Household solid waste composition and characterization in Indonesia Urban Kampong

Juntara Semilu Rosesar1* and Gabriel Andari Kristanto1
1Environmental Engineering, Civil Departement, University of Indonesia
*Email: juntara.semilu@ui.ac.id

Abstract. Household waste compositions and characteristics are the basic Information needed in planning a waste management system. The data are affected by many factors, such as the area characteristic and their income. As a part of city growth, urban Kampong is generally established due to urbanization and can be characterized by its density, low income residents, and poor sanitation. This research is conducted to analyze the composition and characteristics of solid waste produced in Urban Kampong. Cross sectional study approach was conducted to analyzed the household characteristics; the Indonesia standard of 19-3694-1994 is applied to examined wastes generated with 100 kg of waste samples was collected for 8 days in each urban kampong. The research result shows urban kampong waste composition is dominated by organic waste with 61.62%. While inorganic wastes are dominated by plastic (13.14%), multi-layered (5.52%) and paper (4.12%). The average of waste generation in urban kampong is 0.5 kg/person/day. This study is expected to be the baseline for improving waste management system in urban kampong in Indonesia.

1. Background
Solid waste has become the biggest issue in Indonesia that has not yet to be solved. According to the Ministry of Environment and Forestry and the Ministry of Industry in 2016, Indonesia’s solid waste generation reached 65.2 million ton annually and most of them were not manageable [1]. These issues and challenges are also faced by other developing countries due to the increase in population, living standards, and also changes in their lifestyles thus resulting in more solid waste generation [2]. Therefore the need for solid waste disposal and processing area has increased [3-7]. Other than that, unoptimized solid waste management systems can result in environmental pollution (air, water, and land) producing harm to-human health and the environment [8-11].

This waste related issue is also faced by many other urban kampong in big cities. The high rate of urbanization in urban areas is the main caused of daily waste volume increase [12-13]. At the same time, urban kampong is a highly populated area thus making waste management critical because of its direct effect on the population lives' quality [14]. The increasing urbanization phenomenon makes urban kampong prone to become slum area due to the imbalance between the increasing number of population versus good management on residential areas [15-16]. Aside from urbanization, slum areas also emerge as a consequence of less housing regulations creating illegal and unplanned areas in the city [17]. As the population increases, the number of households consequently increases thus resulting in a higher generation volume of household solid waste. Besides the high volume, the household solid waste composition has the potential of harming society's health [14, 18].
The composition and characteristics of waste are the basic information in planning a waste management system [19]. The appropriate management system according to UU 18/2008 is comprised of 2 main groups, the first one being waste reducing and the other is waste handling [14]. Many factors can effect the solid waste composition such as urbanization, GDP per capita, local culture like food of choice and other activities [13-14, 20-21]. Take for example the city of Taipei, where Taiwan, the high level of urbanization affects the society’s behavior in using plastic increasing plastic waste annually [21]. In Indonesia, the household municipal waste consist of 60% organic and the rest are inorganic waste like plastics (±17%), papers (±7%), clothes (±0.4%), rubbers (±0.1%) and metals (±1.5%) [22-23].

Previous studies have been conducted during the last decade regarding waste in slum area. For example, Sethi et al. (2013) in Jalandhar city, Punjab, India and Ramachandra et al (2018), Gonzalez et al. (2010) in Northern Mexico, Dorenfeld et al. (2012) in Namibia rural areas, Shah et al. (2012) in rural areas near Tekanpur in India; El-Messery et al. (2009) in Egypt rural areas; Mohammadi et al. (2012) in northern Iran, and De Medina-Salas (2013) in Cosautla'n_De Carvajal, Veracruz, Mexico. These research found organic waste was higher than inorganic waste like glasses, metals, plastics and others [24-31].

The lack of accurate specific information on waste compositions and characteristics resulting in the lack of development and planning in waste management in urban kampong. Furthermore, there is little to none attention to waste management in urban kampong from the local governernment. Urban kampong residents also face great health risks due to unmanage waste [14, 18]. The health risks can be increased due to the growth of many vectors that carry diseases from unmanaged waste piles like flies (fly-borne diseases), mosquitos (mosquito-borne diseases),and rodents (rodent-borne diseases) [18]. This study aims to analyze the quality and quantity of household solid waste in urban kampong in two big city in Indonesia. This research is not only important for developing waste management but also as a baseline for various strategies in improving sanitation in urban kampong areas.

