Lead in Painting Workers at Indonesia Land Transportation Manufacture Company

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Abstract

Lead is widely used in various industrial purposes, one of which is in the paint industry. Lead plays an important role in the paint industry which functions as a coloring agent or known as pigment. Lead is a heavy metal whose benefit is unknown in the body. In fact, its existence in the body often causes toxic effects on health. In painting activities, lead can more easily interact and poison paint workers through inhalation, ingestion, and skin. Accute lead poisoning can result in haematological disorders. This study aimed to reveal the level of lead in the air in the painting area and to analyze the differences in lead and hemoglobin levels. This observational study used an analytic cross-sectional design. The study population consisted of 2 groups, namely the study group (exposed group) and the control group (non-exposed group) as a comparison. The research subjects were 20 people consisting of 12 respondents from the exposed group and 8 respondents from the unexposed group.The results of this study indicate that the average exposure to lead levels in the air is0.06834 mg/m^3. There was a difference between the lead levels of the exposed group and the unexposed group (sig: 0,00). And there was no difference between the hemoglobin levels of the both groups (sig: 0,349).

Keywords: *lead exposure, lead in painting workers, blood lead levels.*

Introduction

Metals are divided into 2 types, namely heavy metals and light metals. Light metals are compounds that have a specific gravity <5g/cm3, while heavy metals are compounds that have a specific gravity>5g/cm3. The Pb compound itself has a specific gravity of 11,342 g/cm3 so that Pb can be classified as a heavy metal group(2).

The use of lead in industry is quite widely used, leads are used for the battery industry, anti-explosion of gasoline, metal coatings/metal pipes, radiation protection, ammunition, soldering, coloring pigments in dyes/paints and others(3).Lead is also very important in the paint and ink industry as a colorant. The majority of the paint industry uses Pb as a pigment, besides that lead in paint can also act as a catalytic agent to speed up the paint drying process, and as an anti-rust coating to prevent rusting of coated objects(4).

Essential heavy metals are metals that are in a certain amount needed by living things, but in excess amounts can cause harmful toxic effects, for example, Zn, Cu, Fe, Co, Mn and Se. Meanwhile, non-essential heavy metals are metals whose benefits are unknown in the body and often cause toxic metal effects, for example Hg, Cd, Pb, Sn, Cr (VI) and As. Non-essential heavy metals are often toxic in the body, and can have a negative impact on a human health(1).

Painting activities can cause lead to air dispersion, so that workers in and around it will more easily interact with lead metal. Lead can enter the human body through

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3 routes, namely respiration, digestion, and skin. Lead that is dispersed into the air can poison the human body through inhalation, in addition to that, contact with the paint surface can also cause lead to enter through the skin pores even though the value is a little[5].Lead that sticks to the hands, face and food around the exposedareacan entered the body through digestionif exposed workers do not maintain personal hygiene properly[6].

Lead that enters the body will bind to red blood cells, then distributed to soft tissues such as internal organs, brain, kidneys, and can be stored in bones and teeth. Lead can accumulate and form strong bonds with bones and teeth for a long time (10-25 years)[7]. Lead that has spread in body tissues can be released and re-binds to blood. Lead exposure to humans is like the case of radiation exposure, because lead can accumulate in the body and be stored in the bones, liver and kidneys. The longer person works in an environment with lead exposure, the more leads will be stored in the body[8].

Lead is classically a cumulative or chronic toxin; hence, acute effects are usually observed only following to exposures with high concentrations. Acute lead exposures may cause gastrointestinal disturbances (anorexia, vomiting, nausea, abdominal pain), hepatic and renal damage, hypertension and neurological effects (malaise, encephalopathy, drowsiness) that may lead to convulsions and death. Chronic lead exposure commonly causes haematological effects such as anaemia, or neurological disturbances, including headache, irritability, lethargy, convulsions, ataxia, muscle weakness, tremors and paralysis[9].

Lead in the body can affect the performance of hemoglobin formation, more precisely lead can interfere with the heme synthesis process. The effects of Pb disturbances on hematopoietic is that it is closely related to Hb production, which is to inhibit the process of compiling the enzyme Amino Laevulinic Acid Dehydratase (ALAD) and the insertion of iron in Protoporphyrin. This will result in a decrease in the combination of Hb formation and the erythrocyte life cycle[10]. However, the case of hemopoietic effects as above occurred only in a chronic or long-term exposure to blood lead (PbB) levels of 50 µg/dL or more. Lead inhibits heme synthesis through inhibition of the enzyme ferrochelatase, causing an increase in protoporphyrin in erythrocytes. This can be tested by examining Erythrocyte ZnProtoporphyrin (ZPP) with the fluorometry technique. Lead can cause microcytic anemia because it has the effect of weakening the red blood cell membrane so that it breaks easily and shortens the life of red blood cells[11].

