PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

MEDIÇÃO DA CONCENTRAÇÃO DE CHUMBO NO SANGUE DE MOTORISTAS DE TRANSPORTE PÚBLICO NO DOMÍNIO DE BANDUNG, WEST JAVA, INDONÉSIA

MEASUREMENT OF LEAD CONCENTRATION IN THE BLOOD OF PUBLIC TRANSPORT DRIVERS IN BANDUNG REGENCY, WEST JAVA, INDONESIA

PENGUKURAN KONSENTRASI TIMBAL DALAM DARAH PENGEMUDI ANGKUTAN UMUM DI KABUPATEN BANDUNG, JAWA BARAT, INDONESIA

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Received 18 June 2020; received in revised form 18 August 2020; Accepted 20 October 2020

RESUMO

Como as atividades industriais e de transporte em Bandung Regency estão crescendo rapidamente, a Indonésia pode correr o risco de aumentar os níveis de poluição do ar. Um dos poluentes atmosféricos muito prejudiciais ao organismo é o chumbo (Pb), que pode ser gerado em atividades industriais, mineração, gases de escapamento de veículos e poeira do solo. O chumbo é um metal pesado muito perigoso para o organismo, pois é cancerígeno com seu caráter de atividade como inibidor do metabolismo celular. Este estudo teve como objetivo analisar a concentração de chumbo no sangue de motoristas de transporte público que trafegam diariamente nas rodovias e apresentam maior risco de exposição ao Pb. A medição da concentração de Pb foi realizada em Espectrofotômetro de Absorção Atômica (AAS). Amostras de sangue foram coletadas de motoristas de transporte público no Terminal Soreang, Bandung Regency, West Java, Indonésia. Os resultados da análise mostraram que o teor médio de chumbo no sangue dos motoristas de transporte público foi 1.032 mg/L. O nível mais baixo foi 0,889 mg/L e o mais alto foi 1.200 mg/L. Isso mostra que o teor de chumbo no sangue de motoristas de transporte público já está em níveis excessivos (valores de faixa 0,800-1,200 mg/L) quando comparado com o limite de chumbo no sangue com base no Regulamento do Ministério da Saúde da República da Indonésia (0,10 - 0,25 mg/L) e o valor limite estabelecido pela Organização Mundial da Saúde, que é 0,4 mg/L.

Palavras-chave: *Espectrofotômetro de Absorção Atômica, Metais Pesados, Chumbo.*

ABSTRACT

As industrial and transportation activities in Bandung Regency are growing rapidly, Indonesia could be at risk of increasing air pollution levels. One of the air pollutants that are very harmful to the body is lead (Pb) generated from industrial activities, mining, vehicle exhaust gas, and dust from the ground. Lead is a heavy metal that is very dangerous for the body because it is carcinogenic with its activity character as an inhibitor in cell metabolism. This study aimed to analyze the concentration of lead in the blood of public transport drivers who are active on the highway every day and are most at risk of being exposed to Pb. Measurement of Pb concentration was carried out using an Atomic Absorption Spectrophotometer (AAS). Blood samples were taken from public transport drivers at Soreang Terminal, Bandung Regency, West Java, Indonesia. The analysis results showed that the average blood lead content of public transport drivers was 1,032 mg/L. The lowest level was 0.889 mg/L, and the highest was 1,200 mg/L. This shows that the lead content in the blood of public transport drivers is already in excess levels (range numbers 0.800-1.200 mg/L) when compared with the threshold for lead in the blood based on the Regulation of the Ministry of Health of the Republic of Indonesia (0.10 - 0.25 mg/L) and the threshold value set by the World Health Organization, which is 0.4 mg/L.

Keywords: *Atomic Absorption Spectrophotometer, Heavy Metals, Lead.*

ABSTRAK

Aktivitas industri dan transportasi di wilayah Kabupaten Bandung yang semakin berkembang dengan pesat dapat beresiko untuk meningkatkan tingkat pencemaran udara. Salah satu pencemar udara yang sangat

DOI: 10.52571/PTQ.v17.n36.2020.613_Periodico36_pgs_598_607.pdf

berbahaya bagi tubuh adalah timbal (Pb) yang dapat dihasilkan dari aktivitas industri, pertambangan, gas buangan kendaraan, dan debu yang berasal dari permukaan tanah. Timbal merupakan logam berat yang sangat berbahaya bagi tubuh karena bersifat karsinogenik dengan sifat aktivitasnya sebagai penghambat metabolisme sel. Penelitian ini bertujuan untuk menganalisis kandungan timbal di dalam darah sopir angkutan umum yang setiap hari beraktivitas di jalan raya dan beresiko paling tinggi untuk terpapar Pb. Pemeriksaan kadar Pb dilakukan dengan menggunakan *Atomic Absorption Spectrophotometer* (AAS). Sampel darah diambil dari sopir angkutan umum di wilayah Terminal Soreang, Kabupaten Bandung. Hasil analisis menunjukkan bahwa rata-rata kadar timbal yang terdapat di dalam darah sopir angkutan umum sebesar 1.032 mg/L. Kadar terendah berada pada angka 0.889 mg/L dan kadar tertinggi berada pada angka 1.200 mg/L. Hal ini menunjukkan kandungan timbal dalam darah pengemudi angkutan umum sudah melebihi kadar (kisaran angka 0.800-1.200 mg/L) jika dibandingkan dengan ambang batas timbal dalam darah berdasarkan Peraturan Kementerian Kesehatan Republik. Indonesia (0,10 - 0,25 mg/L) dan nilai ambang batas yang ditetapkan oleh Organisasi Kesehatan Dunia, yaitu 0,4 mg/L.