2. Methods

2.1. Area of study

This research was conducted in an urban kampong in four areas, which were Kampong Markisa, Kampong Cimone, Kampong Gedong Pompa and Kampong Cikini Kramat (Gambar 1). Two of the kampongs are located in Jakarta City as the capital city of Indonesia while the other two located in the city of Tangerang. Kampong Gedong Pompa is located in North Jakarta, which lies close to the Java Sea. Having the lowest GDP in Jakarta, North Jakarta-has the greatest number of slum areas [32]. While Kampong Cikini Kramat is located in Central Jakarta’s administration center with the highest population density of 5000 person / hectares.

![Figure 1. Research location.](image-url)
Kampong Markisa and Kampong Cimone are located in Karawaci sub-district, city of Tangerang. Both kampongs have the same characteristic that is both are slum settlements in Tangerang city. The kampong location is located near an industrial complex subsequently making them gain less attention from the local government. National Slum Upgrading Program (NSUP) recorded the total slum area in Tangerang city reaches 3.59 Ha where the Karawaci sub-district is included in the said area.

These four kampongs are categorized into a dense populated settlement which the road width are mostly less that 1 m. has This condition has become a challenge not only for waste collecting and transporting but also for fire protection and other disaster mitigation. Compare to the central city of Jakarta and Tangerang or surrounding residential areas, he four kampons have inadequate sanitation infrastructure: limited access to clean water sources and availability of sewage. With no availability of clean water supplies and limited waste management from the local government only add insult to injury. The densely populated settlement is also one of the factors in the less number of adequate toilets for bathing, washing, and lavatory.

Figure 2. Slums kampong in Jakarta and Tangerang.

2.2. Urban kampong household characteristic
In this study, household characteristics were collected using cross sectional and systematic random sampling. Cross sectional study is conducted at one short period and usually used to predict a certain result prevalency for a specific population [33]. The sample size were calculated using the sample size formula for population proportion estimation using a complex sample design [34]. 150 respondents were interviewed from each kampong using 50% conservative coverage estimation, 8% precision and 95% confidence level.

2.3. Sampling waste generation and composition measurement method
Household solid waste generations and compositions were identified in temporary dumpsite (TPS) before finally transported into a landfill (TPA). Waste The Indonesian standard of waste sampling, referring to SNI 19-3694-1994 on collection method, waste generation sample measurement and urban waste composition were applied. The solid wastes collected from each household by the garbage collectors then transported TPS where 100 kg of random samples were taken to be analyzed for compositions and characteristics. The analysis of waste composition were conducted for 8 days. Data analysis method. Then, data were analyzed using the 2013 Microsoft excel program (Microsoft Corp) thereby wastecomposition, maximum and minimum and standard deviation standards could be acquired.
3. Result and discussion

3.1. Household and utilities
Urban kampong characteristics are identified as education level, occupation and household income (table 1). It is found that 72% of waste generated was transported by the garbage collectors to a TPS; while other 28% are dumped into the body of water, empty land, or burned. From the TPS the wastes were transported to the landfill which is actually an open dumping (Figure 3).

Table 1. Household characteristics.

| Components        | Description                  | %   |
|-------------------|------------------------------|-----|
| Education         | Low Education Level          | 57.8% |
|                   | Higher Education Level       | 42.2% |
| Occupation        | Farmer                       | 1.7%  |
|                   | Entrepreneur                 | 27.8% |
|                   | Civil servant                | 2.5%  |
|                   | Private Employee             | 32.0% |
|                   | Daily Labourer               | 29.8% |
|                   | Others                       | 6.2%  |
| Household Income  | < Rp. 2,000,000              | 23.7% |
|                   | Rp. 2,000,000 - Rp. 4,000,000| 35.8% |
|                   | Rp. 4,000,000 - Rp. 6,000,000| 22.8% |
|                   | Rp. 6,000,000 - Rp. 8,000,000| 8.2%  |
|                   | Rp. 8,000,000 - Rp. 10,000,000| 4.8% |
|                   | > Rp. 10,000,000             | 4.7%  |
| Waste Processing  | Collected by collector       | 79.2% |
|                   | Composting                   | 0.3%  |
|                   | Open Burning                 | 0.9%  |
|                   | Disposed to body of water    | 4.8%  |
|                   | Random disposal              | 1.3%  |
|                   | Others                       | 13.5% |

Based on table 1, the level of education from 4 kampongs is 57.8%, which is categorized as a low level of education with junior high school as its highest education level. As for occupation, private employees (32%) and daily labourers (29%) are the dominant ones. While household income is 35% dominated by income range of IDR 2 million - 4 million.

