Air quality analysis through measurement of Pb Levels in blood using atomic absorption spectrophotometer

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ABSTRACT

Air pollution is a problem that needs attention, especially pollution by heavy metals such as lead (Pb). This research was conducted to measure the levels of Pb in the blood of people who do a lot of daily activities on the highway in the Ulaanbaatar region, Mongolia, so that an overview of the level of exposure to Pb in the air is obtained. The study was conducted using an observational method by measuring the blood directly from the participants using an atomic absorption spectrophotometer. The participants involved were 20 people who met the criteria. The results showed that the average level of Pb in the blood of people who had daily activities on the highway was 8.97 ppm. Where the smallest level is 5.12 ppm and the highest level is 12.06 ppm. This value is far above the threshold value determined by WHO, which is 0.05 ppm. Therefore, it can be concluded that the air quality in the Ulaanbaatar area is in the poor category with a high level of Pb exposure.

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INTRODUCTION

The environment is an inseparable part of human life because it plays a role in each of their activities, one of which is air. Of course, environmental sustainability, especially air, will affect a person's quality of life because of its role in breathing (Chertok et al., 2004). There are several factors that can reduce air quality, the most common of which are the development of the number of industries and the number of motorized vehicles (Baehaki et al., 2020). Industrial activities and motorized vehicles dominate as a source of pollutants that pollute the air in the world.

Of the various types of air pollutants, the one that needs attention is the heavy metal lead (Pb). Pb is produced from industrial activities and combustion products of motor vehicles (Loukidou, Karanpantios, & Matis, 2004; Lubis et al., 2013). When it enters the air, Pb will stay in the air for 4 to 40 days (Baehaki et al., 2020) so that it will increase the risk of exposure to the human body through breathing. If these metals accumulate in the body, it can cause harmful effects on health (Al Fartosy, Awad, & Shanan, 2014). Even

based on the Agency for Toxic Substance and Disease Registry (ARTS) list, Pb is second only to arsenic as one of the most toxic heavy metals (Kim, Lee, & Yang, 2014).

With such characteristics of lead, of course its presence in the environment, especially the air, due to human activities has become a global public health problem, including cities in Mongolia. Because Pb can be generated from traffic activities, of course people who are active on the highway and its surroundings are the objects with the highest risk of exposure. They are people who work such as traffic police, public transportation drivers, traders, and others. Based on this, this study was conducted to see how much exposure was analyzed by measuring lead levels in the blood of people who do their daily activities on the highway and around.

LITERATURE REVIEW

Lead characteristics

Lead is one of the heavy metals that are harmful to human health (Baehaki et al., 2020). Lead can be produced from human activities, such as industrial activities, mining, traffic activities, soil, rocks, and others (Kiziloz, 2019; Ordouee & Hazheminezhad, 2019; Loukidou, Karanpantios, & Matis, 2004; Lubis et al., 2013; Baehaki et al., 2020; Rodríguez et al., 2018). When entered and accumulated in the body, Pb will cause several symptoms of poisoning, namely abdominal pain, sleep disturbances, nausea and vomiting, body weakness, muscle and bone pain, weight loss, headaches, and decreased appetite (Baehaki et al., 2020; Papanikolaou, 2005; Patrick, 2006; Schober et al., 2006). Even chronic symptoms can also be caused such as hallucinations, epilepsy, anemia, brain tissue attacks, and cancer (Schober et al., 2006; Etiang et al., 2018; Baehaki et al., 2020). Of the various toxic effects, disorders of the nervous system are the most common symptoms of Pb. Because of its harmful effects, WHO (2021) has set a threshold value for Pb levels in the blood, which is 0.05 ppm.

