Characteristic of total suspended particulate (TSP) containing Pb and Zn at solid waste landfill

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Abstract. Activities conducted at municipal solid waste landfills (MSWLs) potentially cause air pollution. Heavy vehicles in MSWLs release various pollutants that can have negative impacts for humans. One noticeable pollutant at MSWLs is airborne total suspended particulate (TSP) which may contain heavy metals such as Pb and Zn and can cause disease when inhaled by humans. In this study, TSP from a landfill in Semarang, Indonesia was collected and characterized to quantify the concentration of Pb and Zn. Meteorological factors (i.e. temperature, humidity and wind velocity) and landfill activities were considered as factors affecting pollutant concentrations. TSP was sampled using dust samplers while the concentration of heavy metals in TSP were analyzed using an Atomic Absorption Spectrophotometer (AAS). Pb concentration ranged from 0.84 to 1.78 µg/m³ while Zn concentration was from 7.87 to 8.76 µg/m³. The levels of Pb were below the threshold specified by the Indonesian Government. Meanwhile, the threshold for Zn has not yet been determined.

1. Introduction
Semarang, a large city in Indonesia, generates approximately 3,500 m³ of solid domestic waste per day which is collected and transferred to landfill for processing. The only landfill in Semarang, Jatibarang, started operating in 1992 and handles up to 700 tons solid waste per day. The site has an area of more than 40 ha and consists of two zones, each equipped with liners to contain leachate which is treated to prevent it harming the environment [1].

The activities in the landfill involve the operation of heavy vehicles and equipment including waste disposal by garbage trucks, waste excavation and stockpiling using excavators, and waste distribution and solidification using loaders. All these activities produce air pollution such as dust, which is also generated from waste degradation, the use of internal combustion engines to generate power for mechanical recycling, composting activities and waste sorting [2, 3].

Dust or total suspended particulate (TSP) are particles with a diameter less than 100 µm. Some characteristics possessed by the particulates are the form of density, size, size distribution, adhesiveness, corrosive nature, reactivity, and toxicity. Of these characteristics, particle size was considered an important parameter that needed to be taken into account [4]. Tests on the relative toxicity of five groups of pollutants showed that the most threatening pollutant for health was particulate, followed consecutively by NO₂, SO₂, hydrocarbon, and Carbon Monoxide [5]. TSP also contain heavy metals, such as lead (Pb) and Zinc (Zn) [6].
Inside the human body, Pb is able to obstruct enzyme activities involved in the formation of haemoglobin (Hb). Pb is also retained in the kidneys, liver, nails, fat tissue, and hair. At low concentrations, Pb can influence psychological and nerve function. Exposure at high levels can damage whole organ systems such as the central nerve system, kidney and blood, and could be fatal [7]. Meanwhile, exposure to Zn can lead to deficiencies in other minerals. Excessive intake of Zn can also cause nausea, vomiting, fever and even liver and kidney disorders [8].

Up to now, there has been no available information related to Pb and Zn concentration in TSP at Jatibarang landfill; therefore, there is a need to explore the amount of heavy metals (Pb and Zn) at Jatibarang landfill and provide information on whether these are at harmful levels for human health.

2. Methods
This study was conducted at Jatibarang landfill, Semarang. Three sampling locations were determined based on consideration of dominant wind direction (Figure 1). The TSP sample was taken using a dust sampler and tested in the laboratory of Environmental Engineering, Diponegoro University, Semarang, using a gravimetric method. The heavy metal (Pb and Zn) contents were analyzed using a wet destruction method involving atomic absorption spectroscopy (AAS).

![Sampling Locations](image)

**Figure 1. Sampling Locations**

The main equipment used in this study were: (1) dust sampler DS 600-MVS to collect TSP; (2) an analytical balance to measure the filter weight before and after sample taking; (3) Fiber Glass Filter, a media for collecting the dust particles (TSP); and (4) atomic absorption spectroscopy (AAS), to analyze the concentration of Pb and Zn in the TSP. Meteorological factors such as temperature, air pressure, and wind velocity were also measured during sampling.
3. Results and Discussions

TSP samples were taken in Jatibarang landfill after considering the specific landfill activities, dominant wind direction and land contours. Samples were taken for six days to obtain results that represented the daily TSP concentration in the landfill. The meteorological conditions, such as temperature, humidity and wind velocity, were also monitored. During the sampling process, temperatures were between 32.6 to 35.7°C with humidity of 46.17-54.82% and the air pressure ranged from 754.1-758.61 mmHg.

Figure 2 shows the concentration of Pb in TSP over the six sampling days. The minimum Pb concentration was 0.84 µg/m³ and the maximum was 1.78 µg/m³. Pb concentration in TSP was below the air quality threshold standard regulated by the Indonesian Government.

The sampling result for the Zn content in TSP was between 7.87 µg/m³ to 8.76 µg/m³ as shown in Figure 2. However, Zn content in TSP has not yet been regulated by the Indonesian Government so there is no standard to compare these figures with. Figure 2 also indicates that Pb and Zn concentration tended to increase as wind velocity increased.

4. Conclusions

This study on Pb and Zn concentration in TSP was conducted at Jatibarang landfill, Semarang to clarify the contribution of landfill activities to air quality, especially TSP containing heavy metals. The maximum concentration of Pb in TSP was 1.78 µg/m³, while the concentration of Zn reached 8.76 µg/m³. These results indicate that the concentration of Pb in TSP meets the air quality standard stated by the Indonesian Government, while the air quality standard of Zn in TSP is not yet regulated.

5. References

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