3.2. Household solid waste management
Field observation in this research was conducted for 8 days in each kampong, and the result shows that four kampongs hadn't been able to optimally manage the household solid waste generated. The waste separation and 3R (Reuse, Reduce, Recycle) process were rarely used. The lack of government attention in facilitating a good household waste management was the main contributor to this issue.

The flow of waste management in kampong urban was still using old paradigm: collect-transport-dispose.
3.3. Waste generation and composition

In average, the urban kampong generates 0.5 Kg/person/day waste where kampong Cikini Kramat generates the highest number of waste which is 0.74 Kg/person/day (Table 2). As the previous research mentioned the higher the waste generation in urban areas, the higher the income and consumption [35]. However Kampong Cikini has the lowest household income compared to other kampongs. The high amount of waste generated is due to its location which lies in the town center because its inhabitants' low income and smaller living space make instant and take away foods as ideal consumption thus creating large amounts of packaging waste.

| Kampong     | Waste Generation (Kg/person/day) | Monthly Income       |
|-------------|---------------------------------|----------------------|
| Markisra    | 0.23                            | Rp. 2.000.000 – Rp. 4.000.000 |
| Cimone      | 0.36                            | Rp. 2.000.000 – Rp. 4.000.000 |
| Gedong Pompa| 0.68                            | Rp. 2.000.000 – Rp. 4.000.000 |
| Cikini Kramat| 0.74                          | < Rp. 2.000.000       |
| Average     | 0.50                            |                      |

The waste generated in urban kampong was dominated by organic waste with an average of 61.23%. While plastic waste (non-multilayered) dominated inorganic waste with an average of 13.14%. The least number of wastes found was electronic waste with 0.11% and rubber with 0.25%. Organic Waste management using the composting system is difficult to implement due to the high price of the land and less space to utilize. The same goes for recycling processes, the low quality of waste makes it impossible to recycle. Thus making the transportation of waste from temporary dumpsite to the landfill the only reasonable method.

One interesting fact was the high number of small size multi-layered plastic waste generation with 5.25%. Multi-layered plastic is a plastic packaging waste created from Low Density Polyethylene (LDPE) which is normally used for snack packaging [36]. Multi-layered is categorized as a food-grade plastic consequently making this plastic used by many food products. Besides from snack packaging,
multi-layered plastics found were also found in many consumer goods like small sized shampoo and conditioners, and personal hygiene products. These small-size consumer goods are main items sold in the small shops or stalls owned by local people in urban kampong.

Table 3 shows comparison data between waste composition of Indonesia's urban kampong and other slum area cities. Slum area inhabitants are usually categorized as the low-income class [17] and it is apparent that the waste composition in an area with a low-income class is dominated by organic waste/food leftovers. In table 3 organic waste composition is at the range of 57% - 83.5%. This high level of organic waste is caused by low-income class mainly consuming traditional food like vegetables, meats, and rice. The different organic percentage in each country is affected by some factors like the society’s activities, local food of choice and the income level [21]. Furthermore, the low income of the society is also an indicator of the low consumption of packaged products. This is evident from the percentage of plastic and paper in each country only showed less than 15%.

In this study, the urban kampong inhabitants generate higher a plastic waste (13.14%) compared to other studies. The income of urban slum area inhabitants in Indonesia is slightly higher; IDR 2-4 million compared to other countries like China (1.234 CNY) and Vietnam (1.5 Juta VND). As a consequence, plastic waste generation in those two countries is less with 9.6% and 8.61% compared to Indonesia. Also, Indonesian society is still used to disposable plastic resulting in bigger plastic generation from total waste generated.

