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# Analysis of Lead (Plumbum) Metal Levels in the Urine of Motorcycle Mechanics in Medan Helvetia District, Medan City

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## ABSTRACT

Lead (Pb) is one of the pollutants originating from vehicle exhaust emissions and materials from vehicle components, such as gasoline, oil, and used batteries. Workshop workers are among the occupations that are highly vulnerable to lead exposure, as their daily activities involve continuous exposure to vehicle exhaust fumes and direct contact with materials from vehicle components during work, thereby increasing the risk of lead exposure. Sampling was conducted at motorcycle workshops located on Jalan Gaperta in Medan City, North Sumatra, and the measurement of lead levels in urine was carried out at the Regional Health Laboratory in Medan City. The purpose of this study was to analyze lead (Pb) levels in the urine of motorcycle workshop workers on Jalan Gaperta, Medan, North Sumatra. The method used in this study was Atomic Absorption Spectrophotometry (AAS). The samples consisted of urine from ten motorcycle workshop workers. The results showed that the highest lead level was found in sample Z04, at 52,5 µg/dL, while the lowest lead level was found in sample Z02, at 3,5 µg/dL. These results indicate that the lead levels in some motorcycle workshop workers exceeded the threshold limit established in the Regulation of the Minister of Health of the Republic of Indonesia No. 1406/MENKES/SK/IX/2002, which states that the permissible threshold limit for lead levels in urine specimens is 10–25 µg/dL.

## Introduction

The number of motor vehicles in Indonesia shows an increasing trend every year. In 2023, the number of motorcycles reached 152.565.905 units. A similar increase has also occurred in several regions, including Medan City. Based on data from the Central Bureau of Statistics (Badan Pusat Statistik Provinsi Sumatera Utara, 2020), the number of two-wheeled vehicles in Medan City was recorded at 1.146.384 units in 2019 and increased to 1.184.887 units in 2020. The continuous growth in the number of vehicles each year has the potential to reduce air quality, particularly due to exhaust emissions, poorly maintained vehicle conditions, and the use of low-quality fuel (Soeryadi, 2021; Agnesya, 2023).

The increase in the number of motor vehicles contributes significantly to air pollution, as polluted air contains toxic particles that have adverse effects on human health. Air is an essential component of life; however, its quality continues to decline along with the growth of urban development and industrial activities (Awalia, Medyati, & Giay, 2021). In urban areas, emissions from the transportation sector are reported to be the main contributor to air pollution in Indonesia, accounting for approximately 85%, with hazardous substances such as the heavy metal lead originating from motor vehicles (Budiasa, 2021).

A previous study by Meliahsari, Yasnani, & Wahid (2024) on the analysis of lead levels in the urine of

**Citation:** .........

two-wheeled vehicle workshop workers in the Jamin Ginting area, Medan, showed that the highest lead level reached 25,01 μg/dL, while the lowest was ≤25,00 μg/dL, analyzed using the Atomic Absorption Spectrophotometry (AAS) method. The high lead levels were associated with the low use of personal protective equipment and a lack of awareness regarding occupational hygiene. The use of urine as a specimen in toxicity testing has several advantages, including ease of collection in large quantities, relatively high concentrations of toxins, no requirement for special preservatives for lead analysis, and its applicability for various poisoning assessments (Meliahsari, Yasnani, & Wahid, 2024; Monika, 2013).

Lead (Pb) is one of the heavy metals classified as an air pollutant, particularly originating from the exhaust emissions of two-wheeled motor vehicles (Nursalam, 2020). Chemically, lead is known as plumbum, symbolized as Pb, and belongs to Group IV-A in the periodic table (Panjaitan et al., 2024). In the automotive industry, lead is used as an additive in certain vehicle components to enhance lubrication and improve combustion efficiency, thereby improving engine performance. The amount of lead emitted by vehicle engines is strongly influenced by engine condition, with well-maintained vehicles tending to produce lower lead emissions compared to poorly maintained vehicles. Individuals working in the automotive sector have a higher risk of lead exposure due to more frequent contact with vehicle exhaust fumes (Rahayu, 2021; Ridulloh & Millah, 2021).

