Techno-Science Research Journal 7 (2019) 1-7

Content list available at ITC

Techno-Science Research Journal

Journal Homepage : www.itc.edu.kh

Techno-Science Research Journal

Behavioural Study of People toward Plastic Bag Generation and Characteristics of Plastic Waste Composition in Phnom Penh

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Abstract: *Plastic bags are used widely across nations and became famous for carrying goods and packing products since 1970 and they start to rapidly popularized in the 20th century. People live in Phnom Penh City, the capital city of Cambodia, also use large amount of plastic bags due to various reasons such as their convenience, inexpensive, get free of charge, and easy to get. Plastic bags use has rapidly increased as result of changing life styles, population growth, urban development and economic growth per capita. As a result, plastic bag wastes have left in a huge amount. The study was conducted in six out of twelve Khans (district) in Phnom Penh, and aims to understand the behaviour of people toward plastic bag generation and to characterize the composition of plastic wastes. Sample size of one-hundred sixty-six households and ninety-six non-households were selected based on the formula of Cochran, and waste samples size followed the Methodology for the Solid Waste Analysis Tool (SWA-Tool). One Way-ANOVA in SPSS was used to identify the degree of plastic bag consumption associated with socio-economic parameters (income, and education level). The positive significance was found with both socio-economic parameters at p = 0.001 (p<0.05). Family income was grouped into low, middle, upper-middle, and high-income. The findings indicated that the families with less education and/or with higher income produced higher amount of plastic bag wastes. Moreover, plastic waste is in the second largest amount after organic waste, which is accounted 11% in PP. The further analysis of plastics showed the composition across different categories with white and colorful - LDPE plastic bags to be found 34% and 18%, while LDPE-other–17%, PS–8%, PET–8%, PP–7%, HDPE–5%, PVC–2%, and other plastic resin–1%, respectively.*

Keywords: characteristics, composition, parameter, plastic bag, socio-economic

1. INTRODUCTION

Plastics have become an integral part of our modern lifestyle because of their convenience for uses. Global production of plastics has surged over the last few decades and it is expected to significantly increase over the next 20 years, with plastics becoming ubiquitous across almost all facets of the economy. As a result, only 15 million tonnes were produced in 1964, growing to 311 million tonnes in 2014 (Leone *et al*., 2017) and 322 million tonnes in 2015 (European Commission, 2015). In 1988, to facilitate the consumers and re-processors, the Society of Plastics Industry (SPI) coded into difference type of plastics resin such as: Polyethylene (PET), High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low Density Polyethylene (LDPE), Polypropylene (PP), Polystyrene (PS), and other plastics.

Urbanization coupled with economic growth will increase standards of living and disposable incomes will also increase, as well the consumption of goods and services (Imura *et al*., 2005; Tata *et al*., 2012).

In this manner, changing lifestyles has also changed waste composition from organic to plastics and packing materials (Azni *et al*., 2004). Thus, plastic bags were a popular means of carrying goods, such as groceries, by hand or otherwise in 1970 (Clapp & Swanston, 2009), and they became popularized rapidly in the last quarter of the 20th century (Sugii, 2008). Annually, 500 billion (UNEP, 2018) to 1 trillion plastic bags are used globally (Spokas, 2008). Supermarkets begin to consistently offer plastic bags to shoppers in 1977 in American, 1980 in Western Europe, and in the 1990s in developing countries (Clapp & Swanston, 2009). The factors to such growth were their density, robust, design and fabrication, inexpensive cost, weightlessness, durability (Vegter *et al*., 2014; Silvarrey & Phan, 2016; DELWP, 2018), streng, functionality (Jalid *et al*., 2013), and convenience for consumers (Muthu *et al*., 2012; Lyons, 2013). Additionally, plastic bags have been used widely by small business owners such as: hawkers, shopping malls (Nitin *et al*., 2016), and retailers (Abdul *et al*., 2013). For instance, approximately 99 billion plastic carrier bags were used in the European Union (EU) in 2010, which equates to

