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Effect of Lead Exposure in the Air to Blood Lead Levels on Lead Smelting Workers

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Abstract- Human exposure to lead resulting from the contribution of natural factor is low. However, the extensive use of this metal in various sectors has resulted in a significant increase of its concentration in the environment. The aim of this study was to know the effect of lead exposure in the air to blood lead levels on lead smelting workers. Study population included chronically lead exposed males workers. The study sample consisted of 24 male workers who were divided into two different groups. Workers in the first group were lead smelter workers, while workers in the second group were unexposed healthy volunteers as control for comparison. The results indicate the blood lead levels of exposed and unexposed groups between 3.80 - 121.5 µg/dL, the average of blood lead levels in exposed group was 87.57 µg/dL and the unexposed group was 6,9 µg/dL. The average of environmental levels of lead in exposed group was 0,14 mg/m^3, and the average of environmental levels of lead in unexposed group was 0,002 mg/m^3. Higher blood lead levels consentration was significantly assosiated with the airborne lead levels (β =0.948 ; p=0.000). These study highlight that airborne lead levels had a positive relationship with blood lead levels. A linear relationship between airborne lead levels and the increase of blood lead levels was observed.

Keywords : Exposure, Lead, Blood Lead Levels, Smelting, Workers

1. INTRODUCTION

Increased industrial activity will produce a wide range of wastes released into the environment and ultimately have an impact on public health. One of the dangers that need attention in connection with industrial development is their exposure to hazardous and toxic substances in the workplace. The most hazardous types of waste for the environment and health is the waste classified as hazardous and toxic waste. Hazardous and toxic waste pollution can be through the soil, water, or air. The pollution causes environmental degradation. One of the hazardous and toxic waste that should be of concern are wastes containing heavy metals one of which is lead. This heavy metal wastes are toxic and persistent, so as to endanger human health and the environment.

Human exposure to lead resulting from the contribution of natural factor is low. However, the extensive use of this metal in various sectors has resulted in a significant increase of its concentration in the environment. Mining, smelting, waste inceneration, acid battery recycling are anthropogenic sources of lead emissions in to the environment (ATSDR, 2007; WHO, 1995; Karrari et al., 2012; Minozzo et al., 2008)

Lead and its compounds into the human body through the respiratory system, through gastrointestinal and dermal contact. Health hazards posed by airborne lead levels related to particle size and the volume of air that is able inhaled. The smaller the particle size of the Lead and the increasingly large volume of respirable air, the greater the concentration of Lead that is absorbed by the body. The first effect on chronic lead poisoning before it reaches the target organ is a disturbance in the biosynthesis of haem for more than 90% Lead metal is absorbed by the blood, binds to red blood cells (erytrocyt). Although the number of Lead in absorbed by the body only slightly, it is still dangerous because it can cause interference to various organ systems such as the nervous system, kidneys, reproductive, endocrine and digestive system (Palar, 2008).

Lead pollution in the air needs to get serious attention, because a variety of health effects caused. Until the year 2012 in Jabodetabek has identified 71 locations of lead contaminated land due to the recycling of batteries. One of the locations contaminated by lead is Cinangka Village, District Ciampea Bogor. The results showed lead levels in soil reach 270.000 ppm (270.000 mg / kg), while standards set by WHO for a maximum of 400 ppm (400 mg / Kg), in addition, levels of lead in the blood of people in the surrounding existing up to 65 µg/dL. These

concentrations exceed the safe limit set by WHO is 10 µg / dL (Ministry of Environment, 2013).

Research conducted over the past decade has shown that there was statistically significant association of lead exposure in low concentrations in the environment with the incidence of renal dysfunction in the population. This study made use of both cross-sectional (Navas-Ancien et al, 2009; Ferraro et al, 2010) and prospective cohort study designs (Kim et al, 1996; Yu et al., 2004).

