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MANAGEMENT OF THE WORK ENVIRONMENT TO REDUCE BLOOD LEAD (BLL) LEVELS IN THE ASSAY LABORATORY

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ABSTRACT

Management of the Work Environment to Reduce Blood Lead (BLL) Levels in the Assay Laboratory. Assay Laboratory in PT Freeport Indonesia's Concentrating Division, especially for conducting fire assay. Litharge (lead oxide) is a reagent used to test mineral levels; the content of precious metals is called Au. Although lead exposure is low, prolonged exposure to lead could accumulate in the human system, resulting in poisoning or toxicity. This study aimed to determine the effect of work environment management in assay laboratories on reducing blood lead levels during fire assay analysis. This research is a quantitative cohort study. The sampling technique used is purposive sampling. Data analysis techniques are used in different tests. Data collection was conducted using laboratory tests to take blood samples once a year regularly for every worker working in the assay laboratory. Based on the results of the different tests, a T value of 5,638 was obtained with a Sig value of 0.011 ($\alpha<5\%$), so it can be concluded that there was a decrease in blood Pb levels in workers before and after managing the work environment. Recommended exposure standards are floor exposure values for laboratories (other than fire test laboratories) not to exceed 2.2 mg/m2 (200 µg/ft2) and surface in dining areas not to exceed 0.43 mg/m2 (40 µg/ft2). Improving working environment conditions by procuring a laundry system and lockers, procuring more than one laboratory coat, procuring sinks in every corner of the laboratory, and having special soap for washing hands has proven to be able to reduce Pb exposure rates in assay laboratories from 2019 to 2022.

INTRODUCTION

Litharge, or lead oxide, is a reagent used in the fire assay laboratory (AAL) to test mineral content, particularly precious metal content, namely Au. This reagent is an important component of the flux material in the testing process, helping to separate the target Au metal from the ore. The biggest source of inorganic lead exposure is the release of particles into the air when fluxing and cupellation materials are mixed [1]. Lead can be absorbed into the body through inhalation or ingestion [2]. Lead has a half-life of approximately 30 days in the blood [3]. After that, the lead diffuses into soft tissues such as the kidneys, brain, and liver. Lead phosphate is then distributed to bones, teeth, and hair [4].

Exposure to inorganic lead can cause adverse health effects. Inorganic lead affects several organs and body systems. These detrimental effects also affect the nervous system, the sense organs, control of the body, and reproduction (5). Lead can accumulate in the body after repeated exposure. Such exposure poses a serious risk to workers who work with and/or near lead-containing reagents. Although the amount of lead absorbed is low, prolonged exposure to Pb can accumulate in the human system, resulting in lead poisoning or toxicity(6). Adverse impacts on health if blood lead is 10 µg/dL or 0.48 µmol/L in adults, where 1 µmol/L is equivalent to 20 µg/dL [2]. The normal function of the nervous system is affected if a person is exposed to lead for a long time. Furthermore, prolonged exposure to lead can have severe effects on both the kidneys and the brain [7]. A fire assay laboratory is a workplace that must be isolated from other work areas because worker exposure to lead must be kept as low as possible. Inorganic lead exposure is best controlled by capturing it at the source. This can be done through engineering controls, such as local exhaust ventilation [1].

The Assay and Analysis Laboratory (AAL) in the Concentrating Division of PT Freeport Indonesia (PTFI) is a laboratory that also carries out fire assays. If lead exposure control measures are inadequate, workers or analysts in fire assay laboratories undoubtedly face significant risks. Blood lead levels were checked and found to be higher than the NAB set by the government of the Republic of Indonesia [8] and international groups like the American Council of Government and Industrial Hygienists (ACGIH), which is 30 µg/dL; the Occupational Safety and Health Administration (OSHA), which is 40 µg/dL; and the Centers for Disease Control and Prevention (CDC), which is 5 µg/dL [9]. The recommended exposure standard is a floor exposure value for laboratories (other than fire test laboratories) not to exceed 2.2 mg/m2 (200 µg/ft2). As for surfaces in eating areas, it does not exceed 0.43 mg/m2 (40 µg/ft2) [1] [10].