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around 198 bags per capita (Lorcan, 2013). For instand, there were roughly 2 billion plastic bags used annually in New South Wales (EPA, 2016), 1.5 billion used in New Zealand (MFE, 2018), and 2 billion carrier bags used annually in Israel (Ofira *et al*., 2009). On the other hand, Phnom Penh (PP) is the capital and the largest city of Cambodia in term of population where people also consumed a lot of plastic bags due to their convenience, as well as their characteristics of being waterproof, lightweight, disposable, and affordable, although the exact number is not known. As a result, they are used in a wide range of situations and sectors, from transporting solids and liquids, to direct consumption, to storing and packing (Oriolo, 2017). According to the reported speech from Ministry of Environment (MoE) in 2018, the capical produced 10 million plastic bag per day. Additionally, the average urban Cambodian, mainly in PP, uses between 2,000 plastic bags (ACRA, 2017) to 2,158 every year and up to 2,700 in the case of housewives (SWITCH-Asia, 2015). This is ten times higher than average consumption in the EU and China.

As consequences, plastics are a pollutant of unique concern because they do not break down quickly and accumulate in the environment as more they produced (Ofira *et al*., 2009; Golam, 2017; CIEL, 2017). Many studies have been performed to investigate the environmental and health hazards linked to the waste disposal of plastic bags. Plastic bags are considered one of the major problems for sewage system clogging, which damages the tourism sector (Abdul *et al*., 2013; Motasem *et al*., 2017; Emma, 2017). It also creates an economic issue for the local government due to the additional cost to clean up the littering plastic bags, the cost to protect and clean storm-water catchment basins and the costs from impacted sorting equipment at materials recovery facilities (Wagner, 2017). Especially, the littering plastic bags can block water flow (Theuri *et al*., 2014; Ohidul *et al*., 2018), water quality and clog drain pipes, contributing to enormous flooding (Abdul *et al*., 2013), littered streets and fast-filling landfills (ACRA, 2015). Moreover, plastic bags when dumped into rivers, streams and the ocean, contaminate the water, soil and air we breathe (Yojna *et al*., 2014). This causes significant disservice to aquatic animals (Shahariah *et al*., 2015).

The current study aims to understand people perception and knowledge on environmental degradation from plastic bag use in PP. The specific objectives of the study were listed below: (1) to identify plastics waste composition, and (2) to understand the behavior of people on plastic bag use in Phnom Penh.

2. METHODOLOGY

2.1 Study Area

The study was conducted in Phnom Penh capital city. In PP, there are 12 Khans; however, only six Khans are selected in this study. Figure 2.1 illustrates the study sites of 2 Khans: Toul Kork and Chamkamorn in the center of the city (inner Khans) and other 4 Khans on outskirts of the city (outer Khans).

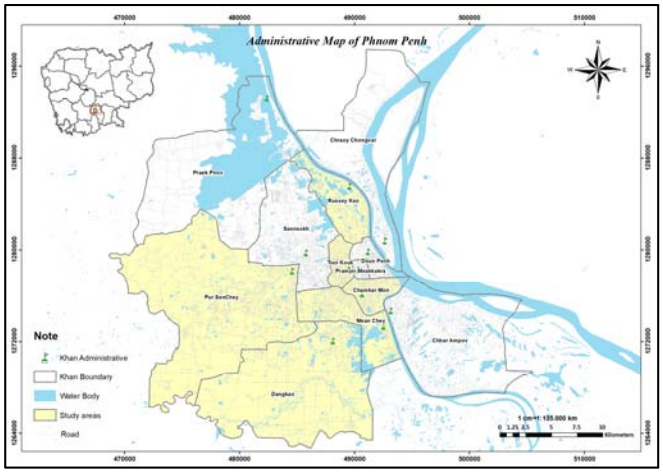

Fig.2.1. Location of study areas

2.2 Household and Non-Household Sampling

Cochran's formula (Cochran, 1977) is used to determine the samples. It is calculated for sample size when the population is infinite. The calculation formula can be determined as:

$$n_0 = \frac{z^2\,pq}{e^2} \qquad \text{(Eq. 1)}$$

where:

n_o = sample size
z = selected critical value of desired confidence level
p = estimated proportion of an attribute that is present in the population (equal 0.5)
q = 1 – p
e = the desired level of precision

To ensure the reliability of sample size, the confidence interval z was chosen to be 99% for household and 95% for non-household within 10% error level. As a result, the total sample size for the household survey is 166 while non-household is 96. Additionally, for both household and non-household sources were determined base on the study on municipal solid waste in PP by JICA in 2005 (JICA, 2005). Likewise, household refers to local residents, whereas, non-

household refers to the business establishment such as: shop, market, hotel, restaurant, and office.