Material and Method

This quantitative research is an observational study where the researcher only takes the data in the field without making any intervention to the subject. The research design was cross-sectional analytic, where all data were collected simultaneously without considering outcome status and exposure.

This study used 2 groups of research subjects, namely painting workers as the study group (exposed) and administrative workers as the control group (non-exposed). The study population was determined in each group with these following inclusion criteria; male(sex); not consuming blood-boosting drugs; not having the same name; working on shift 1 (morning-evening). From the inclusion criteria obtained population of 13 people in the painting area and 9 people in the administrative area. Sampling was using simple random sampling method for each group, and the number of samples was determined using the Slovin's formularesulting in 12 samples of the exposed group and 8 of the unexposed group. This research was conducted at the train manufacturing company PT. X.

This study was supported by occupational health laboratories (LaboratoriumK3 Jatim), environmental laboratories (Laboratorium Mutiara Sidoarjo), and health laboratories (Sarana Medika) in analyzing data in the field. Testing of lead samples in air and blood was carried out using the AAS method, while hemoglobin levels used the cyanmethemoglobin method.

Laboratory test results data are then inputted and presented in tabular form. Furthermore, the data were analyzed using the help of SPSS software with the Independent T-test comparison. This study aims to reveal the amount of air lead exposure, and the differences in blood lead and hemoglobin levels between the exposed and non-exposed groups.

Result

Laboratory Check Result of Lead Levels in the Air of Work Environment

Air sampling was taken in 2 areas, there are the area of painting workshop and the Graha building as the administration office. The air sampling in the painting Indian Journal of Forensic Medicine & Toxicology, area was taken by 4-points, because the painting workshophas a large coverage area and the type of painting work is dynamic work that moving around the workshop. And for the administrative office area is enough to do 1-pointair sampling because the work area is not so large and the type of work is static where the administration workers are not moving into places.

Table 1. Lead Levels in The Air Work Environment

Sample Point	Time (GMT+7)	Lead Levels (mg/m3)	Temp (oC)	Relative Humi-dity
Painting B	09.29	0,00629	32,1	60
Painting A	09.34	0,10822	31,9	58
Painting C	09.54	0,00046	32,8	56
Administration Office	10.17	<0,00046	28,4	72
Painting D	13.15	0,15839	34,2	55

It can be seen in table 5.7, the level of lead (Pb) in the air in the administrative work area is very small amount so that it can hardly be detected with levels below 0.00046 mg/m3.The value of the lead content in the air of the painting location which will be used in the next analysis use an average value of 0.06834 mg/m3.

Laboratory Check Result of Blood Lead Levels

Testing of lead levels in the blood was carried out by Environmental Laboratory Mechanical Laboratory and Calibration Mutiara KebonagungSidoarjousing the Atomic Absorbance Spectrophotometer method. The results of testing the blood lead levels of research respondents can be seen in the following table 2.

The results of testing the level of lead in the blood of all research respondents had an average value of 8.6 µg/dL with a standard deviation of 3.98. The smallest lead content was at 2.884µg/dL and the highest value was at 15.478µg/dL.

Table 2. Blood Lead Levels Laboratory Test Result

Exposed Group Blood Lead Levels (µg/dL)	Unexposed Group Blood Lead Levels (µg/dL)
8.592	8.036
9.125	6.029
8.612	6.151
9.921	5.335
7.938	3.438

Cont... **Table 2. Blood Lead Levels Laboratory Test Result**

8.149	5.106
8.503	2.884
15.114	3.176
13.822	
15.478	
13.552	
14.287	
Mean = 11,09108	Mean = 5,01938
StandarDeviasi = 3.04628	StandarDeviasi = 1.77142
Min-Max = 2.884 - 8.036	Min-Max = 7.938 - 15.478

Laboratoty Check Result of Hemoglobin Levels

Hemoglobin levels were measured by the cyanmethemoglobin method by Sarana Medika's laboratory can be seen in the following table 3. The average value of the hemoglobin levels of all respondents was 14.284g/dL with a standard deviation of 0.9. The smallest lead content was at 2.884µg / dL and the highest value was at 15.478µg / dL.