According to research conducted by Muliyadi (2015) note that there was statistically significant airborne lead levels to blood lead levels (β = 0.667; p= 0.000) and no effect blood lead levels with renal impairment (β = 0.572; p = 0.038) in car painting workshop workers in Surabaya.

The aim of this study was to analyze the effect of lead exposure in the air to blood lead levels on lead smelting workers.

2. RESEARCH METHODS

This research is an observational research conducted cross-sectional study. Sampling in this study using simple random sampling or simple random sampling. The study population was all employees smelting of lead in Tegal and after calculation of the samples obtained 24 workers as respondents in this study. The sample size was 12 workers for each group by using the formula (Hulley et al., 2006) :

$$n = \frac{2 \cdot \sigma^2 \cdot (Z_\alpha + Z_\beta)^2}{(\mu_1 - \mu_2)^2}$$

Information :

n : sampel size of each group
Zα : Adjusted standard deviation for α 1 way test (1,65).
Zβ : Adjusted standard deviation for β (0,84).
σ : SD response to the comparison group (1.52)
μ_1 : The average of blood lead levels in the sampel group (7.24 µg/dL)
μ_2 : The average of blood lead levels in the comparison group (5.84µg/dL)
(Pasorong et al., 2007)

Respondents in this study were divided into two groups of lead-exposed and unexposed groups of lead, each group a total of 12 respondents. Respondents who follow the research is lead smelter workers who met the inclusion criteria, among others; male, aged between 20-50 years, working period> 2 years old, had no history of diabetes, no history of chronic kidney disease and are willing to follow the procedures in this study.

Data collection technique by interview using questioner include age, smoking habits, as well as period of work. Blood sampling as much as ± 10 cc by phlebotomy officer of the laboratory, then the blood sample analyze by using Atomic Absorption Spectrophotometry (AAS). Dataset was analize with multiple linear regression by using the statistical program.

Blood specimen collection refers to the Decree of the Minister of Health of the Republic of Indonesia No.1406 / Menkes / SK / XI / 2002 on inspection standards for lead levels in human biomarker specimen. Lead levels compared with Biological Exposure Index (BEI) or an index value for the biology exposure. According to WHO normal values in adults is 10-25 µg / dL.

3. RESULTS AND DISCUSSION

Description of the results of blood lead levels in workers smelting of lead in Tegal Regency can be seen in Table 1.

Table 1. Distribution of Airborne Lead Levels and Blood Lead Levels of lead smelting workers in Tegal 2016

Parameter	Mean±SD	Min	Max
Airborne Lead Levels (mg/m^3)	0.113±0.117	0.0007	0.0455
Blood Lead Levels (µg/dL)	47.24±43.22	3.8	121.5

Source : The primary data source

The mean blood lead levels in workers is 47.24 µg/dL, with a minimum grade of 3.8 µg/dL and a maximum of 121.5 µg/dL. Blood lead levels of workers has exceeded the Biological Exposure Index (BEI) or an index value for the exposure biology. According to the World Health Organization (WHO) in adult normal value is 10-25 µg/dL.

Lead levels in the air were measured in lead smelting site and at the District office workspace Talang, so the results illustrate the presence or absence of exposure to workers. Airborne lead levels were measured using the method SNI 7248: 2009 on methods of measurement with static levels of lead in the workplace. The results of measurements of airborne lead levels in the workplace, at the site of fusion obtained lead in the air amounted to 0.13608 mg/m^3, whereas airborne lead levels in Talang district office work place of 0.002 mg/m^3.

Based on Minister of Manpower and Transmigration No.Per.13/MEN/X/2011 on the Threshold Limit Value Factor Physical and Chemical Factors at Work, that the threshold values of lead in the workplace air is 0.05 mg/m^3. So that the levels of lead in the air at the location of the lead smelting has exceeded the threshold value and the requisite risk of causing health problems in workers.