For household source, random sampling method was used. Under this sampling design, every item of the univers has an equal chance of inclusion in the sample. First, we apply the stratified sampling method in which each district is devided into different blocks, called "strata". Then, a systematic sampling method is also applied to identify which household should be selected for interview by setting a 200 meter interal from each household. Moreover, household income was classified into low, middle, upper - middle, and high income based on the minimum wage, 182 USD per month, for workers in textile, garment and footwear sector adopted by Ministry of Labour and Vocational Training (MoLVT, 2018). It was considered that below 200 USD to be low income while 200 USD was assumed to be difference among level.

2.3 Waste Sampling

Waste sample size was determined with the use of Methodology for the Solid Waste Analysis Tool (SWA-Tool) by the European Commission in 2004 (European Commission, 2004). The significant number of sampling unites depends mainly on four aspects: (1) the demand on the aspired accuracy of the results, (2) the demand on the confidence level, (3) variance of the population, and (4) sample proportion. Thus, the necessary number of sampling units can be determined as illustrated following:

$$n = \left(\frac{t_{\alpha;n-1} \cdot Var\ coeff(x_i)}{\varepsilon_{\hat{\Theta},r}}\right)^2 \text{ for } f = \frac{n\ samping}{N} < 0.05 \qquad \text{(Eq.2)}$$

where:

n = The necessary number of sampling
$t_{\alpha;n-1}$ = Confidence Coefficient (z-value)
(x_i) = Coefficient of variation
$\varepsilon_{\hat{\Theta},r}$ = Maximum allowance for random sampling error
f = Sample proportion
$n_{sampling}$ = Number of sampling units,
N = Number survey units in the parent population

The study uses natural variation coefficient 30%, maximum random sampling error 10%, and confident interval 95% (see Table 2.1). With the formula (equation 2), the necessary number of waste sampling in PP is 35. Additionally, waste was stored with 10 kg of colorful plastic bag and collected for one week, which is equaled to 245 samples. Likewise, It was characterized and sorted into a different type of plastic resin determined by Society of the Plastics Industry (SPI) at the Institute of Technology of Cambodia (ITC). The study also used balances of different scales to measure the weight of sample.

Table 2.1. Calculation of necessary number of sampling units

Natural Variation coefficient Gaung for variation in parent population	**Necessary number of sampling units in (95% confidence level)** with maximum allowance for random sampling error:					
	2.5%	5%	10%	15%	20%	30%
15%	138	35	9	4	2	1
20%	246	61	15	7	4	2
25%	384	96	24	11	6	3
30%	553	138	35	15	9	4
35%	753	188	47	21	12	5
40%	983	246	61	27	15	7
45%	1245	311	78	35	19	9
50%	1537	384	96	43	24	11
55%	1859	465	116	52	29	13
60%	2213	553	138	61	35	15
70%	3012	753	188	84	47	21
80%	3934	983	246	109	61	27
90%	4979	1245	311	138	78	35
100%	6147	1537	384	171	96	43
120%	8851	2213	553	246	138	61
140%	12047	3012	753	335	188	84
160%	15735	3934	983	437	246	109
200%	24586	6147	1537	1537	384	171

2.4 Data Analysis

The data from interview interpreted by One-Way ANOVA (Analysis of Variance) in Statistical Package for the Social Sciences (SPSS) promgram. This tool is used to determine whether there is statistical evidence and/or to identify the degree of association as well as the significant level between plastic bag generations with socio-economic parameter (income, and education level).

3. RESULTS AND DISCUSSION

3.1 Socio-Economic Characteristics of Household

The finding shows that most of respondents were females, accounted for 80.7%. It is belived this is because males are typically not home due to their income generation activities. Additioinally, the study showed that 12.7% was low-income group, 46.4% was middle-income, 28.9% upper-middle income, and 12% was high-income. Likewise, most respondents had enrolled in school with 37.3% of them having enrolled in primary school during the study.

