Analysis Correlation of Municipal Solid Waste Generation and Population: Environmental Perspective

Sudiatmoko Supangkat, Herdis Herdiansyah

School of Environmental Science, Universitas Indonesia, Salemba, Indonesia

Abstract. The rapid development and population growth have resulted in a new of various issues, that causes reduced carrying capacity of the environment. Municipal solid waste is one of the environmental issues that have become a serious problem, especially in big cities with high population. Hence, municipal solid waste has become a big concern, which can pose risk to the environment and to human health. However, some previous research is not fully proved that there is a relationship between municipal solid waste generation and population. This research is conducted in DKI Jakarta, Indonesia because DKI Jakarta is the Capital City of Indonesia. This research aims to know the correlation between municipal solid waste generation and a population that can help waste management in DKI Jakarta. This research method used is correlation analysis and used data came from various agencies, such as Jakarta Statistic Indonesia (BPS) and DKI Jakarta Environment Agency. The result showed that there was a strong relationship between municipal solid waste generation and a population. This research purposes the waste management program that is needed to minimize waste from the source, by making waste bank and waste management with the 3R program.

Keyword: Environmental, DKI Jakarta, Development

1 Introduction
The rapid development in various sectors and the economic growth of Indonesia which has improved the welfare of the population, especially in big cities, which has recorded a percentage of slum houses in urban areas decreasing from 5% in 2015 to 4.07% in 2017 [1]. DKI Jakarta Province as the capital city of Indonesia and also as a Centre of business and industrial activities has led to the migration of people from villages to cities, which is increasing population growth every year which has been recorded since 1961 amounting to 2,906,000 people up to 9,762,000 people in 2011 as shown in Fig.1 [2]-[3]. The city of Jakarta has an area of 662.33 km$^2$ [4]. As a capital city, Jakarta with an increase in its population causes a comparison of the population with unbalanced city size. Thus, resulting in overloading the population in DKI Jakarta which causes environmental damage such as in Trichy City, India [5]. In 2016 recorded, the number of waste generations in Indonesia reached 65,200,000 tons per year with a population of 261,115,456 people [6]. Therefore, population growth is one of the factors that increase the amount of waste generation [6]. In addition, DKI Jakarta has a complex problem in...
terms of environmental management because it involves many technologies [7]. The complex problem mainly due to the increase in a solid, liquid and gas wastes resulting from human activities and thus, has an impact on the decreasing carrying capacity of land and natural resources [8]. Several studies also found that solid waste is not only produced from industrial waste, agriculture but also household solid waste, so the number and type of household solid waste continues to increase [9]. This is also in line with research in India, because of industrialization and increasing population, solid waste or solid waste has increased [10].

Environmental management, which is the handling of waste, becomes a serious problem because its impact is harmful to human health and environmental damage [10], especially the population that continues to increase due to urbanization. Urbanization is caused by uneven development between rural and urban areas that will affect the concentration of population in an urban area. Urbanization causes problems in sustainable development [11], where urbanization directly contributes to the emergence of waste that causes health problems and environmental damage [12]-[13]. Increasing population increases a lot of waste generated from population activities, such as those in Jombang where waste forecasts for 2013-2020 at the final processing site (TPA) of Gedang keret are affected by increasing population [14]-[15]. In addition, urbanization increases population density in one region. Based on data from the Jakarta Statistic Indonesia (BPS), population growth in 2016 caused the average population density to reach 15,211.90 souls/km$^2$ [4]. High population density causes environmental damage both directly and indirectly [16]. Furthermore, the varying levels of people's lives have resulted in many constraints on waste handling, both on transportation and final shelter problems [4].

The increasing population is also in line with behavior or lifestyle and the consumption patterns so that it will also affect the volume of waste produced [11]-[13]. The changing of consumption pattern is seen from the daily lives of urban residents, such as the habit of buying fast food that absolutely produces, for example disposable food containers. This consumption pattern greatly affects the increase of waste generation [6]. In handling the waste problem, the government already has regulation on Number 18 of 2009 concerning waste management and its derivatives to solve waste problems in Indonesia [6]. Besides of that, the community can also take a role in reducing waste through community involvement by managing waste produced for example recycling and disposing to the places that will not cause pollution or new problems [6]-[17]. Therefore, this problem needs community participation in waste separation activities. The level of participation is influenced by the level of knowledge of the community, attitude toward the environment, and dissemination information regarding waste separation activities [17]. Another condition that may help influence participation is the availability of facilities [17]. The purpose of this research is to find out the correlation between municipal solid waste generation and population so that it can help sustainable waste management in DKI Jakarta.
2 Methodology

2.1 Source of data
The data sources used in this research came from existing data from various agencies to solve the problem, such as Jakarta Statistic Indonesia (BPS) and the DKI Jakarta Environment Agency. Data collection is only focused on data relating to the population data and environmental data. The data is obtained through the agencies by verifying the data first to get better accuracy, and then the data will be used in further analysis.