Based on the explanation above, the aim of this research is to determine the effect of changes in work environment management in the fire assay laboratory on reducing blood Pb levels in analysts.

MATERIALS AND RESEARCH METHODS

This research is a quantitative study with a cohort study design that aims to compare blood Pb levels before and after changes in work environment management in the fire assay laboratory. The research location is in the fire assay analysis unit at the assay and analysis laboratory (AAL) of the Concentrating Division of PT Freeport Indonesia (PTFI). The research population includes all employees who work at AAL. The sampling technique used was purposive sampling.

Parametric statistical testing is the data analysis technique used. The use of different tests is due to the type of data in the form of an interval scale, namely the results of testing the analyst's blood Pb levels. Data collection was carried out using laboratory tests to take blood from each employee who works at AAL. Blood samples are taken once a year, periodically, to see the increase or decrease in Pb levels in each worker at AAL.

RESEARCH RESULTS AND DISCUSSION

Figure 1 below shows the results of measurements taken from 2011 to 2022, which experienced a fluctuating decline. The period 2011–2013 saw a decrease in workers' blood Pb. However, from 2014 to 2017, blood Pb had an average consistency of over 10 g/dL. A significant decrease occurred from 2018 to early 2022, namely, blood Pb levels were below 10 µg/dL. In general, blood Pb levels in workers are still below the average standards set by

PTFI, OSHA, and ACGIH. The thing that deserves attention is that the average figures until 2022 still do not meet the standards set by the CDC (9).

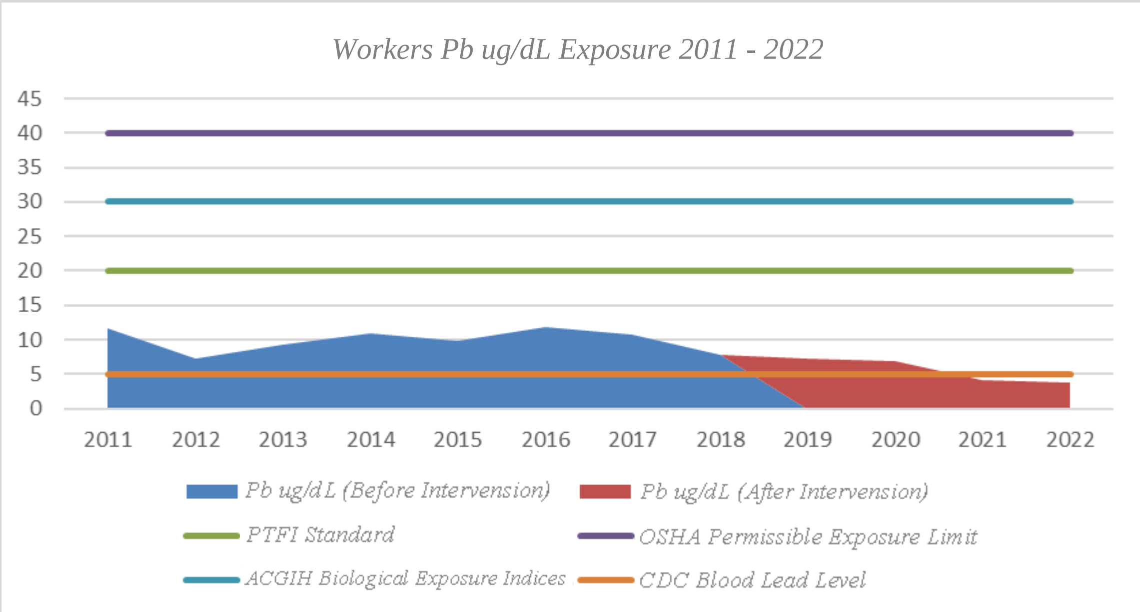

Figure 1. Blood Pb Exposure Graph from Fire Assay Analysts in 2011-2022.

