class/office					
		Number of Students/pupils	0.738***	0.655**		0.689***	0.746***
		Number of Class	0.754***	0.612**		0.567**	0.746***
		Number of Classrooms	0.706***	0.619**		0.739***	0.758***
		(2) Canteen (food stall)					
		Number of Students/pupils	0.603**	0.652**	-		-
	Number of Class	0.699**	0.742***	-		-	
	Number of Classrooms	0.517*	0.669**	-		-	
	Healthcare	Number of beds	0.988***	-	-	-	0.969***
		Number of staff	0.986***	-	-	-	0.964***
		Number of patients	0.983***	-	-	-	0.957***
	Offices	Number of rooms	0.441**	-		-	-
		Number of staff	0.526***	-		0.496**	0.420**
		Land area (m <sup>2</sup> )	0.395*	-		0.647***	0.487**
Floor area (m <sup>2</sup> )		0.744***	-		0.977***	0.798***	
Garden area (m <sup>2</sup> )		0.863***	-		0.955***	0.786**	
Commercial waste	Hotel	Number of workers	0.907***	0.752***	0.913***	0.485**	0.916***
		Floor area (m <sup>2</sup> )	0.441*	0.622**	0.585**	0.264	0.522*
		Number of rooms	0.803***	0.670**	0.855***	0.418**	0.834***
		Number of beds	0.911***	0.678***	0.931***	0.441**	0.923***
		Number of guest	0.673***	0.384***	0.693***	0.328***	0.713***
		Net-sales	0.772***	0.536***	0.682***	-	0.775***
	Restau- rant	Number of total staff	0.645***	0.283**	0.479***	-	0.668***
		Number of tables	0.817***	0.222*	0.266*	0.318**	0.612***
		Number of chairs	0.816***	0.242*	0.293**	0.299**	0.651***
	Market and supermarket		NA	NA	NA	NA	NA
	HH with business	(1) Business facilities					
		Number of staff	0.386***	-	-	-	0.375***
		(2) Household					
	Household size	0.308***	-	-	0.173*	0.204*	

(★) Correlation analysis using Pearson correlation (2-tailed) \*  $p < 0.05$  \*\*  $p < 0.01$  \*\*\*  $p < 0.001$  NA: Not available



### **Relevant factors influencing waste generation**

The authors analyzed the correlations between the generation rates and the relevant factors such as business scale indicators, household size, and net-sales. The analyses were implemented by 4 waste types and total: general waste, recyclable waste, food residues, garden waste, and total waste. The results of correlation analyses were presented in Table 5. The positive significant correlations were found in many sub-categories of the commercial and institutional sectors to relevant factors. Among 5 segments of waste type, the authors found numerous significant correlations in the waste generation rate for general waste and total waste, followed by recyclable waste, garden waste, and food residues.

### **CONCLUSION AND RECOMMENDATION**

The major focus of this study was to estimate the generation and characteristic of waste generated from the commercial and institutional sectors. The waste generation rate (*kg/unit/day*) was discussed by business category, business scale indicators. The physical compositions were also analyzed and estimated. The interrelationships among the waste generation, the business category and business scale were analyzed.

This is the first step for developing predictive models. Further studies are necessary in consideration of a deep and wide analysis of relevant factors and levels. Through these studies, it would be possible to develop predictive models on commercial and institutional waste generation, and they will support the waste authorities for prediction, planning, and integrated solid waste management.

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