Lead exposure in workers smelting lead can enter through the respiratory, gastrointestinal and skin. The entry of lead compounds in the blood will provide lead compounds dissolved in the blood is carried around the body system. Circulation of blood enters

the glomerulus is part of the kidney. The glomerulus is a process of separation of the end of all blood-borne materials. Lead dissolved in the blood will move into the urinary system (kidneys) that can lead to damage to the kidneys. Damage occurs due to the formation of intranuclear inclusion bodies is accompanied by symptoms amnociduria, namely the excess of amino acid in the urine (Palar, 2008).

Lead excretion process which takes place in the kidneys can cause adverse effects on the kidneys. Although the kidney weight is only about 0.5% of the total weight, the kidneys receive blood by 20% - 25% of the cardiac output through the renal artery. The high flow of blood to the kidneys that cause a wide variety of drugs, chemicals and heavy metals in the systemic circulation was sent to the kidneys in large numbers. These toxic substances accumulate in the kidneys and cause kidney damage.

Proximal tubule is the most frequently damaged due to exposure to nephrotoxic agents. Predisposing factors resulting in proximal tubular cells are easily damaged is the role of the proximal tubule reabsorb 60% - 80% results in glomerular filtration. Another predisposing factor is the extent of the surface areas of tubular reabsorption, active transport system for ion and organic acids, as well as the ability to concentrate substances tubules. Active transport systems for ions, acids - organic acids, low molecular weight proteins, peptides and heavy metals mostly occurs in the proximal tubule, causing accumulation and toxicity to the proximal tubules which ultimately resulted in damage to the proximal tubules.

Besides causing direct tubular damage, toxic substances also has the ability to damage the kidney through external effects by influencing the hemodynamic, immunological system, as well as metabolites of a substance. Some toxic substances can alter intrarenal hemodynamics that trigger vasoconstriction. Prolonged vasoconstriction resulting in decreased perfusion pressure, decrease glomerular hydrostatic pressure, decreased GFR and tissue hypoxia due to reduced flow of oxygen and nutrients that the eventual destruction of the tubules. (Schnellman et al, 2001; Kumar et al, 2005).

Table 2 Description of the characteristics of lead smelting workers in Tegal 2016

Variable	n	Mean±SD	Min	Max
Age (year)	24	37.91±6.54	25	47
Period of work (year)	24	14.67±6.88	4	26
Smoking habits (stems per year)	24	106.17±98.94	0	380

Source : The primary data

In this study, there are several confounding variables such as age, period of work and smoking habits. The average age of lead smelting workers is 37.91 years, the average period of work is of 14.67 years, while the average of smoking habit is 106.17 stems per year.

Effect of airborne lead level, age, smoking habits and periode of work toward blood lead levels were analyzed using multiple linear regression with the following results:

Table 3 Analysis of the effect of airborne lead levels to blood lead levels on lead smelting workers in Tegal 2016

Variable	Blood lead levels	
	β	P
Airborne lead levels	0.948	0.000
age	-0.149	0.065
Period of work	0.140	0.086
Smoking habits	0.017	0.079

Source : The primary data

Based on Table 3 shows that there is influence between the airborne lead levels to blood lead levels (β = 0.948; p = 0.000). So it can be said that the airborne lead levels affect the blood lead levels on lead smelter workers. While age, period of work and smoking habits does not affect the increase of blood lead levels on lead smelting workers.

This study found an effect between airborne and blood lead levels (β = 0.948; p = 0.000). This result agreed with Karita et al.,(2000) who reported a correlation between blood lead levels and airborne lead levels among the copper-smelter workers in Japan. And this result in line with research conducted by Decharat S et al., (2012) who founded a correlation between airborne and blood lead levels (r =0.747 ; p<0,01) among the nielloware workers in thailand.