2.2 Data analysis
The research used correlation analysis. This analysis is used to obtain the correlation coefficients of two variables, one variable X, representing of population number and one variable Y, representing of municipal solid waste generation. The research is used to find out the size or strength of the correlation between the variable of municipal solid waste generation and population number using the IBM SPSS Statistic (Statistical Package for Social Sciences) version 22.00 as a processing software application. In order to meet the criteria between two variables, it needs to meet the following criteria, if [18]:

- 0.00 – 0.199 : The correlation is very weak.
- 0.20 - 0.399 : The correlation is weak.
- 0.40 - 0.599 : Medium correlation.
- 0.60 - 0.799 : Strong correlation relationship.
- 0.80 - 1.0 : The correlation is very strong.

The correlation between two variables was considered statistically significant if the p-value is lower than 0.05 and the correlation between two variables was considered not significant if the p-value is greater than 0.05. The scope of this research is limited on DKI Jakarta province.

3 Result and Discussion

3.1 Population number and population density based on area
Jakarta as the capital city is very attractive for the migration of people. The increase in population is not only from birth but also with the presence of migrants. The community behavior is also one of the key environmental conditions, such as littering [4]. Table 1 it can be seen that the average population density in DKI Jakarta reaches 15,515.04 people per-km²; the total population is 10,277,628 people.
Table 1. Area, population, number and density by regency/city

| No. | Regency/ City   | Area (km$^2$) | Population | Population Growth (%) | Density |
|-----|----------------|---------------|------------|-----------------------|---------|
| 1   | Jakarta Selatan| 141.37        | 2,206,732  | 0.96                  | 15,609.62 |
| 2   | Jakarta Timur  | 188.03        | 2,868,910  | 0.88                  | 15,257.72 |
| 3   | Jakarta Pusat  | 48.13         | 917.754    | 0.39                  | 19,068.23 |
| 4   | Jakarta Barat  | 129.54        | 2,496,002  | 1.32                  | 19,268.20 |
| 5   | Jakarta Utara  | 146.66        | 1,764,614  | 0.99                  | 12,032.01 |
| 6   | Kepulauan Seribu | 8.70        | 23,616     | 1.18                  | 2,714.48  |
|     | Total          | 662.33        | 10,277,628 | 5.72                  | 15,515.04 |

3.2 Municipal waste generation presentation based on cities
Population density is considered as a threat to the environment that has led to increased production of municipal solid waste. This is similar to research conducted in Oman [19]. The condition of population density, as well as the diversity of life levels of the population, has resulted in many constraints on waste handling, both on transportation and final shelter problems. Table 2 shows that the total amount of waste per-day is 34,948.05 kg/day.

Table 2. Estimated amount of waste per-day

| No. | Regency/ City   | Population | Waste Generation (kg/ day) |
|-----|----------------|------------|----------------------------|
| 1   | Jakarta Selatan| 2,206,732  | 7,503.77                   |
| 2   | Jakarta Timur  | 2,868,910  | 9,755.44                   |
| 3   | Jakarta Pusat  | 917.754    | 3,120.73                   |
| 4   | Jakarta Barat  | 2,496,002  | 8,487.41                   |
| 5   | Jakarta Utara  | 1,764,614  | 6,000.39                   |
| 6   | Kepulauan Seribu | 23,616    | 80.30                      |
|     | Total          | 10,277,628 | 34,948.05                  |

3.3 Correlation test between population number and municipal solid waste generation
According to the results of correlation analysis in Table 3, population number is significantly correlated with municipal solid waste generation.