### Table 3. Table comparison of waste composition to other countries.

| Category          | This research | Thu Dau Mot (Vietnam) [37] | Xinhaiyuan (China)[38] | Lahore (Pakistan) [39] | Slum Area (Nigeria) [40] | Ahvaz (Iran) [41] |
|-------------------|---------------|----------------------------|------------------------|------------------------|--------------------------|------------------|
|                   | (%)           | (%)                        | (%)                    | (%)                    | (%)                      | (%)              |
| Organic           | 61.62         | 70.07                      | 73.59                  | 76.95                  | 76                       | 83.5             |
| Paper/Card        | 4.12          | 5.61                       | 6.52                   | 1.41                   | 6.6                      | 5.2              |
| Plastic           | 13.14         | 9.6                        | 8.61                   | 4.15                   | 4                        | 6.15             |
| Metal             | 0.57          | -                          | 0.46                   | -                      | 2.5                      | 1.25             |
| Rubber            | 0.25          | -                          | -                      | 0.02                   | -                        | -                |
| Textile           | 2.90          | -                          | 1.9                    | 0.43                   | 1.4                      | 1.4              |
| Glass             | 0.82          | 3.63                       | 2.87                   | 0.73                   | 3                        | 1.5              |
| Wood              | 1.51          | -                          | -                      | -                      | -                        | -                |
| Multi-layered     | 5.52          | -                          | -                      | -                      | -                        | -                |
| Hazardous waste   | 1.18          | -                          | -                      | 0.53                   | -                        | -                |
| Other Waste       | 8.64          | 11.09                      | 1.20                   | 15.62                  | 6.5                      | 1                |
| Total             | 100           | 100                        | 100                    | 100                    | 100                      | 100              |
| Kg/person/day     | 0.5           | <=4,000,000                | <=1,500,000            | <30,000                | -                        | -                |
| Income/month      | IDR           | <1,500,000                 | 1.234 CNY              | PKR                    | <300                     | <300             |
|                   | 1 USD         | 22.710                     | 104.97                 | PKR                    | 1 USD                    | 68279 CNY PKR    |
| Income (USD)      | <288 USD      | <66.05 USD                 | 181.47 USD             | <285.79 USD            | -                        | -                |

- = Not Reported; IDR (Indonesia Rupiah); VND (Vietnam Dong); CNY (China Yuan); PKR (Pakistan Rupee); USD (United States Dollar)

4. Conclusions
In this research, organic waste is still dominant in waste generated from slum kampong in Jakarta and Tangerang. Daily waste generation has an average of 0.5 Kg/person/day with two biggest compositions of Organic (61.62%) and Plastic (13.34%). While the smallest waste composition categories are Rubber (0.25%), Metal (0.57) and Glass (0.82%). The low household income is one of the contributing factors in more organic waste composition. Moreover, the low level of waste management like recycling programs at household level creating unreduced waste before transported into landfills. Land space limitation and little to none attention from local government have been the crucial factor in less 3R facilities (reuse, reduce, recycle) like a waste bank or composting process.

The availability of waste bank and composting can increase and push society's awareness in segregating waste from generated waste. The program can also add economic value from waste generated in slum areas. The main benefit from optimal waste management is making the residential area better and healthier; far from slum stigma although the area is densely populated.

5. References
[1] BPS-Statistic Indonesia 2018 Environment Statistics of Indonesia
[2] Rebehy, P. C. P. W. et al 2017 Innovative social business of selective waste collection in Brazil: Cleaner production and poverty reduction, Journal of Cleaner Production 154 462–473
[3] Idris, A., Inanc, B. and Hassan, M. N 2004 Overview of waste disposal and landfills/dumps in Asian countries, Journal of Material Cycles and Waste Management, 6, 104–110
[4] Hazra, T. and Goel, S 2009 Solid waste management in Kolkata, India: practices and challenges Waste Management 29 470–478
[5] Al-Khatib, I. A. et al 2010 Solid waste characterization, quantification and management practices in developing countries. A case study: Nablus district - Palestine Journal of Environmental Management 91 1131–1138
[6] Xue, B. et al 2011 An overview of municipal solid waste management in Inner Mongolia Autonomous Region, China Journal of Material Cycles and Waste Management 13 283–292
[7] Menikpura, S. N. M., Gheewala, S. H. and Bonnet, S. 2012 Sustainability assessment of municipal solid waste management in Sri Lanka: problems and prospect Journal of Material Cycles and Waste Management 14 181–192
[8] Sujauddin, M., Huda, S. M. S. and Hoque, A. T. M. R 2008 Househld solid waste characteristics and management in Chittagong, Bangladesh Waste Management 28 1688–1695
[9] Alavi Moghadam, M. R., Mokhtarani, N. and Mokhtarani 2009 B Municipal solid waste management in Rasht City, Iran Waste Management 29485–489
[10] Staley, B. F. and Barlaz, M. A 2009 Composition of municipal solid waste in the united states and implications for carbon sequestration and methane yield Journal of Environmental Engineering 135 901–909
[11] Kurian Joseph et al. 2012 Integrated approach to solid waste management in Chennai: An Indian metro city Journal of Material Cycles and Waste Management 14 75–84
[12] Wibowo, A. and Djajawinata, D 2005 Integrated Waste Handling 1–11
[13] Edjabou, M. E. et al 2015 Municipal solid waste composition: Sampling methodology, statistical analyses, and case study evaluation Waste Management 36 12–23
[14] Damanhuri, E., Padmi, Tri 2018 Integrated Waste Management
[15] Yach, Derek. Mathews, Catherine. Buch, Eric 1990 Urbanisation and health: methodological difficulties in undertaking epidemiological research in developing countries Soc Sci Med 31 507
[16] Montgomery, Mark R. 2009 Population Bulletin. Urban poverty and health in developing countries
[17] Uddin, N 2018 Assessing urban sustainability of slum settlements in Bangladesh: Evidence from Chittagong city Journal of Urban Management 7 32–42
[18] Wilson, D.G 1997 Handbook of Solid Waste Management
[19] Villalba, L. et al 2020 Household solid waste characterization in Tandil (Argentina):
Socioeconomic, institutional, temporal and cultural aspects influencing waste quantity and composition Resources, Conservation and Recycling 152

