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ENVIRONMENTAL IMPACT ASSESSMENT OF DIFFERENT TEMPORARY WASTE DISPOSAL SITES IN BANDUNG, INDONESIA: FURTHER STEP TO SUSTAINABLE WASTE MANAGEMENT

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Abstract. The population growth, urbanization, and social lifestyle changes lead to the generation of rapidly growing amounts of municipal solid waste (MSW). Severe environmental issues and health risks associated with improper municipal solid waste management (MSWM) are important challenges in developing countries like Indonesia. In Bandung city, municipal solid waste is collected and stored in inappropriate temporary waste disposal sites (TWDS). The objective of this research is to evaluate environmental impact of various TWDS located in four districts of Bandung city. Subsequently, the environmental impacts of these TWDS will be compared. A number of indicators, e.g., the daily volume of incoming waste, waste treatment facilities, sanitation facilities, waste composition, and more, will be included in the measurement of the environmental impact. Furthermore, chemical and toxicological analysis of leachate and soil will be included in the environmental impacts' measurements. Samples for laboratory testing will be collected directly on the TWDS and the surroundings. This research follows our previous work that has been the first step in a detailed waste management picture in Bandung city.

Key words: Waste management; Waste analysis; Toxicological analysis; Environmental impact; Environmental risk; Pollution.

INTRODUCTION

The improper municipal waste disposal has a complex impact on the environment. Such impacts include worsened aesthetic value, deterioration of groundwater and water and soil quality, threat to biodiversity, spread of pathogens and bacteria. Therefore, improper waste disposal has a negative effect on human health and the environment (Lestari, P., Trihadinigrum, Y. 2019).

Nowadays, Bandung city produces about 1,600 tons of MSW per day; from this quantity, only 61% is handled or collected by municipality services (Tarigan, A.K.M. et al. 2016). MSW volume is predicted to increase 1-5% per year. The increasing MSW volume in Bandung is primarily caused by inhabitants' lifestyle that is becoming highly consumptive and citizens' awareness of proper waste disposal, despite promoted campaigns, is very low (Indartik, I. et al. 2018). In Bandung, MSWM is responsibility of the municipality or so-called local government (Sudibyo, H. et al. 2017). Waste originating from households is managed by municipal-owned cleaning service company – Perusahaan Daerah Kebersihan (PDK) at the citizen association level and then taken to a TWDS managed by PDK or informal agencies (Barnadi, D.A. 2010). This company ensures MSWM services in the form of collection, street cleansing, disposal, and transporting waste from TWDS to final disposal sites. PDK cannot cover most of the collection services for the residential area, despite the fees; this company faces a lack of finances and labour (Barnadi, D.A. 2010; Siyaranamual, M.D. 2013). Municipality services consist of trucks that are directly collecting waste, if the infrastructure allows, from households, buildings, and markets on an irregular basis to more than 200 TWDS. These TWDS are distributed to various locations in the city, often in close proximity of households, and are not documented on any infrastructure map (Tarigan, A.K.M. et al. 2016; Dethier, J.J. 2017). Waste collected to TWDS is taken afterward to the final waste disposal site (FWDS). However, one to two-third of collected MSW does not leave these TWDS. This fact negatively influences environmental conditions straight in the city, well-being of inhabitants and booster born of bacteria and viruses, breed of insects and rodent vectors (Siyaranamual, M.D. 2013). On the other hand, some of the TWDS have established compost sites and use organic material for small-scale biogas stations that supply TWDS with cooking. Several studies (Choudhury, D., Gupta, S. 2017; Gill, J. et al. 2019) investigated the impact of FWDS on the environment. On the other hand, there is a lack of information in the scientific community about the environmental impact of TWDS.

This research aims is to analyse environmental impact assessment of several TWDS in Bandung, Indonesia. The environmental impact assessment will be set up from main areas as waste composition,

soil samples composition, leachate composition, and others. These indicators will be evaluated and compared to each other to achieve a complex environmental impact assessment of TWDS. This assessment will broaden comprehension of TWDS issue and will be helpful in further research.

MATERIALS AND METHODS

In this research, the environmental impact assessment of TWDS will be used and will target the following areas: waste composition and volume, soil composition, leachate composition, construction appropriateness of disposal site, presence of facilities to waste treatment in disposal sites (i.e., compost site, biogas station) and presence of untreated waste in the surroundings of TWDS.

Waste composition and volume. Following E. Gidarakos et al. (2006), the determination of a mean waste composition will be based on a collecting and manual sorting of a number of samples of waste from incoming vehicles to TWDS. Vehicles loads of waste will be chosen conveniently. The samples from waste will be sorted manually into waste components. The weight of each fraction will be calculated by the weights of the components. The mean waste composition will be calculated using the results of the composition of each of the sorting sample. According to ASTM (2003) standard D5231-92, the number of sorting samples (n) is a function of the component under consideration and the confidence level. The equation for n is as follows:

$$n = (t^*s/ex)^2$$

where t* is the student t statistic corresponding to the desired level of confidence, s is the estimated standard deviation, e is the desired level of precision, and x is the estimated mean.