Table 2.2. Socio-economic characteristics

Variable Names	Frequency	Percentage (%)	Cumulative (%)
Sex			
Male	32	19.3	19.3
Female	134	80.7	100
Income (dollars)			
Low-income	21	12.7	12.7
Middle-income	77	46.4	59.0
Uper-middle-income	48	28.9	88.0
High-income	20	12.0	100
Education			
Primary School	62	37.3	37.3
Secondary School	36	21.7	59.0
High School	34	20.5	79.5
Higher Education	34	20.5	100

3.2 Physical Characteristics of Plastic Waste

The result showed that the highest proportion is food/organic waste at 78%, followed by plastics at 11%, which is the second largest proportion. Additionally, the current study went further by categorizing type of plastic resins. As indicated in Figure 3.1, it showed that clear and colorful – LDPE plastic bag use accounted for 52%, followed by LDPE-other equal to 17%, while PS, PET, PP, HDPE, PVC, and other plastics consist of 8%, 8%, 7%, 5%, 2%, and 1%, respectively. In addition, the results showed that household sources were the largest contributer of plastic bag use (64.8%), followed by non-household sources such as: shop, market, restaurant, office, school, and hotel (35.2%)

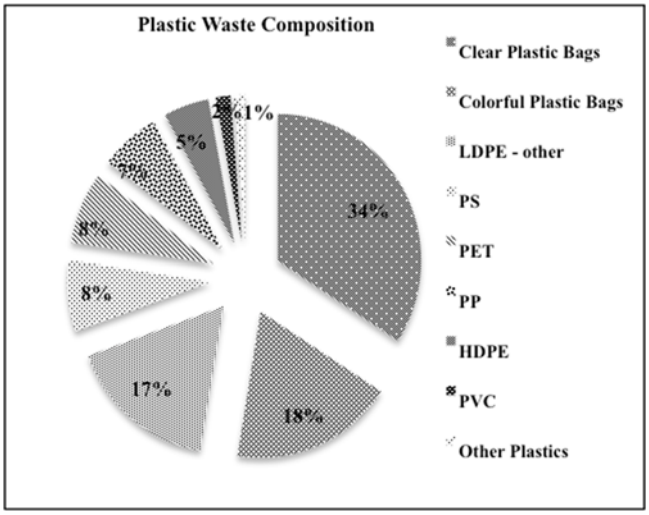

Fig.3.1.Plastic waste composition in PP

3.3 Socio-Economic Analysis

3.3.1 Plastic Bag Generation by Income Level

Table 2.3 showed analysis result by ANOVA with the positive correlation of daily plastic bag use and income generation at 95% confidence level {F (3, 162) = 12.322, p = 0.001}. Also, Between Groups in ANOVA is used to measure variation between separate groups of interest, whereas, Within Groups, It refers to variations caused by differences individual groups. In other words, not all values within each group are the same.

Table 2.3. The significance of plastic bag and income

ANOVA					
Plastic Bags use daily					
Sum of Squares		df	Mean Square	F	Sig.
Between Groups	35.291	3	11.764	12.322	0.001
Within Groups	154.667	162	0.955		
Total	189.958	165			

Additionally, as indicated in Figure 3.2, it showed that families who generated more income will comsme more number of daily plastic bags than those families with low-income. The previos study in Dhanbad city, India showed that high-income families used more plastic bags than medium and low-income groups (Qu *et al*., 2009; Samadder *et al*., 2018). It is reasonable to explain that people with high-income have more ability to purchase and consume more goods and services while they use plastic bags for packing products as their functional, inexpensive, disposable and convenient uses.