Keywords: *Atomic Absorption Spectrophotometer, Logam Berat, Timbal*

1. INTRODUCTION:

In the development of increasingly modern times, air quality has experienced a lot of declines. Air is a basic human need for breathing. Good air quality can support human life (Chertok, Voukelatos, Sheppeard, and Rissel, 2004). The decrease in air quality is caused by an increase in industrial activity and traffic. Based on The World Bank data, in 2020, it is estimated that half of Indonesia's population will experience air pollution problems (Gunawan, 2015; Suksmerri, 2008). One city that has a high level of air pollution is the City of Bandung. This is directly proportional to the increase in the number of vehicles and industries. Andriyawan (2018) revealed that the number of vehicles in Bandung increases by 11% per year. Data in 2018 showed there were 1,251,080 units of two-wheeled vehicles and 536,973 units of four-wheeled vehicles. Also, the development of the number of industries in the city of Bandung also continues to increase. Research conducted by Gunawan (2015) shows that the level of air pollution in Padalarang, Bandung Regency Suspended Particulate Matter (TSP/dust) is very high, around 255.58 $\mu g/Nm^3$. From 2010 to 2015, the average Pb pollutant air pollution level has been above 1 $\mu g/Nm^3$ (annual national ambient quality standard). Only in the first semester of 2011, the Pb pollution level was below 1 µg/Nm3 and the highest in the second semester of 2010, which was around 1.96 $\mu g/Nm^3$, occurred at the location of the Padalarang toll gate.

One of the pollutants produced from industrial activities and traffic is lead (Pb) (Abdi and Kazemi, 2015; Loukidou, Zouboulis, Karapantsios, and Matis, 2004; Lichtfouse and Schwarzbauer, 2012; Kiziloz, 2019; Ordouee and Hazheminezhad, 2019; Suksmerri, 2008). Lead is usually added to the fuel to increase the octane value (Ismail, 2004; Intani, 2010). Traffic activity is the largest source of lead, which is 60% (Ardillah, 2016). Aside from traffic activities, lead can also be produced from industrial waste, burning coal, rocks, soil, and plants (Olukanni, Agunwamba, and Ugwu, 2014; Rodríguez, Cárdenas-González, Juárez, Pérez, Zarate, and Castillo, 2018; Acar and Malkoc, 2004). Sources classified as large are coal combustion, smoke from factories that process alkyl-Pb compounds, Pb-Oxides, Pb ore smelting, and motor vehicle fuel transfer alkyl-Pb compounds contained in these fuels are very volatile (Palar, 2012). The problem that arises from lead is its very small size, 0.02-1.00 µm, with a period of stay in the air for 4 - 40 days (Naria, 2005). This causes the risk of lead inhaled by humans to be higher.

The traffic sector is becoming more concerned with air pollution by Pb metal, especially for residents who work as public transport drivers. This profession has a very high risk because the working area is on the highway. Especially if the traffic conditions are very congested. Air quality on high traffic with high road density contains a higher lead than air on road with low traffic density (Ardillah, 2016).

The entry of lead into the body will be hazardous because it has no biological function so that it can disrupt the health of the body (Rodríguez, Cárdenas-González, Juárez, Pérez, Zarate, and Castillo, 2018). Lead metal can enter the body in three ways: the skin, respiratory tract, and digestive tract (Palar, 2012; Nasir, 2018). Of the several forms of the lead entering the body, the respiratory pathway is the most common lead (Patrick, 2006). When the lead enters through breathing, the absorption process takes place in the inner lungs. Lead absorption through respiration can reach 30% of the total amount entered, while it is only 5-10% in the digestive track. When absorbed, the lead will enter the circulatory system and bound in red blood cells by

90% and 15% stored in body tissues and excreted mainly through the kidneys and digestive tract (Palar, 2012). Lead absorbed by blood is distributed to soft tissues (liver, lungs, kidneys, spleen, heart, brain) and to hard tissues (bones, hair, teeth) (Palar, 2012; Wittmers Jr., 2010; Rabinowitz, 1991; Kosnett *et al*., 2007).