Table 3. Hemoglobin Levels Laboratory Test Result

Exposed Group Blood Lead Levels (µg/dL)	**Unexposed Group Blood Lead Levels (µg/dL)**
13.62	14.14
13.71	13.97
14.74	13.98
15.05	13.97
15.10	13.07
15.95	14.37
14.75	14.10
15.16	14.98
12.00	
13.30	
15.36	
14.36	
Mean = 14.4250	Mean = 14.0725
Standard Deviation = 1.09133	Standard Deviation = 0.52806
Min-Max = 12,00 – 15,95	Min-Max = 13,07 – 14,98

The Differences Blood Lead Levels Between the Exposed and Unexposed Group

From table 4, it can be seen that the average value of lead (Pb) levels in the blood between exposed and unexposed groups shows different values. The exposed group had a mean value of 11.09 µg/dL with a standard deviation of 3.046, while the unexposed group had an average value of 5.02 µg/dL with a standard deviation of 1.771. Both values were tested using the Student Independent T-test, and obtained a ρ-value of 0.00. The statistical test showed significant results because of ρ-value <0.05 then H_o was rejected, which means that there was a difference in Blood Lead Levels between the exposed and unexposed groups

Table 4. The Differences Blood Lead Levels Between the Exposed and Unexposed Group

Respondent Group	N	Mean	Standard Deviation	Lavene Test	t-Test Independent
Exposed Respondent	12	11.09108	3.046289	ρ = 0.003	ρ = 0.000
Unexposed Respondent	8	5.01938	1.771427		

The Differences Hemoglobin Levels Between the Exposed and Unexposed Group

According to WHO standards in 2011, the hemoglobin level in the blood of an adult male (≥15 years) is above 13g/dL[12]. From the table 3 above, it can be seen that the respondents have normal hemoglobin levels. There is only 1 respondent who has hemoglobin levels that are below the standard.

Table 5, shows the results of the blood hemoglobinlevels of the exposed and non-exposed groups of respondents. The mean value of the exposed group was 14.425 g/dL with a standard deviation of 1.09. Meanwhile, the unexposed group showed an average yield of 14.0725 g/dL with a standard deviation of 0.52.

Of the two groups, the lowest minimum value is in the exposed group with a value of 12.00 g/dL. Tests using the Student Independent T-test statistical test showed the results of ρ-value>0.05, so the results were not significant and H_o was accepted. From these tests, it can be concluded that there is no difference in hemoglobin levels between the exposed and unexposed groups.

Table 5. The Differences Hemoglobin Levels Between the Exposed and Unexposed Group

Respondent Group	N	Mean	Standard Deviation	Lavene Test	t-Test Independent
Exposed Respondent	12	14.4250	0.52806	ρ = 0.048	ρ = 0.349
Unexposed Respondent	8	14.0725	1.09133		

Discussion

This study was conducted at PT. X, which is the largest train manufacture company that produces train to supply local markets and to exports abroad. This research was conducted at the location of the finishing-painting building as a study and the main administration building as a comparison.

Limitation of exposure to chemical substances in Indonesia is regulated through the Peraturan Menteri Ketenagakerjaan No. 5 Tahun 2018 tentangKeselamatan dan Kesehatan KerjaLingkunganKerja. In this regulation, the Threshold Limit Value (NAB) for lead chemicals is 0.05mg/m^3 [13]. This regulation is in accordance with the recommendations of OSHA, NIOSH, and ACGIH which all state that the Threshold Limit Value for lead exposure is 0.05mg/m^3. The administration office point has a very low lead exposure, this is because the administration building is isolated from outside air. All areas in the building have a central air conditioning system, so the air quality, temperature and humidity are well maintained.

Meanwhile, in painting workshops there are 2 points whose amount of exposure match to TLV, but there are also 2 points that exceed the TLV.Painting A and painting D are the same sampling points, but taken at different times. In the results of laboratory check, painting A and painting D tended to be consistent giving a very high exposure. This is because at the time of sampling, painting points A and D have a highproduction activity as well. At this location there is no mechanical exhaust, so the air circulation is not good. In addition, this point is the location where the colored paint was applied so that the lead level released would be even higher.According to research conducted by Kasanah (2016), the color painting process will provide greater lead exposure than painting without color[14].