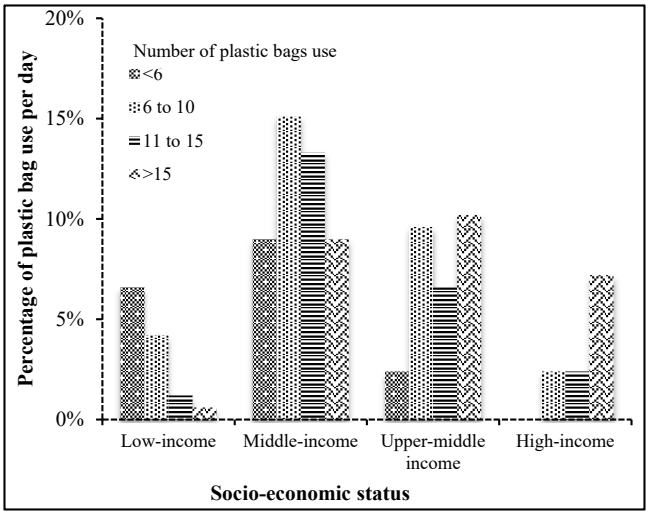

Fig.3.2. Plastic bag use and socio-economic status

3.3.2 Plastic Bag Generation by Education Level

The study also identified the statically significant of daily plastic bags generation and education level. The result indicated in table 2.4, that there is positive correlation as $p<0.05$, {$F(3, 162) = 9.485$, $p = .001$}.

Table 2.4. The significant of plastic bag and education.

ANOVA					
Plastic Bags use daily					
Sum of Squares		df	Mean Square	F	Sig.
Between Groups	28.381	3	9.460	9.485	0.001
Within Groups	161.577	162	0.997		
Total	189.958	165			

Likewise, Figure 3.3 showed that people who enrolled in primary school consume greater number of plastic bags if we compare to people with higher education. The study in Beijing, China also showed that the advance education level which is enrolled in school more than 12 years used fewer plastic bags than those who enrolled only in primary and secondary school (Qu *et al*., 2009). It is possible to conclude that people who have more education, they concern the bad influences of plastic bags to the environment and human health. However, households with lower education have limited knowledge and understanding of the negative effects of daily used plastic bags on the environment.

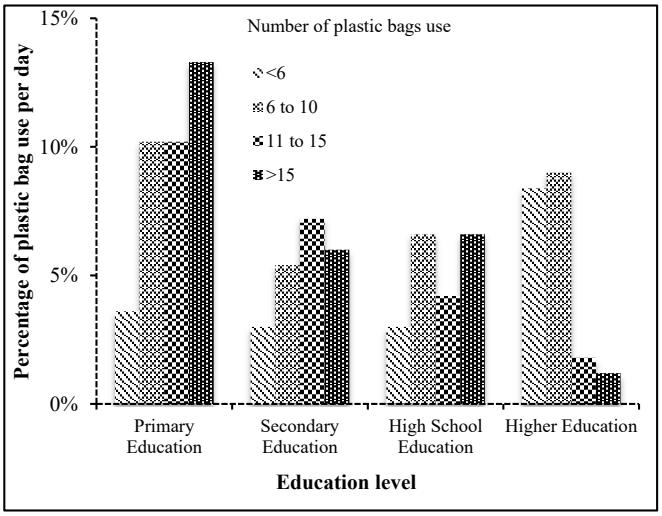

Fig.3.3. Plastic bag use and education level

4. CONCLUSIONS

The results of the study showed that there are statistically correlation of socio-economic factors (income and education) on daily plastic bags use of household in PP at $p = 0.001$ ($p<0.05$). The findings indicated that the families with higher income and/or with less education produced higher amount of plastic bag wastes. Additionally, plastic waste in PP comprised of different types of resins. Clear and Colorful - LDPE plastic bags accounted for 52%, followed by LDPE-other equal to 17%, while PS, PET, PP, HDPE, PVC, and other plastics consist of 8%, 8%, 7%, 5%, 2%, and 1%, respectively. The further study should be comprehensively conducted on the behavior of vendors whether how do they distritube plastic bags to their customers. Last but not least, for a better result, larger waste sampling size is recommended according to SWA-Tool Methodology.

ACKNOWLEDGMENTS

The authors gratefully acknowledge to Mr. Visoth Sim, lecturer of mathematics at Paññāsāstra University of Cambodia, for helping with SPSS data analysis. We also thank students from Paññāsāstra University of Cambodia (PUC) and Royal University of Phnom Penh (RUPP), School of Environmental Science, for their kind assistance on data collection as well as respondents who live in the study area.

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