When the lead enters the body and spreads in the body, the excretion or excretion process does not occur as a whole. This is because the half-life of lead in the blood is ± 25 days, in the soft tissue for ± 40 days, while in the bones for ± 25 years (Nordberg, 1998). This prolonged excretion process can cause lead to accumulate quickly in the body. The toxic effects of lead can cause symptoms of sleep disorders, weakness, headaches, muscle and bone pain, abdominal pain, nausea and vomiting, weight loss, and reduced appetite (Naria 2005, Gusnita, 2012; Rosita, and Sosmira, 2017; Papanikolaou *et al*., 2005; Anies, 2005). Meanwhile, chronic diseases can be caused, namely epilepsy, hallucinations, anemia, and even cancer (Nasir, 2018; Ardillah, 2016; Patrick, 2006; Etiang *et al*., 2018; Schober *et al*., 2006). Pb can cause anemia because it interferes with the process of hemoglobin formation (Needleman, 2004). Of the various toxic effects caused, the nervous system is the most sensitive part of Pb. Besides, Pb can also attack brain tissue.

Needleman (2004), Richard, Phillips, and Kushner (2006), and Dwilestari (2012) explained that lead could inhibit the formation of hemoglobin by inhibiting the activity of the delta-aminolevulinic acid dehydratase enzyme (delta-ALAD and ALAD). When the total lead level in the blood exceeds 0.20 mg / L, ALAD activity will be inhibited by 50 percent. This inhibition is characterized by an increase in the level of aminolevulinic acid (ALA) in the urine, a substrate that accumulates due to a decrease in ALAD. Delta-ALAD inhibition will also prevent ALA from being converted into porphobilinogen to inhibit the incorporation of iron into the protoporphyrin ring. Thus, heme synthesis will be reduced, both for hemoglobin and for cellular respiration.

Toxic effects can be caused because Pb is an inhibitor. This means that Pb can inhibit the performance of certain enzymes in the body. Toxic effects begin when lead buildup occurs in the body. Febrianti and Azizah (2015) and the World Health Organization (1995) divided the threshold value for male workers by 0.4 mg / L and for female workers by 0.3 mg / L. Meanwhile, according to the Decree of the Minister of Health of the Republic of Indonesia Number 1406 / MENKES / SK / IX / 2002, the threshold value of lead levels in blood specimens in normal adults is 0.10 - 0.25 mg / L. Pb concentrations in the blood that exceed this threshold value can cause symptoms of poisoning. The amount of lead in the blood will continue to increase as the air quality gets worse. Measurement of Pb levels in the blood is very important because it can be used as an index of exposure and level of danger (Ardillah, 2016; Gunawan, 2015). Based on the threshold value determined by the Government of Indonesia and the World Health Organization, Palar (2012) categorizes the level of Pb exposure in the blood in Table 1.

To measure the concentration of Pb in the blood, an Atomic Absorption Spectrophotometer (AAS) can be used. Using AAS, the measurement method is a quantitative analysis method whose measurement is based on light absorption with certain wavelengths by metal atoms in the free state in the gas phase (Aprilia and Rahayu, 2015; Anshori, 2005; Slavin, 1978). Measurement of metal concentrations with AAS is considered more accurate because it has high accuracy and selectivity (Dewi, Mahmudah, Kumalawati, and Amalullia, 2019; Slavin, 1978).

The research method used is descriptive. Based on Saryono and Anggraeni (2013) and Notoatmodjo (2012), this study aimed to analyze the concentration of lead in the blood of public transport drivers who are active every day on the highway and are most at risk for exposure to Pb. The value of the content obtained can provide information about the description of the level of air pollution by the presence of Pb. The test results obtained were then compared with the threshold value of lead exposure in the blood.

2. MATERIALS AND METHODS:

The research was carried out at the Laboratory of Applied Chemistry and Toxicology, Rajawali Institute of Health, and the Central Laboratory of Padjadjaran University. Samples were taken in the form of venous blood obtained from public transport drivers in the Soreang Terminal area, Bandung Regency, West Java, Indonesia. Before the venous blood was drawn, participants were asked about their willingness to take blood as a sample. They were also given a general description of the research and its benefits to them. After they agree, they were required to fill out the informed consent (IC) as written consent.

Participants were determined randomly using accidental sampling technique from public transport drivers operating at Soreang Terminal.

All participants were male. The selected participants were determined based on their tenure, namely being a public transport driver for 5 years and working a minimum of 8 hours a day. Consideration of this criterion was carried out to see the relationship between the time of exposure and the Pb level in the blood. Driver's age data was also collected to see how age affects Pb levels in the blood. Based on these criteria, there were as many as 10 public transport drivers who caould fulfill this. Also, to obtain more in-depth data, interview sessions were also conducted with the ten participants covering their daily activities, residence location, and work length per day.

Then the blood sample was taken to the laboratory for measurements. Research in the laboratory was carried out in several stages, namely sample preparation, destruction, standard curve creation, and measure of blood lead levels (Ardillah, 2016; Baehaki, Rudibyani, Aeni, Perdana, and Aqmarina, 2020; Batool, Ahmad, Zahidqureshi, Mahboob, and Nimra, 2018; Takwa, Bujawati, and Mallapiang, 2017).

2.1. Sample Preparation

Of the ten public transport drivers who meet the criteria, 3 mL of blood each was obtained using a pipette into a cup and added 500 mg of potassium citrate. Next, 5 ml of concentrated nitric acid is added until the color turns blackish brown to destroy the organic compounds.