Lead exposure in the human body can occur through the consumption of contaminated food and beverages, inhalation of dust or fumes, and contact with lead-contaminated paint. Lead is a toxic substance that can affect almost all organ systems, with the central nervous system as the primary target of its toxicity. Health effects of lead exposure include gastrointestinal disorders, increased blood pressure, anemia, and, at high exposure levels, brain and kidney damage in adults, miscarriage in pregnant women, and reduced fertility in men (Rosita, Hidayat, & Yuliani, 2021).

Lead accumulated in the body can be detected through various biological specimens such as blood, urine, hair, bone, and nails, with blood lead concentration commonly used as an important indicator for evaluating exposure levels. However, in this study, urine samples were selected because their collection is non-invasive, more acceptable to respondents, and does not cause pain compared to blood sampling.

## Methods

**Time and Place of Research**

This research was conducted at the Regional Health Laboratory of North Sumatra from February to June 2025. The sampling method used was total sampling, which included all accessible motorcycle mechanics. It is known that there are only 10 motorcycle mechanics in the Gaperta area.The inclusion criteria were: working in a motorcycle workshop for more than 5 years, being over 20 years of age, working more than 3 days per week, and being willing to participate as a respondent. The exclusion criteria were: having worked for less than 5 years and not being willing to participate as a respondent.

**Preparation of Lead (Pb) Test Samples**

A 30 mL test sample was taken and placed into a 100 mL beaker. Then, 5 mL of concentrated nitric acid ($HNO_3$) was added. The beaker was covered with a watch glass, and the mixture was heated until the volume was reduced to approximately 15–20 mL. The watch glass was then rinsed, and the rinsing water was added back into the beaker. The solution was subsequently transferred into a 50 mL volumetric flask (filtered if necessary), diluted to the calibration mark with distilled water, and homogenized.

**AAS Procedure**

The liquid sample was introduced into the Atomic Absorption Spectrophotometer (AAS) instrument. The sample was atomized in a flame or graphite furnace to convert Pb into free atoms. A lead (Pb) hollow cathode lamp emitted light at a specific wavelength. The light was absorbed by Pb atoms in the sample. The detector measured the intensity of the absorbed light and converted it into concentration data based on the Beer-Lambert law.

**Data analisys**

The data were analyzed descriptively. The results of the AAS examination were presented in tables and accompanied by explanations. No specific statistical analysis was performed in this study.

## Results

The results of lead (Pb) metal levels in ten urine samples from motorcycle mechanics are presented in the following table:

**Table 1. Charactericsation of Respondent**

| Characterization | Number |
|---|---|
| *Age<br>Average (Min, Max) | 37,9 (53–27) |
| *Work Duration<br>Average (Min, Max) | 15,4 (25–5) |
| Concentration of Pb (μg/dL)<br>Average (Min, Max) | 21,4 (52,5–3,5) |

**Table 2. Results of Lead (Pb) Level Measurements in Motorcycle Mechanics' Urine Samples Using the Atomic Absorption Spectrophotometry (AAS) Method**

| Sample Code | Age (Year) | Work Duration (Year) | Pb (μg/dL) | Pb (ppm) | Intrepretation |
|---|---|---|---|---|---|
| Z01 | 40 | 10 | 15,6 | 0,156 | Normal limit |
| Z02 | 28 | 9 | 3,5 | 0,035 | Normal limit |
| Z03 | 39 | 20 | 18,4 | 0,184 | Normal limit |
| Z04 | 40 | 25 | 52,5 | 0,255 | Over limit |
| Z05 | 28 | 10 | 22,2 | 0,222 | Normal limit |
| Z06 | 37 | 14 | 25,1 | 0,251 | Normal limit |
| Z07 | 27 | 5 | 9,5 | 0,095 | Over limit |
| Z08 | 43 | 20 | 24,4 | 0,224 | Normal limit |
| Z09 | 44 | 25 | 26,5 | 0,285 | Over limit |
| Z10 | 53 | 16 | 16,3 | 0,163 | Normal limit |

## Discussion

Lead (Pb) is a Group IV element and a metallic element with a bluish-gray color and high density. Lead pollution results from various human activities. Lead levels in motorcycle mechanics can be determined by analyzing urine, blood, hair, or nails. Several theories indicate that a number of factors influence lead levels in the human body, one of which is occupational exposure. Urine analysis to determine lead levels can be performed using the Atomic Absorption Spectrophotometry (AAS) method. According to the Regulation of the Minister of Health of the Republic of Indonesia No. 1406/MENKES/SK/IX/2002, the permissible threshold limit for metal contamination in urine is 10–25 μg/dL (JDIH BPK Database Peraturan, 2019).