Fire assay analysts are AAL workers with a high risk of Pb exposure [1]. This is because the analyst has to work for 8 hours to carry out the assay work. The series of fire assays starts with weighing flux, weighing ore samples, mixing, fusion, cumulation, and parting in one isolated place with Pb at the workplace. Previous research revealed that there was no detailed explanation for lead poisoning with levels exceeding the ACGIH standard of 30 g/dL in similar laboratories in the United States (US). This is because there are institutional or personal protection measures in place, although they are not yet optimal [11].
The prevalence of blood Pb levels in workers working in workplaces where lead-containing materials were used in the US between 1988 and 1994 was 2.5%. There is an indirect correlation between advanced age and lead poisoning. Another point to consider is that prolonged exposure to lead-contaminated environments can lead to an increase in blood lead levels [12]. Recent research has found a link between high levels of lead in the blood and all types of cancer deaths, including brain cancer, COPD, ischemic heart disease, laryngeal cancer, lung cancer, and non-Hodgkin's lymphoma. There is also a possible link between high levels of lead in the blood and chronic kidney disease and death from rectal cancer [13].

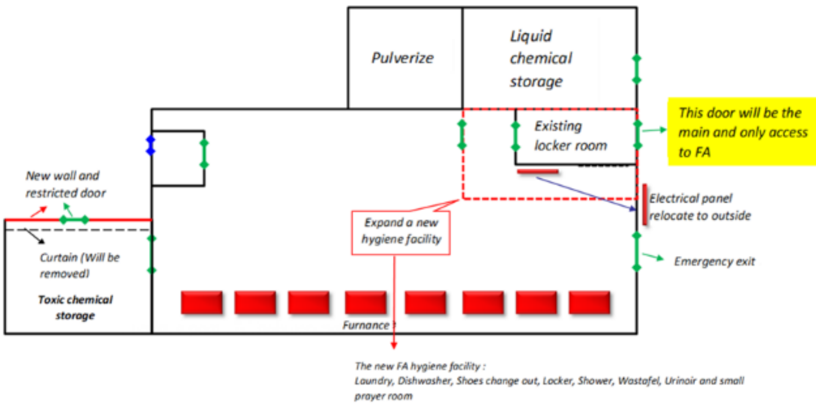

Figure 2. Plan of Assay and Analytical Laboratory Room Placement 2019-2022.

Workplace conditions have an influence, especially those closely related to personal hygiene practices. Prior to 2018, AAL lacked adequate facilities and infrastructure for personal hygiene and standard laboratory sanitation. The availability of facilities ranging from showers, changing room lockers, work shoe facilities, sticky mats, laundry systems, provision of laboratory uniforms and robes, washing soap for special hands, special shampoo and body soap, and sinks can be important variables in reducing lead absorption because analysts can implement better personal hygiene practices. This is particularly true if the fire assay analyst is well-versed in hygiene (14). This condition, where there is a lack of standard facilities and infrastructure at AAL, can illustrate why there can be high Pb levels in workers' blood, with an average of more than 10 μg/dL.

Personal hygiene practices have the primary goal of improving health (15). The facilities provided by AAL before 2018 still do not meet the standards set by OSHA. According to OSHA, a written lead compliance program must include a description of the operations where lead is emitted and how the facility will comply with OSHA standards. According to previous research, when workers work without a cleaning area to create lead-free clothing, it increases lead exposure in the worker's blood (16).

The study's findings from a comparison of fire assay laboratories in 2018 provide steps for AAL management to transform the design of the laboratory room, as depicted in Figure 2. The change in AAL's floor plan aims to reduce lead exposure for fire assay analysts. The function of dividing and separating the assay and analytical rooms is to ensure that lead emitted into the air during the analysis process does not spread to other rooms. This will certainly improve the quality of the indoor environment and, as a result, prevent lead from being absorbed by other workers (17). Figure 3 shows how the intervention was carried out. It involved improving the facilities and infrastructure in the flux mixing area and adding a dust hood to collect dust that contains lead during the analysis process. Additionally, assay analysts can limit lead exposure by adhering to safe work practices and maintaining mixing consistency (1) (18).

Picture. 3. Intervention in the Mixing Flux Area.