2.2. Sample Destruction

Blood samples that have been prepared are then destructed to damage organic compounds. Destruction was carried out for 6 hours at 400 ^{0}C until it turns to ashes. The resulting ash was dissolved using sufficient 0.5 M nitric acid solution. The solution was then filtered using filter paper to obtain 10 mL of filtrate using a measuring flask.

2.3. Making Standard Curve

Making a standard curve is done by making a series of standard solutions $Pb(NO_3)_2$ with a concentration of 1 mg/L, 2 mg/L, 3 mg/L, 4 mg/L, 5 mg/L. The solution was made by diluting a 100 mg/L standard $Pb(NO_3)_2$ solution. The solution was made using dilution formula, which are:

$$V_1.C_1 = V_2.C_2$$

where V_1 is the volume of the stock solution to be diluted, C_1 is the concentration of the stock solution (100 mg/L), V_2 is the final volume of the dilute solution, and C_2 is the final concentration (in this case 1 mg/L, 2 mg/L, 3 mg/L, 4 mg/L, and 5 mg/L).

The calculations for making standard solutions can be seen below.

- Standard solution 1 mg / L
  100 mg/L x V_1 = 1 mg/L x 100 mL
  $V_1 = \frac{1 \, x \, 100}{100}$ = 1 mL
- Standard solution 2 mg / L
  100 mg/L x V_1 = 2 mg/L x 100 mL
  $V_1 = \frac{2 \, x \, 100}{100}$ = 2 mL
- Standard solution 3 mg / L
  100 mg/L x V_1 = 3 mg/L x 100 mL
  $V_1 = \frac{3 \, x \, 100}{100}$ = 3 mL
- Standard solution 4 mg / L
  100 mg/L x V_1 = 4 mg/L x 100 mL
  $V_1 = \frac{4 \, x \, 100}{100}$ = 4 mL
- Standard solution 5 mg / L
  100 mg/L x V_1 = 5 mg/L x 100 mL
  $V_1 = \frac{5 \, x \, 100}{100}$ = 5 mL

To each solution, 0.5 mL of nitric acid solution was added to the mark on the 100 mL volumetric flask. Absorbance measurements were performed at a wavelength of 283 nm. The curve is created by plotting the concentration value (x axis) and absorbance value (y axis). Making this curve is used to calibrate the instrument and calculate the Pb concentration in the sample.

2.4. Measurement of Lead Concentration in Blood Samples

The blood sample that has been degraded is dissolved into 0.5 mL of concentrated nitric acid and diluted in a 10 mL volumetric flask. The dilution solution was pipetted and put into a cuvette measured using AAS at 283 nm wavelength.

3. RESULTS AND DISCUSSION:

3.1 Standard Curve $Pb(NO_2)_3$ Solution

A standard curve was done to obtain a straight line equation that can be used to calculate Pb concentration in a sample. This method is a standard way of measuring using AAS. Generally, the greater the concentration, the higher the absorbance value (Table 2). The data in Table 2 were then plotted into the x axis (concentration) and the y axis (absorbance). Plots of these values can form a straight line with the equation y = mx + c.

Based on the data plotted in Table 2, a straight line is obtained with the equation y = 0.0095x + 0.0007 with an R^2 value of 0.9991 (see Figure 1). The ideal linear relationship is achieved if R^2 = 1 or R^2 = -1 (Harmita, 2004). If the value of R^2 is getting closer to the value of 1 or -1, then the value of R^2 is getting closer to the ideal. Therefore, the R^2 value obtained in this study shows that the resulting line equation can be used to determine the Pb content in the sample.