The research results obtained in line with research conducted by Muliyadi (2015) which shows that there is influence of the air against the Lead levels Lead blood levels (β = 0.667; p = 0.000). Results of research conducted by Ayub (2005) also showed that there was a significant relationship between the level of blood Lead to Lead in the air (r = 0.815, p <0.05). linear regression analysis found that beyond blood lead increased by 0.22 µg/dL. Lead in the air contribute as much as 66.3% of the variation in blood lead.

Based on this study demonstrated that the blood lead levels on exposure group is higher than the unexposed group. The average of blood Lead levels in the exposed group was 87.57 µg/dL, while the average level of blood lead unexposed group was 6.9 µg/dL. High levels of blood Lead in lead smelting workers because the majority of workers do not wear masks to minimize exposure Lead particles produced from the smelting of lead. The relationship between airborne lead levels and blood lead levels among lead-exposed workers has been the subject of a number of studies. The main pathway for raising blood lead levels among the lead-exposed workers is probably from inhalation route. This is supported by Chuang et al., (1999).

While other exposure pathways, namely digestion because the majority of workers eating and drinking at the site smelting of lead so as to increase the intake of lead via the oral route. And although the pathways of exposure through the skin is often overlooked because the effect is not so great but in this study found the majority of workers use a short clothes. That is still possible direct contact lead particles into the pores of the skin of workers during the melting process progresses.

4. CONCLUSION

These study highlight that environmental levels of lead had a positive relationship with blood lead levels. A linear relationship between environmental levels of lead and the increase of blood lead levels was observed ($\beta = 0.948$; $p = 0.000$), which means that the higher airborne lead levels can increase the levels of worker's blood lead level. Blood lead levels of exposure group had higher levels compared with the unexposed group. The mean blood Lead levels in the exposed group was 87.57 µg / dL (range 54.4 to 121.5 µg / dL), while the average level of blood Lead unexposed group was 6.9 µg / dL (range: 3.8 to 17,2 µg /dL).

Suggestions from this study is the need to implementation of air quality measurement lead in the workplace and routinely as ambient environmental quality monitoring efforts. Management of risk management among other aspects of working time arrangements and the provision of health insurance for workers smelting of lead and reviewing of environmental permits for the smelting of lead.

Aspect Communications, Information, Education and Communication (IEC) in the form of socialization to workers about the importance of using personal protective equipment, the implementation of clean and healthy lifestyle, reducing smoking and regularly taking anti-oxidants. Technological aspects include adjusting the stack height corresponding standard size to minimize the exposure of lead to the environment and workers.

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REFERENCES

[1] Agency for Toxic Substances and Disease Registry, (2007): Toxicological Profile for Lead, Atlanta, GA: Agency for Toxic Substances and Disease Registry, Division and Environmental Medicine/Applied Toxicology Branch; http://www.atsdr.cdc.gov/toxprofiles/tp13.pdf.

[2] Ayub, Ismail, (2005), Aras Plumbum darah dan faktor-faktor yang mempengaruhi di kalangan pekerja kilang pembuat baterai. Jabatan Kesihatan Masyarakat, 2005 Jilid II.

[3] Chuang HY, Lee M.L., Chao K.Y., Wang J.D., Hu H., (1999): Relationship of blood lead levels to personal hygiene habits in lead battery workers: Taiwan, 1991-1997. Am J Ind Med 1999; 35: 595-603.

[4] Decharat S., Kongtip P., Thampoophasiam P., Thetkathuek A., (2012) : An examination of Blood lead levels in Thai Nielloware Workers. Saf Health Work 2012; 3:216-23.

[5] Departemen Kesehatan RI, (2002): Keputusan Menteri KesehatanNo.1406/MENKES/SK/XI/ 2002 Tentang Standar Pemeriksaan Kadar Timah Hitam Pada Spesimen Biomarker Manusia, Jakarta : Departemen Kesehatan.

[6] Heryando Palar, (2008) : Pencemaran dan Toksikologi Logam Berat, Jakarta : Rineka Cipta.