Based on the researchers' observations, there were more than five motorcycle mechanics in the Gaperta area, with a total of ten mechanics included as samples in this study. Motorcycle workshops generally provide vehicle maintenance and repair services such as oil changes, battery replacement, and modification of vehicle tools and engines. These maintenance and repair activities can generate hazardous waste, including heavy metal contamination such as lead, which may have adverse effects on the health of workshop workers (Saskia, Idris, & Sumiaty, 2023; Subhaktiyasa et al., 2025).

The destruction (digestion) process in this study began by pipetting 5 mL of a urine sample and transferring it into a beaker. Then, 5 mL of concentrated nitric acid ($HNO_3$) was added to accelerate the digestion process, as nitric acid is a strong oxidizing agent capable of dissolving metals effectively by oxidizing lead into a soluble form. This was followed by the addition of 5 mL of concentrated sulfuric acid ($H_2SO_4$) to further accelerate the oxidation process. The sample was then heated on a hot plate at a temperature of 60 °C. Heating aimed to break the complex bonds between lead metal and organic compounds present in the sample, allowing the sample to dissolve more easily in the acidic solvent.

Complete digestion was indicated by the formation of a clear solution, signifying that all components had dissolved completely and that the organic compounds had been fully decomposed. Once the sample appeared clear, the digestion process was stopped and the sample was cooled to room temperature. After cooling, the digestion process was continued by adding 10 mL of concentrated nitric acid, followed by reheating on the hot plate until the solution became completely clear. The clear digested solution was then allowed to cool and transferred into a 25 mL volumetric flask, after which distilled water was added up to the calibration mark. The solution was subsequently filtered to separate any remaining solid particles, ensuring that the solution to be analyzed was clear and free of particulates (Subhaktiyasa, 2024; Meliahsari, Yasnani, & Wahid, 2024).

After completion of the digestion process, lead levels in the urine samples were determined using the Atomic Absorption Spectrophotometry (AAS) method. This method was selected due to its high sensitivity, its ability to detect very low concentrations, and its relatively simple and rapid analytical procedure.

Based on the data presented in Table 2, the results showed that among the ten urine samples collected from motorcycle workshop workers on Jalan Gaperta, three samples (Z04, Z06, and Z09) exceeded the permissible threshold limit for lead, while the remaining seven samples did not exceed the threshold limit. According to the Regulation of the Minister of Health of the Republic of Indonesia No. 1406/MENKES/SK/IX/2002, the threshold limit for lead levels in urine specimens is 10–25 µg/dL.

This study has limitations in determining the research sample, which was limited to only 10 respondents. This small sample size makes it difficult to draw strong conclusions or propose policies. Therefore, this study can be considered a preliminary study or pilot project for further research that we plan to conduct. It is hoped that future studies will include respondents from an entire province, which would allow stronger conclusions to be drawn and potentially support policy formulation (Monika, 2013; Budiasa, 2021; Ridulloa, 2022).

## Conclusions

The results indicated that lead (Pb) levels in urine exceeded the threshold limit in three samples, while the remaining seven samples were within the permissible limit. Although this study has limitations due to the small sample size, we recommend that routine Pb testing for workshop mechanics be conducted regularly and supported financially by workshop owners.

## Author contributions

DGRA contributed to the concept and design of the study, while ZZ contributed to sample collection and testing. All authors participated in manuscript preparation, with DGRA contributing to the review process.

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## Ethical approval statement

The study received ethical approval from the Ethics Committee certificate number No. 2851/F/KEP/USM/VI/2024.

## Conflicts of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Supplementary materials

No supplementary material available.

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