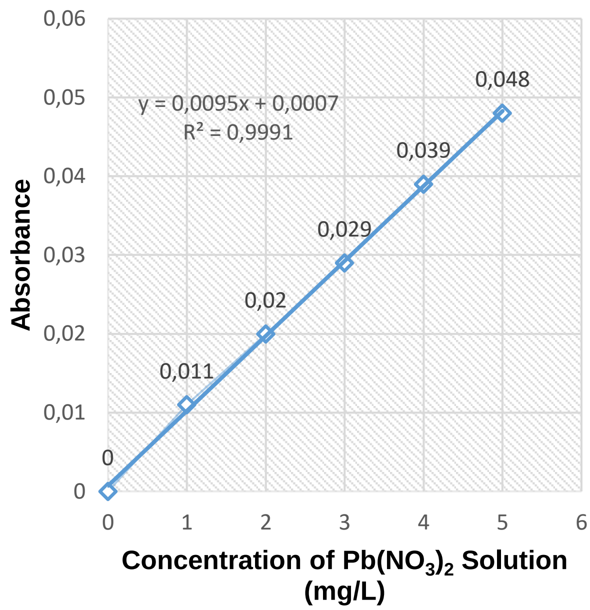


Figure 1. *Standard Curve of Pb $(NO_3)_2$ Solution*

3.2. Sample Measurement Results

The measurement results show a high Pb concentration value in the blood of public transport drivers (see Table 3). The average Pb concentration measured was 1.032 mg / L. Even the lowest Pb concentration was found in sample S4 with a value of 0.889 mg / L. This concentration value has exceeded the threshold for Pb concentration in the blood based on the Regulation of the Minister of Health of the Republic of Indonesia Number 1406 / MENKES / SK / IX / 2002, namely 0.10 - 0.25 mg / L blood. This value also has exceeded the threshold value determined by the World Health Organization, namely 0.4 mg / L (Febrianti and Azizah, 2015; The World Health Organization, 1995). If we look at the classification of Pb concentrations in the blood by Palar (2012) (see Table 1), the mean Pb concentration is in the excessive category and is close to the dangerous level. These data indicate that the level of Pb exposure in the sample work area is very high (Zolaly *et al*., 2012). Even the average value is in the range of values with an over-classification and begins to show poisoning (Palar, 2012). Symptoms commonly felt by all participants were easy fatigue and reduced concentration. The high Pb level in the blood is following the results of a survey conducted by Mujahidin (2019) in the Soreang area, Bandung Regency, West Java, Indonesia, which shows traffic density and industrial activity. According to Ardillah (2016), the higher the traffic activity, the higher the air pollution by the lead.

The relationship between driver's age and Pb levels is also analyzed from Table 3. This is because age is one factor that can affect Pb levels in the body (Suciani, 2007). The older a person is, the higher their Pb level. Based on the data in Table 3, the pattern of this relationship is not visible, so further research is needed to examine in more depth about this problem. This is possible due to the influence of other factors, namely the length of exposure (working hours per day) and lifestyle. The duration of exposure has a close relationship with the amount of Pb levels in the body (Frank, 1995).

The relationship between length of work and blood levels of Pb can be seen in Figure 2. In general, Figure 2 shows the increase in Pb levels with increasing work hours. But graphic patterns only show trends. For example, the interesting thing is in the S3 sample data, the sample has been working as a public transport driver for ± 23 years, but the measured Pb concentration is 0.996 mg/L. This Pb concentration value is smaller than the S1 sample that has only been working as a public transport driver for ± 10 years with a measured Pb concentration value of 1.010 mg/L. The existence of this phenomenon requires the deepening of extracting information.

The results of the interview provide more in-depth information. Sample S3 and sample S1 have the same average working hours for 8 hours per day (see Table 3). Their activities are almost the same at work. However, they reside in different areas. Sample S1 resides right on the edge of the highway, while the sample residence S3 is far from the highway. This could explain the phenomenon in the graph of the relationship of work duration with the concentration of Pb in the blood (Figure 2). This is quite influential because it means that the S1 sample takes longer to interact in the Pb exposure area than the S3 sample. Residence right on the side of the road has a higher risk of exposure due to traffic activities. This is under Frank (1995) statement, who said that the duration of exposure is one of the factors that determine the level of Pb in the blood. Other factors are also found, such as daily habits like smoking, not washing your hands before eating and taking supplements. According to Hasan (2012), the habit of drinking supplement drinks can reduce Pb levels in the blood. Supplements that contain calcium and intake of magnesium, phosphate, alcohol, and fat can reduce the absorption of Pb in the body (Bogden *et al.*, 1992; Mahaffey, Gartside, Glueck, 1986; Barltrop and Meek, 1979; Barltrop and Khoo, 1975). However, there are no substantial data on the influence of these factors on Pb exposure, so further research is needed to do this.

4. CONCLUSIONS:

Lead levels (Pb) in the blood of public transport drivers in Soreang Terminal are in the excess category. Where the average concentration of Pb in the blood is 1.032 mg/L. Levels of this category have led to symptoms of mild poisoning. Generally, the public transport driver used as a sample feels his body easily tired and reduced concentration. This data can be used as a basis for the government or public transport facility managers to minimize exposure to public transport drivers. One simple effort that can be done is the use of masks when working, familiarizing clean life (washing hands before eating), reducing smoking habits, and so on. Also, there is a need for policies in handling traffic activities by setting vehicle rules that must reduce the levels of smoke produced by exhaust, urge to use public transportation rather than private vehicles, and limit road access for large vehicles (trucks and buses) so on. So that traffic activity can be minimized or at least can be reduced.

5. ACKNOWLEDGMENTS:

The authors are grateful to The Institut Kesehatan Rajawali and Central Laboratory, Padjajaran University, who were willing to cooperate in completing this research. The authors also want to thank all those who have helped both material and moral so that this research can be carried out well.