Table 3. Correlation test result

| No. | Variable X        | Variable Y                  | Correlation “r” | p-value |
|-----|-------------------|------------------------------|-----------------|---------|
| 1   | Population Number | Municipal Solid Waste Generation | 1               | 0.000   |

Based on the result of the research, this finding is confirmed by a significance p-value lower than 0.05 and the correlation between the number of populations and waste generation included a very strong correlation with the value of $r > r_{table}$ is 0.811. Hence, It can be said that the higher population number, the greater municipal solid waste generated. The population is one of the factors contributing to waste generation, as the world report data from 1.3 million tons-per-year will increase to 2.2 million tons-per-year by 2025 [20] in accordance with [21], who found that there was a positive relationship between population and solid waste generation in Qatar. This study showed that the current waste management system in Qatar is highly inadequate to meet with the growing population of the country [21]. In addition, in India, due to an increase in population, the volume of garbage has increased by 68.8 million tons/day [22]. This is also in line with the research conducted in Ethiopia, where Jimma as a city in Ethiopia has an increasing population causing environmental problems, that become a threat to sustainability with the generation of waste and poor management of waste management [23]. The result of the correlation analysis was in line also with the research which was conducted in Bandung stated that, the emergence of waste in the city of Bandung, one of which increased by the increase in the number of people who increased 1,523 tons/day to 1,670 tons/day. Because there needs to be a strategy to overcome the problem of waste from the source [24]. In contrast, the research that
was conducted in Japan revealed that even though as the population number increase and the volume of waste in the city will increase, they invest in the waste management system by making waste-to-energy that convert solid waste to electric energy and heat [25].

It is clear that a good waste management strategy will achieve sustainable development such as that in Brunei with a small population; Brunei makes a futuristic goal by reducing waste by 25% by 2020, 50% by 2025 and 75% by 2030. Besides that, other condition that can achieve the waste management program is facility availability such as a variety of waste bins. There are four types of bins, namely organic materials, bottles, paper, and general waste), as well as to reduce pollution of Hazardous waste, such as the Brunei government prepare locations for electronic waste collection and Hazardous waste [26]. These reasons are in line with previous research who found that inadequate facilities at secondary waste collection points have been creating several health and environmental pollution issues [27]. Some researchers argue that preparation of facilities in the form of a good garbage bin will encourage the community to help the government in separating waste and providing an understanding of how the benefits of separating waste [20]. Waste disposal facilities is a part of waste management due to according to estimates, a person produced a waste is an average of 0.5 kg/ capita/ day. So, with the large waste potential, a proper waste management is needed. If it is not quickly handled properly, these cities will be drowned in unison with all the negative impacts they cause [28]. In addition, the generation of municipal solid waste has been found to be related with population and behavior. The consumption behavior is the key factor of municipal solid waste generation [29].

4 Conclusion
The results in this research can be concluded that the number of population can increase the amount of waste volume. Therefore, to achieve a sustainable solid waste management system from environment perspective, the Provincial Government of DKI Jakarta needs to carry out programs that can minimize waste from its sources, such as by making waste bank and handling waste with 3R program, as well as preparing facilities in the form of good waste bins so as to encourage the community to build waste the place and can separate the garbage.

Acknowledgment
This research is funded by Master Thesis Research or Penelitian Tesis Magister Universitas Indonesia-DRPM Ministry Research, Technology and Higher Education 2019, in the contract number NKB-1902/UN2.R3.1/HKP.05.00/2019.

References
[1] Badan Pusat Statistik Indonesia, “Indikator Kesejahteraan Rakyat,” p. 225, 2018.
[2] BPLHD DKI Jakarta, Status Lingkungan Hidup Daerah Provinsi Daerah Khusus Ibukota Jakarta Tahun 2014. Jakarta, 2014.
[3] Pemerintah Provinsi DKI Jakarta, Laporan Status Lingkungan Hidup Daerah Provinsi Daerah Khusus Ibukota Jakarta Tahun 2011. Jakarta, 2011.
[4] Dinas Lingkungan Hidup Provinsi DKI Jakarta, “Dokumen Informasi Kinerja Pengelolaan Lingkungan Hidup Provinsi DKI Jakarta Tahun 2016,” p. 398, 2016.
[5] C. Study, C. Vijayabanu, R. Renganathan, V. Srinivasakumar, and V. Vijayanand, “Auditing Waste Management Practices in an Indian City,” vol. 7, no. 1687, pp. 1687–1690, 2013.
[6] Badan Pusat Statistik, “Statistik Lingkungan Hidup Indonesia 2018,” Jakarta, 2018.
[7] G. Tchobanoglous and F. Kreith, Handbook of Solid Waste Management, 2nd ed. New York: The McGraw-Hill Companies, Inc, 2002.
[8] O. O. Ayeleru, F. N. Okonta, and F. Ntuli, “Municipal solid waste generation and characterization in the City of Johannesburg: A pathway for the implementation of zero waste,” Waste Manag., vol. 79, pp. 87–97, 2018.
[9] K. Kovalenko and N. Kovalenko, “The problem of waste in the Russian Federation,” MATEC Web Conf., vol. 193, p. 02030, 2018.
[10] N. Gupta, K. K. Yadav, and V. Kumar, “A review on current status of municipal solid waste
management in India,” *J. Environ. Sci. (China)*, vol. 37, pp. 206–217, 2015.