[7] Hulley SB, Cummings SR, Browner WS, Grady D., Hearst N Newman, TB, Eds, (2006), Designing Clinical Research : An Epidemiologic Approach, 3rd Edition, Baltimore : Lippincott Williams and Wilkins.

[8] Karita K., Shinozaki T., Amari N., (2000), Blood Lead Levels in Copper Smelter Workers in Japan. Ind Health 2000; 38:57-61.

[9] Kementerian Lingkungan Hidup, (2013), Penutupan Kegiatan Pemulihan Lahan Terkontaminasi Limbah B3 Tahap 1 Di Desa Cinangka Kecamatan Ciampea Kabupaten Bogor, http://www.menlh.go.id/.

[10] Kementerian Tenaga Kerja dan Transmigrasi, (2011), Peraturan Menteri Tenaga Kerja dan Transmigrasi Nomor PER. 13/MEN/X/2011 Tahun 2011 Tentang Nilai Ambang Batas Faktor Fisika dan Faktor Kimia Di Tempat Kerja, Jakarta : Kemenakertrans.

[11] Kumar V, Abbas AK, Fausto N, editors, (2005), *Robins And Cotran Pathology Basis Of Disease*, 7th ed, Philadelphia : Sauunders Elsevier ; 2005.P.564-566.

[12] Mukono.H.J, (2010), Toksikologi Lingkungan, Surabaya : Airlangga University Press.

[13] Muliyadi, Mukono J, Haryanto Notopuro, (2015), Paparan Timbal Udara terhadap Timbal Darah, Hemoglobin, *Cystatin C* Serum Pekerja Pengecatan Mobil, *Jurnal Kesehatan Masyarakat*, Kemas 11 (1) (2015), Hal.87-95.

[14] Schnellman RG, Goldstein RS, (2001), *Toxic Responses of Kidney*, In Klasen CD, Editor. Casarett and doull's toxicology the basic

sciences of poisons. New York : The Mc Graw-Hill; P.417-430.

[15] Ferraro P.M., Costanz, S., Naticchia, A., Sturniolo, A., Gambaro, G., (2010): Low Level Exposure to Cadmium increases the risk of chronic kidney disease:analysis of the NHANES 1999-2006. BMC Pub.Health 10, 304-311.

[16] Karrari, P., Mehrpour, O., Abdollahi, M., (2012): A systematic review on status of lead pollution and toxicity in Iran; guidance for oreventive measures, Daru 20 (1), 2.

[17] Kim, R., Rotnitsky, A, Sparrow, D., Weiss, S, Wager, C., Hu, H., (1996): A longitudinal study of low level lead exposure and impairment of renal function, The normative Aging Study, JAMA 275, 1177-1181.

[18] Minozzo, R., Minozzo, E., L., Deimling, L.,I., Santos-Mello, R., (2008): Blood Lead Levels in the Battery recycling industry of the metropolitan region of Porto Alegre, RS. J. Bras, Patol, Medlab 44, 407-412.

[19] Navas-Ancien, Tellez-Plaza, M., Muntner, P., Silbergeld, E., Jaar, B., Weaver, V., (2009): Blood Cadmium and Lead chronic kidney disease in US adults; a joint analysis, Am, J.Epidemiol, 170, 1156-1164.

[20] Pasorong M., B.,, Hari Purnomo, Kusha Wijaya, Nawi Ng, Vitalis Pribadi, (2007), Hubungan Antara Kadar Plumbum (Pb) dan Hipertensi pada Polisi Lalu Lintas di Kota Manado, Berita Kedokteran Masyarakat, Vol.23, No.2, Juni 2007, Hal.81-88.

[21] Yu, C.-C., Lin, J.-L., Lin-Tan, D.-T., (2004): Environmental Exposure to Lead and Progression of chronic Renal Diseases: A Four-Year Prospective Longitudinal Study. J.Am.Soc.Nephrol.15, 1016-1022.