6. REFERENCES:

1. Chertok, M., Voukelatos, A., Sheppeard, V., and Rissel, C. (2004). Comparison Of Air Pollutan Exposure For Five Commuting Modes In Sydney-Car, Train, Bus, Bicycle And Walking. *Health promotion journal of Australia: official journal of Australian Association of Health Promotion Professionals*, 15(1).
2. Gunawan, G. (2015). Tingkat Pencemaran Udara Debu Dan Timbal Di Lingkungan Gerbang Tol. *Jurnal Jalan Jembatan*, 32(*2*).
3. Suksmerri (2008). Dampak Pencemaran Logam Timah Hitam (Pb) Terhadap Kesehatan. *Jurnal Kesehatan Masyarakat*, 2(2).
4. Andriyawan, D. (2018). Pertumbuhn Kendaraan di Bandung 11% Tiap Tahunnya, *Car Pooling* Dinilai Efektif". *(Online)*, https://bandung.bisnis.com/read/20181002/549/1114194/pertumbuhan-kendaraan-di-bandung-11-per-tahun, accessed on July 3 2019.
5. Abdi, O., Kazemi, M. (2015). A Review Study of Biosorption of Heavy Metals And Comparison Between Different Biosorbents. *J. Mater. Environ. Sci.*, 6(5), 1386-1399.
6. Loukidou, M. X., Zouboulis, A.I., Karapantsios, T.D., and Matis, K.A. (2004). Equilibrium and kinetic modeling of chromium(VI) biosorption by *Aeromonas caviae*. *Colloids and Surfaces A: Physicochem. Eng. Aspects*, 242*,* 93-104. doi:10.1016/j.colsurfa.2004.03.030
7. Lichtfouse, E., Schwarzbauer, J., and D. Robert. (2012). *Environmental Chemistry For A Sustainable World Volume 1: Nanotechnology And Health Risk*, New York: Springer.
8. Kiziloz, B. (2019). Investigation Of Some Hazardous Agents And Trace Elements In Drinking Water Of Kocaeli Region. *Periodico Tche Quimica*, 16(31), 381–389.
9. Ordouee, B., Hazheminezhad, H. (2019). Measurement And Adsorption Of Heavy Metals Ion From Water Using Porous Nano-Adsorbents By Atomic Absorption Method. *Periodico Tche Quimica*, 16(*32*), 228–238.
10. Ismail F. (2004). *Hubungan antara penggunaan masker hidung karbon aktif dengan kadar timbal urin petugas parkir yang terpajan emisi timbal pada sebuah perusahaan disebuah basemen mall di Jakarta*. Jakarta: Universitas Indonesia.

11. Intani Y.C. (2010). *Pengaruh Timbal (Pb) pada Udara Jalan Tol Terhadap Gambaran Mikroskopis Testis dan Kadar Timbal (Pb) dalam Darah Mencit Balb/c Jantan*. Semarang: Universitas Diponegoro.

12. Zolaly M.A., *et al*. (2012). Association between blood lead levels and environmental exposure among Saudi schoolchildren in certain districts of Al-Madinah. International Journal of General Medicine, 5:355–364. http://doi.org/10.2147/ijgm.s28403

13. Ardillah, Y. (2016). Faktor Resiko Kandungan Timbal Di Dalam Darah. *Jurnal Ilmu Kesehatan Masyarakat*, 7(*3*), 150-153. https://doi.org/10.26553/jikm.2016.7.3.150-155

14. Olukanni, D. O., Agunwamba, J. C., and Ugwu, E. C. (2014). Biosorption of Heavy Metals In Industrial Wastewater Using Microorganisms (*Pseudomonas Aeruginosa*). *American Journal Of Scientific And Industrial Research, 5*(2), 81 – 87.

15. Rodríguez, I. A., Cárdenas-González, J. F., Juárez, V. M. M., Pérez, A. R., Zarate, M. G. M., Castillo, N. C. P. (2018). Biosorption of Heavy Metals by *Candida albicans*. *Advances in Bioremediation and Phytoremediation*, 43–62. http://dx.doi.org/10.5772/intechopen.72454

16. Acar, F. N. And Malkoc, E. (2004). The Removal Of Cr(VI) From Aqueous Solutions By Fagus Orientalis L. *Bioresource Technology*, *94*, 13–15.

17. Palar, H. (2012) *Pencemaran Dan Toksikologi Logam Berat 5th Edition*. Jakarta: PT. Rineka Cita.

18. Naria, E. (2005). Mewaspadai Dampak Bahan Pencemaran Timbal (Pb) Di Lingkungan Terhadap Kesehatan. *Repositori Institusi Universitas Sumatera Utara*, 17(4).

19. Nasir, M. (2018). Analisis Perbandingan Kadar Timbal (Pb) dan Besi (Fe) Dalam Darah Petugas Parkir Ruang Terbuka Dengan Ruang Tertutup. *Jurnal Media Analis Kesehatan*, 9(1), 69 – 71.

20. Patrick L. (2006). Lead toxicity, a review of the literature. Part 1: Exposure, evaluation, and treatment. *Altern Med Rev*, 11(1): 2-22.

21. Wittmers Jr., *et al*. (2010). Lead in Bone. IV. Distribution of Lead in the Human Skeleton. *Archives of Environmental Health: An International Journal*. 43(6): 381-391. https://doi.org/10.1080/00039896.1988.9935855

22. Rabinowitz MB. (1991). Toxicokinetics of bone lead. *Environ Health Perspect*, 91:33-37. https://doi.org/10.1289/ehp.919133

23. Kosnett M.J. *et al*. (2007). Recommendations for Medical Management of Adult Lead Exposure. *Environ Health Perspect*. 115(3): 463–471. https://dx.doi.org/10.1289%2Fehp.9784

24. Nordberg G. 1998. *Metal: Chemical Poperties and Toxicity. In: Stellman Jm (ed); Encyclopedia of Occupational Healtha and Safety (4 ed).* Geneva: ILO.