[11] B. Fan, W. Yang, and X. Shen, “A comparison study of ‘motivation–intention–behavior’ model on household solid waste sorting in China and Singapore,” *J. Clean. Prod.*, vol. 211, pp. 442–454, 2019.

[12] D. Vij, “Urbanization and Solid Waste Management in India: Present Practices and Future Challenges,” *Procedia - Soc. Behav. Sci.*, vol. 37, pp. 437–447, 2012.

[13] N. Mokhtar, W. F. W. Ishak, N. S. Romali, S. F. C. Osmi, and M. A. A. Samah, “Municipal solid waste composition study of selected area in Gambang, Pahang,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 16, no. 1, pp. 2–6, 2013.

[14] B. Syafii’ul Novnania Karina, Dwiyono Hari Utomo, “Analisis Karakteristik dan Prakiraan Volume Sampah Tahun 2013-2020 di Tempat Pembuangan Akhir (TPA) Gedangkeret Kabupaten Jombang,” 2013.

[15] D. S. A. Hapsari and W. Herumurti, “Timbulan dan Komposisi Sampah Rumah Tangga di Kecamatan Rungkut Surabaya,” *J. Tek. ITS*, vol. 6, no. 2, 2018.

[16] S. A. Zahra, “Analysis on the management of waste domestic system in populous neighborhoods,” *E3S Web Conf.*, vol. 74, p. 09004, 2018.

[17] V. Ruliana, R. W. Soemantojo, and D. Asteria, “Assessing a community-based waste separation program through examination of correlations between participation, information exposure, environmental knowledge, and environmental attitude,” *ASEAN J. Community Engagem.*, vol. 3, no. 1, pp. 1–27, 2019.

[18] B. Winarso, “Cara Menghitung Nilai Korelasi Menggunakan Microsoft Excel 2010,” 2016. [Online]. Available: https://dailysocial.id/post/cara-menghitung-nilai-korelasi.

[19] T. M. Palanivel and H. Sulaiman, “Generation and Composition of Municipal Solid Waste (MSW) in Muscat, Sultanate of Oman,” *APCBEE Procedia*, vol. 10, pp. 96–102, 2014.

[20] S. F. Ayob and L. Sheau-ting, “Key Determinants of Waste Separation Intention among Students on Campus,” *EDP Sci.*, vol. 00066, 2016.

[21] H. Bello, “Impact of Changing Lifestyle on Municipal Solid Waste Generation in Residential Areas: Case Study of Qatar,” *Int. J. Waste Resour.*, vol. 08, no. 02, 2018.

[22] A. R. E. Williams and S. Kumar, “Solid Waste Management in Vellore District, Tamil Nadu,” *Springer Int. Publ. Switz.*, pp. 2–7, 2016.

[23] T. Getahun et al., “Municipal solid waste generation in growing urban areas in Africa: Current practices and relation to socioeconomic factors in Jimma, Ethiopia,” *Environ. Monit. Assess.*, vol. 184, no. 10, pp. 6337–6345, 2012.

[24] F. A. Pratiwi, J. Soemirat, and S. Ainun, “Hubungan Partisipasi Masyarakat terhadap Sistem Pengelolaan Sampah di Kelurahan Sukaluyu,” *J. Online Inst. Teknol. Nas.*, vol. 2, no. 1, pp. 1–12, 2017.

[25] K. Matsunaga and N. Themelis, “Effects of affluence and population density on waste generation and disposal of municipal solid wastes,” *New York*, 2002.

[26] S. Shams and Z. Guo, “Integrated and Sustainable Solid Waste,” no. November, 2014.

[27] S. Suthar and P. Singh, “Household solid waste generation and composition in different family size and socio-economic groups: A case study,” *Sustain. Cities Soc.*, vol. 14, no. 1, pp. 56–63, 2015.

[28] Sudrajat, *Mengelola Sampah Kota*. Depok: Penebar Swadaya, 2006.

[29] H. Z. Fu, Z. S. Li, and R. H. Wang, “Estimating municipal solid waste generation by different activities and various resident groups in five provinces of China,” *Waste Manag.*, vol. 41, pp. 3–11, 2015.