Lead metabolism in the human body

Exposure to lead that enters through the air about 30-40% will be absorbed into the blood (Baehaki et al., 2020). In the blood, lead will bind to red blood cells as much as 90% so that it can inhibit heme synthesis through the binding of the thiol group to the Aminoluvucinic Acid Dehydrase enzyme (Baehaki et al., 2020; Palar, 2012). When it enters the body, the process of Pb excretion does not occur completely because of its high half-life, which is in the blood for ± 25 days, in soft tissue for ± 40 days, and in the bone for ± 25 years (Nordberg, 1998). This long half-life causes the accumulation of Pb in the human body. Lead will also damage antioxidant enzymes such as Superoxide dismutase (SOD), Catalase (CAT), and Glutathione Peroxidase (GPx) resulting in the formation of free radical compounds in the form of Reactive Oxygen Species (ROS) uncontrolled (Klopfleisch, Sutomo, & Iravati, 2017). The imbalance between many free radicals and antioxidants causes oxidative stress to occur which is associated with cell membrane damage, DNA, RNA and damage to brain cells (Ercal, Gurer-Orhan, and Aykin-Burns, 2001; Farmand et al., 2005). Malondialdehyde (MDA) is often used in many laboratories as an indicator to determine the level of damage caused by oxidative stress. Malondialdehyde is one of the main aldehydes, originating from peroxidation of reactive three-carbon lipids in cell membranes and forming complex bonds with other elements in tissues. The higher the oxidative stress that occurs in the body's cells has the same impact as the increased MDA value (Miyamoto et al., 2012;

Valko et al., 2014). Exposure to heavy metals (Cu, Zn, Cd, Pb, As) was reported to cause an increase in MDA levels (Ściskalska et al., 2014).

METHODS

This study is an observational study with a cross-sectional approach. Pb levels were measured using an atomic absorption spectrophotometer. In a cross-sectional study, researchers measure outcomes and participants' exposure at the same time. Interviews were also conducted on participants to dig deeper into the information.

Participants

In this study, the number of participants involved was as many as 20 people consisting of people who carry out daily activities on the highway and its surroundings in the Ulaanbaatar region, Mongolia. This is because they are people who are at high risk of exposure to Pb. They will be asked to fill out a consent form as a participant whose blood will be taken to measure the level of lead in it. They were also given an explanation regarding this research, the purpose of the research, and its benefits for them. If they agree, then they must sign the consent form.

Sample preparation

The sample preparation carried out refers to the procedure carried out by Baehaki et al. (2020) and Batool et al. (2018). A total of 3 ml of blood was put into a container and added with 5 mg of potassium citrate. And then added 5 ml of concentrated nitric acid so that the color becomes blackish brown which indicates a reaction to the destruction of organic compounds.

Destruction

The destruction procedure carried out refers to the procedure performed by Baehaki et al. (2020) and Batool et al. (2018), where the prepared sample was heated at 600 °C for 6 hours to become ash. The resulting ash was then dissolved with 0.5 M nitric acid solution and filtered using filter paper. Filtering was carried out until 10 ml of filtrate was obtained.

Standard Curve Creation

The procedure for making standard curves refers to the procedure carried out by Baehaki et al. (2020) and Batool et al. (2018), by making 100 ml of Pb(NO₃)₂ standard solution with concentrations of 1 ppm, 2 ppm, 3 ppm, 4 ppm, and 5 ppm. Into each solution, 0.5 ml of 0.5 M nitric acid was added and distilled water was added up to the mark on the volumetric flask. Then, the absorbance of each solution was measured using an atomic absorption spectrophotometer at a wavelength of 283 nm.

Lead level measurement

The procedure for measuring the level of Pb in the sample carried out refers to the procedure carried out by Baehaki et al. (2020) and Batool et al. (2018). The sample that has been added with 0.5 ml of nitric acid solution is then put into a cuvette and its absorbance is measured using an atomic

absorption spectrophotometer at a wavelength of 283 nm.

RESULTS

Standard curve

The standard curve is obtained from the absorbance measurement of the standard solution that has been prepared. Data on the concentration of the standard solution and its absorbance values are plotted into a curve that can be seen in Figure 1.