25. Gusnita, D. (2012). Pencemaran Logama Berat Timbal (Pb) Di Udara Dan Upaya Penghapusan Bensin Bertimbal. *Berita Dirgantara*, 13(3), 95-98.

26. Rosita, B. (2017). Verifikasi Analisa Kadar Logam Timbal (Pb) Dalam Darah Dan Gambaran Hematologi Darah Pada Petugas Tambang Batu Bara. Sosmira, E. *Journal of Sainstek*, 9(1), 68 – 75.

27. Papanikolaou N.C., *et al*. (2005). Lead toxicity update. A brief review. *Med Sci Monit,* 11:RA329-RA336.

28. Anies (2005). *Penyakit Akibat Kerja*. Jakarta: PT. Elex Media Komputindo.

29. Etiang N.A. *et al*. (2018). Environmental Assessment and Blood Lead Levels of Children in Owino Uhuru and Bangladesh Settlements in Kenya. *Journal of Health & Pollution*, 8(18):180605.

    http://doi.org/10.5696/2156-9614-8.18.180605

30. Schober S.E. *et al*. (2006). Blood Lead Levels and Death from All Causes, Cardiovascular Disease, and Cancer: Results from the NHANES III Mortality Study. *Environ Health Perspect*. 114(10): 1538–1541. https://dx.doi.org/10.1289%2Fehp.9123

31. Needleman H. (2004). Lead poisoning. *Annu Rev Med*,55:208-222.

32. Richard S.A., Phillips, J. D., and Kushner, J.P. (2006). Biosynthesis of heme in mammals. *Biochemistry and Biophysics Actual*, 17(63):723–36.

33. Dwilestari K.O.H. (2012). *Analisis Hematologi Dampak Paparan Timbal pada Pekerja Pengecatan (studi Kasus: Industri Pengecatan Mobil Informal di Karasak, Bandung)*. Bandung: Institut Tenologi Bandung.

34. Febrianti, L. D. dan Azizah, R. (2015). Karakteristik Kadar Timbal (Pb) Dalam Darah, Dan Hopertensi Pekerja *Home Industry* Aki Bekas Di Desa Talun Kecamatan Sukodadi Kabupaten Lamongan. *Jurnal Kesehatan Lingkungan*, 8(1), 92-94.

35. The Decree of the Minister of Health of the Republic of Indonesia Number 1406 / MENKES / SK / IX / 2002 Regarding the standard for checking lead levels in human biomarker specimens, the measurement of lead levels in the human body can be done through blood, urine, and hair specimens.

36. Aprilia, D., Rahayu, D., dan Ayu, D. R. (2015). Spektropotometer serapan atom. *(online)*, https://www.academia.edu/13867003/Spektrofotometri_Serapan_Atom_AAS_ , accessed on July 3, 2019.

37. Anshori, J. (2005). *Materi Ajar Spektrofotometer Serapan Atom*. Bandung : UNPAD Press.

38. Slavin (1978). *Atomic Absorption Spectroscopy*. New York: Willey.

39. Dewi, D. C., Mahmudah, R., Kumalawati, O. R., dan Amalullia, D. (2019). Analisis Kadar Logam Timbal (Pb) Pada Bedak Tabur Dengan Variasi Zat Pengoksidasi Dan Metode Destruksi Basah Menggunakan Spektroskupis Serapan Atom (AAS). *Alchemy Journal of Chemistry*,7(1). http://dx.doi.org/10.18860/al.v7i1.7016

40. Saryono dan Anggraeni, D. M. (2013). *Metodologi Penelitian Kualitatif Dan Kuantitatif Dalam Bidang Kesehatan*. Yogyakarta: Nuha Medika.

41. Notoatmodjo, S. (2012) *Metodologi Penelitian Kesehatan*. Jakarta: Rineka Cipta.

42. Baehaki, F., Rudibyani, R. B., Aeni, S. R. N., Perdana, R., and Aqmarina, S. N. (2020). Utilization Of *Salacca Zalacca* Seeds As Chromium(VI) Adsorbents. *Periodico Tche Quimica*, 17(34), 381–389.

43. Batool, M., Ahmad, K. S., Zahidqureshi, Mahboob, N., and Nimra. (2018). Determination Of Heavy Metal Toxicity In Blood And Health Effect By AAS (Detection Of Heavy Metals And Its Toxicity In Human Blood). *Lupine Publisher*,1(2). http://dx.doi.org/10.32474/ANOAJ.2018.01.000107

44. Takwa, A., Bujawati, E., dan Mallapiang, F. (2017). Gambaran Kadar Timbal Dalam Urine Dan Kejadian *Gingival Lead Line* Pada Gusi Anak Jalanan Di Flyover Jl. Ap. Pettarani Makassar. *Higiene Jurnal Kesehatan Lingkungan*, 3(2), 114 – 123.

45. Mujahidin, M. (2019) *Jalur Wisata Bandung Selatan Ke Ciwidey Mulai Dipadati Kendaraan, Ada Beberapa Titik Kemacetan Metro Bandung*, Jawa Barat: Tribunnews. https://jabar.tribunnews.com/2019/06/07/jalur-wisata-bandung-selatan-ke-ciwidey-mulai-dipadati-kendaraan-ada-beberapa-titik-kemacetan), accessed on July 8 2019.

