Analysis of respirable particulate exposure and its effect to public health around lead smelter and e-waste processing industry in West Java, Indonesia

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Abstract. Respirable particulate exposure strongly affects human health, especially for children who lived around industrial area. This study was conducted to evaluate the effect of respirable particulate exposure to lung capacity of children. Study location in this study was Parung Panjang District, area of lead smelter industry and also in Astana Anyar District, area of e-waste processing industry. Thirty children were involved in Astana Anyar District and also thirty children in Parung Panjang District. The control groups were also studied in both areas. Predicted average daily intake (ADD) of respirable particulate was estimated and lung or respiration condition of children was measured by using spirometer. The lung condition of respondents was estimated by \(\text{FEV}_{1.0}\) and \(\text{FVC}\) values. As the result, the predicted ADD of children in lead smelter area is 3 times higher than the predicted ADD of children in e-waste processing area. It was correlated positively with the higher \(\text{PM}_{2.5}\) concentration in Parung Panjang District than the \(\text{PM}_{2.5}\) concentration in Astana Anyar District. Metals concentration in Parung Panjang was also measured with X-Ray Fluorescence (XRF) in this study and it was clearly state that metals concentration in location study were higher than metals concentration in control area.

1. Background
Numerous studies had been performed to associate respirable particulate exposure with respiratory diseases such as respiratory illness, chronic obstructive pulmonary disease (COPD), asthma, fibrosis, and even lung cancer as well. Dyosi (2007) stated that ambient lead concentrations in the areas of refining and smelting in used batteries industries have exceeded the Occupational Exposure Limit (OEL) and can exposed the worker. Slaughter (2010) declared that there is a positive relationship between the high concentration of respirable particulates, formaldehyde, and carbon monoxide from smoke to the lung capacity of fire-fighters which declared by the decrement of \(\text{FEV}_{1.0}\) value. The research was conducted in the western of United States. Jain (2007), that \(\text{FEV}_{1.0}\), \(\text{FVC}\), \(\text{FEV}_{1.0}/\text{FVC}\) may be less sensitive to factors that associated with respiratory tract alteration and can detect the severity of respiratory tract obstruction.

This study discussed the respiratory health risk of children living around industrial area in two separate studies in Indonesia. The first study was conducted around e-waste processing activity in Astana Anyar District, Bandung Regency, West Java and the second one was in children who living around lead smelter industry in Parung Panjang District, Bogor Regency, West Java.
Astana Anyar District was selected because there is some school that is located very near to e-waste processing activity. Study in Parung Panjang District was obtained to analyze the effect from lead smelter industry to children around that area. Both of this study will discussed and compare the impact of those industrial activity on children respiratory health risk.

2. Materials and method

The measurement of respirable particulate was done by using personal sampling pump with flow rate of 1.7 L/min that is placed for 4 hours on each respondent. This research used Mixed Cellulose Ether (MCE) with a diameter of 25 mm and pore size is 8 µm as filter. According to Occupational Safety and Health Administration (OSHA), MCE is a good filter to catch metal particulates. The filter was weighed in a room with 21°C temperature and 55% humidity.

The measurement was performed on boy and girl respondents. The respondents were group of children aged 10-14 years old that goes to school near the lead smelter industry in Parung Panjang and also the e-waste processing activity in Astana Anyar. There were 15 boy respondents and 15 girl respondents in both location study. Every respondent has been selected based on their teaching-learning activities in an open window classroom. The sampling process is carried out for 4 hours.

Respiratory function was measured using spirometer tool Minato AS-500 from Japanese manufacturers. Lung function values expressed in FEV<sub>1.0</sub> (Forced expiratory volume in one second), is forced expiratory volume in one second and FVC (Forced Vital Capacity) is the forced vital capacity (Ward, 2008) The measurement of FEV<sub>1.0</sub> was conducted on respondents who have no smoking habit that can reduce the lung health. Metals concentration in Parung Panjang was also measured with X-Ray Fluorescence (XRF) analysis.

3. Results and discussion

The measurement of respirable particulate was done by using personal sampling pump with flow rate of 1.7 L/min that is placed for 4 hours on each respondent. This research used Mixed Cellulose Ether (MCE) with a diameter of 25 mm and pore size is 8 µm as filter. According to Occupational Safety and Health Administration (OSHA), MCE is a good filter to catch metal particulates. The filter was weighed in a room with 21°C temperature and 55% humidity.