Soil and leachate composition. Following D.M. Vaverková et al. (2018), the soil samples (ecembe. 300 g) will be collected in the depth of 0-15 cm using a handle steel soil sampler. The samples will be placed in polyethylene bags and delivered to the laboratory for various chemical testing. The chemical analysis and toxicity test of leachate from TWDS will be conducted. According to I. Trabelsi et al. (2009), the analysis will be carried out on raw leachate. Heavy metals and pH will be measured in a laboratory.

Construction appropriateness of disposal site. According to H. Rahardjo et al. (2017), temporary waste disposal sites have to meet operational standards such as:

Concrete bottom layer to prevent leachate leak

TWDS have to be surrounded by the wall (brick fence)

Ideally, all the waste should be shifted to FWDS the next day, if it is not possible, the waste should be covered by plastic foil to prevent negative impacts (i.e., odour, rodents, waste spread)

Presence of sanitary facilities for workers

These factors will be observed and statistically evaluated.

Presence of facilities to waste treatment in disposal sites and presence of untreated waste in the surroundings. There are several issues with the waste treatment in Bandung city. One of them is a waste volume; this could be partly solved on TWDS, if there is a possibility to use some fraction of waste as a source for compost or small biogas station. These facilities are not so frequently present at TWDS, though they could decrease rapidly environmental impact on surroundings (Barnadi, D.A. 2010; Indartik, I. et al. 2018). These factors will also be observed and added to the environmental impact assessment.

RESULTS AND DISCUSSION

Several studies investigated single or complex impact of improper waste management at waste disposal sites from different perspectives (Haile, T. et al. 2012; Taheri, M. et al. 2014; Caicedo-Concha, D. et al. 2016; Yash, D.M. et al. 2018; Lestari, P., Trihadinigrum, Y. 2019). A relatively large number of studies approached the improper waste disposal issue through the environmental impact assessment, life cycle assessment, risk assessment or combination of these methods (Taheri, M. et al. 2014; Deshmukh, K., Aher, S. 2017; Vaverková, D.M. et al. 2018; Balogun-Adeleye, R. et al. 2019). Our preliminary research was focused on public perception and approach to MSWM, where we obtained results from stakeholders of waste management. Our vision is to deepen, clarify, and add value to this topic by follow up research aimed on hard scientific data and environmental impact assessment as a support attest to involved stakeholders.

In this research, we decided to incorporate the volume of waste produced in Bandung as it is a primary concern of Southeast Asia countries in the field of waste management in environmental impact assessment. The volume of produced solid waste in cities frequently exceeds the capacity of the municipality for its ma-

nagement. Thus, this waste is stored in the TWDS that are often not well-managed (Yang, H. et al. 2018).

As a consequence of improperly managed TWDS resulting in leachate leak, affect soil, and water quality in its surroundings (Hölzle, I. 2019). This phenomenon has direct impact on inhabitants living in close proximity to the TWDS. The leachate often contains heavy metals, is a great medium for bacteria and viruses spread and form odours. Since heavy metals and others mentioned above have had negative impact on human health it is crucial to know their presence in the leachate at TWDS that is often untreated and could eventually pollute underground water or surroundings as rice fields and contaminate basic food source of human (Francisca, F.M., Glatstein, D.A. 2020). The results of toxicological analysis of leachate, soil and if possible underground water or rice fields in the close proximity is the key factor and could be important driver of change for stakeholders' decision making. This result is the next factor involved in environmental impact assessment.

Following steps of the research have to be built upon a relevant base as waste composition analysis. Waste composition at different disposal sites in one city does not vary significantly, mainly due to the same or very similar climate, lifestyle, and environmental conditions (Salem, M. et al. 2020). Despite this fact, waste composition in Bandung is a crucial result for environmental impact assessment, and the samples collected through TWDS will be a testament for the above-mentioned analysis.

The last factor involved in environmental impact assessment is the construction standards of TWDS and present facilities for waste treatment. The construction standards results determine the actual condition of TWDS and the potential for needed development. According to J. Gill et al. (2019), the construction standards should meet at least bottom layers, fences, and sanitary premises for workers. The presence of waste treatment facilities as small biogas stations and composting areas in TWDS are beneficial for waste volume avoidance (Vaverková, D.M. et al. 2018). The results of this research will demonstrate the usage of these facilities and potential places for their implementation in various TWDS.

CONCLUSIONS

The research findings can conduce to the waste management issues in developing countries. The environmental impact assessment of TWDS in Bandung may contribute to a higher standard of these facilities in the future as well as to provide information to policymakers about this issue to be taken into account in further waste management planning in Bandung city. Moreover, this environmental impact assessment could be used as an example for countries with similar environment, economy, and waste management conditions. In addition, this assessment will broaden comprehension of TWDS issue in the scientific community and will be helpful in further research. Since this research has not initiated yet, for now we are predicting our results. On the other hand, our vision is clear and have a potential to bring interesting information for not only the community and government of Bandung city has.

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