Hand mixing of flux and ore should be done in a hood-ventilated area. The mixing speed and tool used to stir the flux must be chosen accordingly. This is intended to minimize the amount of dust containing lead released into the air. This work must be performed and completed on a side draft or downdraft capturing hood. Side-draft capturing hoods, they must have a baffle system with more than one perforated opening to ensure laminar flow through the open front of the hood. For this type of hood, the face operational speed should not exceed 0.64 meters per second, or 125 feet per minute, because speeds exceeding this create eddies in the air current that allow contaminated air to reach the worker's breathing zone. If contaminants cannot be captured adequately with a face velocity of 0.64 m/s (125 ft/min) or less, a different type of hood should be used (1) (19).

Picture. 4. New Design on Fume Hood and Flooring.

Another intervention carried out to control the amount of lead dust is the use of a new design for the fume hood and flooring, as in Figure 4. The canopy-style hood effectively captures dust. In the mixing process, the hood is placed 1.2 meters (4.0 feet) above the work area. In addition, it increases air flow into the hood by 850% [20]. To improve the effectiveness of a canopy hood system, increase the fan size and/or speed of the existing system and install a secondary canopy hood over the furnace door. A secondary hood for smoke capture is most effective when it extends at least 10 cm (4 inches) beyond the front and sides of the door and maintains a face velocity of at least 1.5 m/sec (300 ft/min) [21]. Another work environment improvement is by making enhancements to hygiene and sanitation facilities (lockers, shoe changing places, showers, laundry, sinks, and small prayer rooms) for workers who carry out fire assay work, as depicted in figure 5. Environmental health management is also carried out By creating separate chemical storage rooms, management has also considered door access to minimize Pb exposure to workers around the laboratory area. Visitors or non-lab workers entering the fire assay area are also given limited access.

Figure 5. Hygiene and Environmental Health Management 2019 until now.

When mixing and handling samples that have been mixed with flux, disposable gloves should be worn. Fine lead particles easily stick to the skin and are difficult to remove [22]. Disposable gloves should also be worn when cleaning lead-contaminated areas and when handling lead-contaminated equipment. Controls must also be in place to mitigate the risk of thermal burns when working in fusion and cuplation furnaces, as well as hot samples. Hand and arm guards used for this purpose must be rated to protect against radiant heat emitted from the furnace and against splashes of molten material.

Fire assay analysts should wash their hands and faces before eating, drinking, or smoking. Hand washing stations should be equipped with nail brushes to remove lead from under nails. Several studies have shown that common decontamination procedures involving soap and water alone do not successfully remove lead from skin (24). Some soaps that specifically remove metal impurities, such as lead, perform better than regular soap and water alone. Lead removal effectiveness has also been shown to increase when scrubbing with a textured surface or rag (22). The amount of lead remaining in workers' hands after hand washing has been correlated with the levels of lead found in workers' blood. This shows the importance of hand washing in reducing Pb exposure (25). Environmental health management has undergone a significant transformation. Each worker who works has been provided with a laundry system and lockers. In addition, providing more than one lab coat as a form of best practice for each worker can increase time efficiency when starting work. Providing sinks in every corner of the laboratory and having special soap for washing hands has proven to be able to reduce Pb exposure rates in the ALL area from 2019 to 2022

CONCLUSIONS AND RECOMMENDATIONS

A significant decrease occurred from 2018 to early 2022, namely, blood Pb levels fell to below 10 μg/dL. Workers' blood Pb is already below the average standard set by PTFI, OSHA, and ACGIH, although by 2022 it will still not meet the standards set by the CDC. AAL's work environment management has an influence on reducing the blood Pb levels of fire assay analysts. Improvement of working environment conditions is carried out by providing a laundry system and lockers, procuring more than one laboratory coat, providing a sink in every corner of the laboratory, and having special soap for washing hands, which has been proven to be able to reduce Pb exposure rates in the AAL area from 2019 to 2022. Improving conditions, We implement the work environment by creating hygiene and sanitation facilities for workers carrying out fire assay work, which can be regularly maintained to ensure the creation of high-quality facilities.

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