[20] Tchobanoglous, G., Theisen, H., Eliassen, R 1982 Desechos sólidos; principios de ingeniería y administración Serie Ambiente y Recursos Naturales Renovables.

[21] Chen, Y. C 2018 Effects of urbanization on municipal solid waste composition Waste Management 79 828–836

[22] Azkha, N 2016 Analysis of waste generation, composition and characteristics in Padang city Public Health Journal 1 14–18

[23] Ratya, H. and Herumurti, W 2017 Household Waste Generation and Composition in Rungkut Sub-district, Surabaya ITS Engineering Journal 6

[24] Sethi et al 2016 Characterization of Municipal Solid Waste in Jalandhar City, Punjab, India J Hazard Toxic Radioact Waste 17 97-106

[25] Ramachandra et al, 2018 Municipal solid waste: Generation, composition and GHG emissions in Bangalore, India. Renewable and Sustainable Energy Reviews 82, 1122–1136

[26] Gonzalez, T.P et al 2010 Household solid waste characteristics and management in rural communities Open Waste Management Journal 3 167–173

[27] Dorenfeld E et al 2012 Improving solid and human waste management in rural Namibian communities

[28] Shah R, Sharma US, Tiwari A 2012 Sustainable solid waste management in rural areas Int J Theor Appl Sci 4 72–75

[29] El-Messery MA, Ismail GA, Arafa AK 2009 Evaluation of municipal solid waste management in Egyptian rural areas J Egypt Public Health Assoc 84 52–71

[30] Mohammadi, A. et al 2012 Open access research article a survey on the rural solid wastes characteristics in North Iran (Babol) 2 149–153

[31] De Medina-Salas L, Castillo-Gonzalez E, Romero-Lopez R 2013 Physical and chemical characteristics of municipal solid waste in a rural locality-study case: Cosautlan De Carvajal Veracruz, Mexico

[32] Putri, Siti Delima Amanda, R. A. and Chotib 2020 Detecting informal settlement development in Penjaringan Sub-District, North Jakarta, Indonesia IOP Conference Series: Earth and Environmental Science 43, 0–9

[33] Levin, K. A 2006 Study design III: Cross-sectional studies, Evidence-Based Dentistry 7 24–25

[34] Lemeshow, S. et al 1997 ‘Stanley Lemeshow, David W Hosmer Jr, Janelle Klar a’

[35] Taghipour, H. et al 2016 Characterizing and quantifying solid waste of rural communities Journal of Material Cycles and Waste Management. Springer Japan 18 790–797

[36] Juliatuti, S. R. et al 2015 Multilayer ldpe (Low Density PolyEthilene) plastic packaging waste processing using pyrolysis microwave method Prosiding Chemical Engineering National Seminar “Kejuangan” (2009) 1–7

[37] Trang, P. T. T. et al 2017 The Effects of Socio-economic Factors on Household Solid Waste Generation and Composition: A Case Study in Thu Dau Mot, Vietnam Energy Procedia. Elsevier B.V 107 253–258

[38] Qu, X. yan et al 2009 Survey of composition and generation rate of household wastes in Beijing, China Waste Management 29 2618–2624

[39] Kamran, A., Chaudhry, M. N. and Batool, S. A. 2015 Effects of socio-economic status and seasonal variation on municipal solid waste composition: a baseline study for future planning and development Environmental Sciences Europe. Springer Berlin Heidelberg 27

[40] Ogwueleka, T. C 2013 Survey of household waste composition and quantities in Abuja, Nigeria Resources, Conservation and Recycling. Elsevier B.V 77 52–60

[41] Monavari, S. M. et al 2012 The effects of socioeconomic parameters on household solid-waste generation and composition in developing countries (a case study: Ahvaz, Iran) Environmental Monitoring and Assessment 184 1841–1846