3.1. Measurement of PM<sub>2.5</sub> and predicted average daily intake (ADD)

PM<sub>2.5</sub> is particulate less than 2.5 micrometers in diameter (PM<sub>2.5</sub>) that referred as "fine" particles and believed to pose the greatest health risks. The concentration of PM<sub>2.5</sub> in area of e-waste processing industry showed the average of 186.75 ± 125.1 µg/m<sup>3</sup>. Furthermore, in area around lead smelter industry, the concentration of PM<sub>2.5</sub> was average of 225.9 ± 214.9 µg/m<sup>3</sup>. Table 1 below showed that the concentration of PM<sub>2.5</sub> in Parung Panjang District was higher than those in Astana Anyar measurement.

| Location of Children | Astana Anyar District | Parung Panjang District |
|----------------------|-----------------------|-------------------------|
| Study Area           | 186.75 ± 125.1        | 225.9 ± 214.9           |
| Control Area         | 80.5 ± 42.6           | 75.11 ± 39.7            |

Predicted average daily intake (ADD) of respirable particulate was estimated for both area of study (table 2). Children living around e-smelter processing was estimated to have ADD of 32.14 ± 28.42 µg/kg.day. Whereas in Parung Panjang, the ADD was 42.36 ± 39.66 µg/kg.day higher than those in Astana Anyar. For both studied area, the concentration of PM2.5 in area of e-waste processing industry showed the average of 186.75 ± 125.1 µg/m<sup>3</sup>. Furthermore, in area around lead smelter industry, the concentration of PM2.5 was average of 225.9 ± 214.9 µg/m<sup>3</sup>.
3.2 Respiratory function analysis

Table 3 described the FEV\textsubscript{1.0} result of the children. It was observed that the lung capacity of boys in Parung Panjang was always lower than the lung capacity in Astana Anyar. This is the same pattern with the lung capacity of girls in Parung Panjang was always lower than the lung capacity of girls in Astana Anyar. For both study area, FEV\textsubscript{1.0} and FVC value in location study were always higher than in control area. The proportion of fine particle in the air quality had affected the lung capacity of respondents. The air pollution in Parung Panjang was also considered worsen as the lead smelter activity generated other pollutant than particulate matter.

Table 3. FEV\textsubscript{1.0} and FVC measurement results of sampled children.

| Location    | Children | Study Area | Control Area |
|-------------|----------|------------|--------------|
|             |          | FEV\textsubscript{1.0} (l) | FVC (l) | FEV\textsubscript{1.0} (l) | FVC (l) |
| Astana Anyar| Boys     | 1.41 ± 0.19 | 1.23 ± 0.22 | 1.51 ± 0.24 | 1.79 ± 0.20 |
|             | Girls    | 1.49 ± 0.16 | 1.09 ± 0.28 | 1.52 ± 0.20 | 1.78 ± 0.21 |
| Parung      | Boys     | 1.18 ± 0.23 | 1.68 ± 0.25 | 1.21 ± 0.22 | 1.24 ± 0.12 |
| Panjang     | Girls    | 1.06 ± 0.25 | 1.77 ± 0.14 | 1.52 ± 0.18 | 1.19 ± 0.12 |

Figure 1 and 2 showed that age of the children differentiated the lung function and condition. Figure 1 showed comparison of FEV\textsubscript{1.0} and FVC condition related to age of the children in Astana Anyar District. Respondents around e-waste processing industry exhibited lower FEV\textsubscript{1.0} and FVC at the age of 10-12 years. The value of FEV\textsubscript{1.0} and FVC in location study in area of e-waste processing industry was lower than the value in control area, it was caused by the higher pollution of respirable particulate in location study than in control area.

Figure 1. Comparison of FEV\textsubscript{1.0} and FVC in Astana Anyar District
Figure 2 showed the lung condition of respondents in Parung Panjang District, area around lead smelter industry. The value of FEV$_{1.0}$ and FVC in location study showed a lower value than the value in control area. It was also noted that the age of 11 years in respondents around Parung Panjang District did not perform different FEV$_{1.0}$ and FVC values in both location study and control area. Besides that, resulted measurement of FEV$_{1.0}$ and FVC showed that lung condition of respondents at Parung Panjang was lower compare with lung condition of respondents at Astana Anyar District.

3.3. Metal concentration in respirable particulate

Based on figure 3 below, it can be seen that the concentrations of metals in samples of respirable particulate in Parung Panjang was higher than the concentrations of metals in samples of respirable particulate in control area. This shows that the air pollution in Parung Panjang is higher than the air pollution in control area.
4. Conclusion
The concentration of PM$_{2.5}$ in area of e-waste processing industry showed the average of 186.75 ± 125.1µg/m$^3$. Furthermore, in area around lead smelter industry, the concentration of PM$_{2.5}$ was average of 225.9 ± 214.9µg/m$^3$. Whereas in Parung Panjang, the ADD was 42.36 ± 39.66 µg/kg.day higher than those in Astana Anyar. It was observed that the lung capacity of boys in Parung Panjang was always lower than the lung capacity in Astana Anyar. This is the same pattern with the lung capacity of girls in Parung Panjang was always lower than the lung capacity of girls in Astana Anyar. This is positive relevant with the concentration of PM$_{2.5}$ dan ADD (average daily dose) of respirable particulate in Parung Panjang District was higher than Astanta Anyar District.

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