Next is painting B, this location is where the primer coating is applied as a base paint. This location has installed a mechanical exhaust, there is a large fan to liquefy the air so that the air circulation is good enough, it causes point B have a lead exposure that does not exceed the TLV value. In facts, in the painting workshop at points A, B, and D already have a local exhaust for do painting, but the painting workers do their work not in the local exhaust.

The last one is painting C, this point is the place for the application of colored paint. Painting C is located in a building where a central exhaust system has been installed. When the painting process will begin immediately, all doors will be closed and the exhaust system will be activated. The exhaust system is working by circulating the air in the building through the ventilation holes below and then flowing it out of the building, meanwhile clean air is flowed into the building from above. According to Hasbiah (2016) in her research in the parking area, which states that another factor that can affect lead levels in the air is ventilation. The better the exchange of clean air to the exposed area, the lower the lead content in that air[15].

Lead exposure in the human body can be checked through several biomarkers including blood, hair and nails, bones and teeth, urine, saliva and sweat, and cement. However, the most common method and gives the best result is measurement of PbB through blood. According to the CDC in 2010, adults (≥16 years) can be considered lead poisoning if the lead level in the blood shows a number ≥10 µg/dL. From examining result of blood lead levels, this study showed that there were 5 respondents from the exposed group who had blood lead levels reaching ≥10 µg/dL, while the remaining 15 respondents are ≤10 µg/dL.

According to the comparative test of the two groups' lead levels using an independent t-test, the result shows thatρ-value = 0.00 which can be interpreted that there is a difference in blood lead levels between the exposed and unexposed groups. The results of the examination of the exposed group had higher blood lead levels than the unexposed group. This is consistent with Muliyadi's research, the results of his research at car painting workshops showed that the lead levels in the blood of painting workers were higher than administrative workers with an average of 11.20:8.25 µg/dL[16].

The increase in lead in the blood (PbB) caused by exposure to Pb that enters through inhalation, ingestion, and dermal will accumulate in the blood as much as 95%[10]. The largest absorption of Pb is through respiration, so that Pb in the air contributes most of Pb in the blood. Toxins through the respiratory tract will quickly enter the body in significant amounts. Because in the respiratory tract, there is analveoli with a very thin

Indian Journal of Forensic Medicine & Toxicology, layer, and it is a place for oxygen and carbondioxideexchange from blood which is directly related to the blood circulatory pathway. That way, the respiration is the most dominant entry route for toxins[17].

The existence of lead in the body can interfere with the synthesis of heme through three mechanisms, there are by disrupting the incorporation of Glycine and Succinyl Co-Enzyme A, depression against ALAD, and disrupting the Ferrochelatase enzyme which functions to combine iron (Fe) with protoporphyrin[16].

The results of hemoglobin levels medical examination can be seen at table 3. According to the WHO 2011 standards, the normal amount of hemoglobin levels for adults (> 15 years) are ≥13g/dL. The majority of respondents in all studies had normal hemoglobin levels, only 1 respondent was classified as light anemia with an Hb 12g/dL from the exposed group.Then the comparative test of hemoglobin levels between the two groups was calculated by using the Independent T-test analysis, from the results of the analysis obtained ρ-value = 0.349 which could be stated that there was no difference in hemoglobin levels between the exposed and unexposed groups.

The no differences between the two groups might occur because indeed the lead levels in the blood of the respondents were still within normal limits.According to the American Conference on Governmental Industrial Hygienists, the highest value of Biological Exposure Indices which is a best practice for practitioners to be applied in carrying out lead biomonitoring is 20µg/dL[18]. OSHA provides a maximum limit for the BEI for lead is 50 µg/dL. If workers get a blood lead level of>50 µg/dL, then the worker must be temporarily suspended from work or transferred to another job until the lead level shows a value of<40 µg/dL[19].Meanwhile, the Indonesian government through the Peraturan Menteri Ketenagakerjaan No. 5 tahun 2018 regulates the BEI limit for lead in blood is 30 µg/dL[13]. From all recommendations, the lead levels in the research respondents' blood were still at normal levels. This may cause no significant difference in hemoglobin levels between the exposed and unexposed groups.

Conclusion

Based on the results of research that has been held at PT. X, can be concluded that there are 2 points in the painting area whose exposure value exceeds the recommendation value. However, this can be prevented by enforcing the use of mechanical ventilation for painting workers. Between the two groups, there was a difference in blood lead levels where the exposed group had higher blood lead values than the unexposed group. However, there was no significant difference in hemoglobin levels between the two groups.

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