46. Suciani S. (2007). Kadar Timbal Dalam Darah Polisi Lalu Lintas dan Hubungannya dengan Kadar Hemoglobin (Studi pada Polisi Lalu Lintas yang Bertugas di Jalan Raya Kota Semarang). Semarang: Universitas Diponegoro.

47. Frank, C. (1995) *Toksikologi Dasar : Asas, Organ, Sasara Dan Penilaian Resiko*. Jakarta : UI-Press.

48. Hasan, W. (2012). Pencegahan Keracunan Timbal Kronis Pada Pekerja Dewasa Dengan Suplemen Kalsium. *Makara Kesehatan*, 16(1), 1 – 8.

49. Bogden J.D., *et al*. (1992). Dietary calcium modifies concentrations of lead and other metals and renal calbindin in rats. *J Nutr*, 122:1351-1360.

50. Mahaffey K.R., Gartside P.S., Glueck C.J. (1986). Blood lead levels and dietary calcium intake in 1- to 11-year old children: the Second National Health and Nutrition Examination Survey, 1976 to 1980. *Pediatrics*, 78:257-262.

51. Barltrop D. and Meek F. (1979). Effect of particle size on lead absorption from the gut. *Arch Environ Health*, 34:280-285.

52. Barltrop D. and Khoo H.E. (1975). The

influence of nutritional factors on lead absorption. *Postgrad Med J*., 51:795-800.

Table 1. *Classification of Lead Blood Exposure*

Category	mg Pb/L bloods	Description
A (normal)	< 0,40	Normal exposure level
B (can be tolerated)	0,40 – 0,80	Increased absorption from exposure but can still be tolerated
C (excessive level)	0,80 – 1,20	Increased absorption from large exposures and begins to show signs of poisoning
D (danger level)	> 1,20	Absorption reaches danger level with signs of mild to severe poisoning

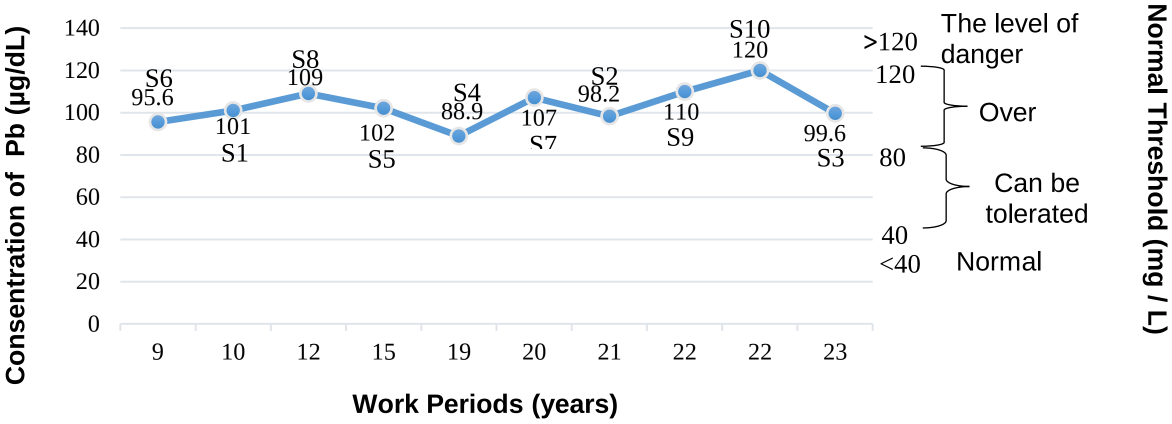
Table 2. *Results of absorbance measurements on $Pb(NO_3)_2$ standard solution*

Concentration (mg/L)	Absorbance
0	0
1	0,011
2	0,020
3	0,029
4	0,039
5	0,048

The data in Table 2 is plotted into a standard curve (Figure 1) so that it produces a straight-line equation.

Table 3. *Results of examination of lead concentration in blood transport general transport in soreang terminal, bandung regency*

Sample	Age (years)	Work Periods (years)	Average Length of Work per day (hours)	Concentration of Pb (µg/mL)
S1	39	10	8	101,0
S2	56	21	8	98,2
S3	54	23	8	99,6
S4	69	19	8	88,9
S5	46	15	8	102,0
S6	39	9	8	95,6
S7	46	20	8	107,0
S8	52	12	8	109,0
S9	37	22	8	110,0
S10	45	22	8	120,0
Average				**103,2**
Maximum				**120,0**
Minimum				**88,9**



Note:

S1: Sample from participants 1
S2: Sample from participants 2
S3: Sample from participants 3
S4: Sample from participants 4
S5: Sample from participants 5
S6: Sample from participants 6
S7: Sample from participants 7
S8: Sample from participants 8
S9: Sample from participants 9
S10: Sample from participants 10

Figure 2. *Relationship between a work period and Pb level in the blood of public transportation driver.*