Figure 1. Standard curve

The curve in Figure 1 shows the equation of the line $y = 0.0093x + 0.0025$, where this equation can be used to determine the levels of Pb in the sample. However, the value of R^2 also needs to be considered first. Figure 1 shows that the resulting R^2 value is 0.9905, meaning that the equation of the line on the curve is suitable for measuring Pb levels in the sample. This is because the linearity of the resulting line will determine the feasibility of the equation (Baehaki et al., 2020). The value of R^2 that is closer to 1 will give more accurate results.

Lead content in sample

Pb levels in the blood resulted from the measurement of the absorbance of the sample. The absorbance value is then substituted in the line equation in Figure 1. The results of the calculation of Pb levels in the blood samples can be seen in Table 1.

Table 1. Results of Measurement of Pb in the bloods

Sample Code	Concentration of Pb (ppm)	Average (ppm)
X ₁	10.01	8.97
X ₂	9.82	
X ₃	9.96	
X ₄	8.89	
X ₅	10.20	
X ₆	9.56	
X ₇	10.70	
X ₈	10.90	

X₉	11.00
X₁₀	8.70
X₁₁	12.06
X₁₂	7.55
X₁₃	8.33
X₁₄	6.43
X₁₅	5.12
X₁₆	8.68
X₁₇	9.40
X₁₈	7.57
X₁₉	6.83
X₂₀	7.81

The data in Table 1 have provided an overview of Pb exposure to participants. Where the average value of Pb levels in their blood is 8.97 ppm. The smallest Pb level was found in the blood in the sample with the code X₁₅, which was 5.12 ppm and the highest Pb level was in the blood in the sample with the code X₁₁ 12.06 ppm. Of course this value is included in the high category where the threshold value determined by WHO itself is 0.05 ppm (WHO, 2021). Looking at the threshold value, it can be seen that the Pb content in the blood of people whose daily activities on the road is far above the threshold value. This certainly needs to be a concern because high levels of Pb can cause health problems in the community. As revealed by Baehaki et al. (2020), Patrick (2006), Schober et al. (2006) that when entered and accumulated in the body, Pb will cause several symptoms of poisoning, namely abdominal pain, sleep disturbances, nausea and vomiting, body weakness, muscle and bone pain, weight loss, headaches, and decreased appetite. Even chronic symptoms can also be caused such as hallucinations, epilepsy, anemia, brain tissue attacks, and cancer (Schober et al., 2006; Etiang et al., 2018; Baehaki et al., 2020)

DISCUSSION

Data mining needs to be done by interviewing participants, especially those with the highest and lowest Pb levels. Participants with code X₁₁ are people with professions as public transport drivers. His daily work activities are on the streets with a duration of more than 8 hours. And it has worked like that for over 10 years. Of course this is the factor that most affects the levels of Pb in the blood. Meanwhile, participants with code X₁₅ work as office employees. But every day walking through the sidewalk on the side of the highway. It can be said that these participants interacted with exposure on the highway for a lesser amount of time so that the Pb levels in their blood were lower. This is in accordance with the statement expressed by Frank (1995) and Baehaki et al. (2020) where the length of exposure will determine the level of Pb in the blood. However, there is an interesting thing that needs to be studied where during the pandemic, Ulaanbaatar residents use masks every day outside the room. So that this too can be a factor in the level of Pb in the blood which might exceed the value now measured before the pandemic. However, this needs to be studied first to obtain more valid data.

CONCLUSION

Based on the research results obtained, it can be concluded that the levels of Pb in the blood of people who carry out daily activities on the highway in Ulaanbaatar have levels above the threshold value, which is 0.05 ppm. Even the lowest level value is at 5.12 ppm. This means that the air quality in the area is in the poor category. Therefore, it is necessary to deal with the problem of air pollution by the government to improve the quality of life of the community.

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