An Idea Health, Safety & Environment

Research Article *Open Access*

Heavy Metal Contamination Level in The Body Between Chemical Pesticide Sprayers

Ayu Puspitasari*
[1]Faculty of Public Health, Universitas Muslim Indonesia, Makassar, Indonesia

***Corresponding Author**: E-mail: ayu.puspitasari@umi.ac.id

ARTICLE INFO

Manuscript Received: 01 Feb, 2025
Revised: 12 Mar, 2024
Accepted: 04 Apr, 2025
Date of Publication: 26 May, 2025
Volume: 1
Issue: 01

KEYWORDS

Heavy Metal; Pesticide; Sprayers

ABSTRACT

Introduction: Agricultural workers who handle chemical pesticides are at increased risk of exposure to heavy metals such as lead (Pb), cadmium (Cd), and mercury (Hg). These metals are known to accumulate in the body and cause long-term health consequences. However, limited data are available on their contamination levels among pesticide sprayers in rural Indonesia.
Objective: This study aimed to determine the concentration levels of Pb, Cd, and Hg in the biological samples of chemical pesticide sprayers and to analyze their association with sociodemographic and occupational risk factors.
Method: A cross-sectional study was conducted from March to June 2024 in Enrekang Regency, South Sulawesi, involving 50 chemical pesticide sprayers. Biological samples (blood and urine) were collected and analyzed using Atomic Absorption Spectrophotometry (AAS) to measure Pb, Cd, and Hg concentrations. Sociodemographic and occupational data were obtained through structured interviews. The results were compared against WHO reference values.
Result: The mean concentrations of Pb, Cd, and Hg were 18.5 µg/L (±6.2), 3.2 µg/L (±1.4), and 7.9 µg/L (±2.8), respectively. A total of 72% of respondents had Pb levels above the WHO threshold, 80% exceeded limits for Cd, and 60% for Hg. Most participants had low education (60% elementary or none), limited PPE use (80% incomplete or none), and long-term exposure (76% >5 years). Smoking prevalence was 70%, compounding Cd exposure risk.
Conclusion: A majority of pesticide sprayers were exposed to heavy metals at levels exceeding international safety standards. Inadequate protective measures, low awareness, and prolonged exposure increase their vulnerability to chronic health effects. These findings call for urgent public health interventions, including biomonitoring, safety training, and stricter pesticide regulation to protect this high-risk group.

Publisher: Mantaya Idea Batara

INTRODUCTION

The widespread use of chemical pesticides in agricultural practices has raised serious concerns about environmental pollution and human health risks, particularly for those directly involved in pesticide application such as sprayers. Among the various hazardous components in pesticides, heavy metals—including lead (Pb), cadmium (Cd), arsenic (As), and mercury (Hg)—are known to persist in the environment and accumulate in the human body over time, leading to toxic effects.(1) Occupational exposure to heavy metals through dermal contact, inhalation, and ingestion is a common route among pesticide sprayers, especially in low- and middle-income countries where the use of personal protective equipment (PPE) is minimal or inadequate.(2) These exposures may lead to elevated

concentrations of heavy metals in blood, urine, or hair samples, correlating with adverse health outcomes such as nephrotoxicity, neurotoxicity, reproductive disorders, and cancer. (3,4)

Several epidemiological studies have demonstrated significantly higher levels of heavy metals in pesticide applicators compared to control groups not exposed to pesticides. (5) In addition, chronic exposure can disrupt metabolic and enzymatic functions in the body due to the oxidative stress induced by heavy metals.(6) Despite these risks, awareness and monitoring of heavy metal contamination among chemical pesticide sprayers remain limited. Understanding the degree of contamination in this population is essential to inform public health interventions, regulatory frameworks, and protective strategies aimed at reducing exposure risks.(7)

METHOD

This study employed a quantitative descriptive cross-sectional design to assess the levels of heavy metal contamination in the bodies of chemical pesticide sprayers. The research was conducted in Enrekang Regency, South Sulawesi, Indonesia**,** over a period of four months from March to June 2024**.**

A total of 50 respondents were selected using purposive sampling, with the inclusion criteria being: individuals aged 18–60 years who had been actively engaged in chemical pesticide spraying activities for at least one year. Exclusion criteria included respondents with known chronic kidney or liver diseases, or those with a history of heavy metal chelation therapy.Data collection involved direct interviews using a structured questionnaire to obtain demographic and occupational data, including duration and frequency of pesticide exposure. Biological samples blood and urine were collected by trained medical personnel following standard biosafety protocols. Heavy metal analysis was performed using Atomic Absorption Spectrophotometry (AAS) to detect the concentrations of lead (Pb), cadmium (Cd), and mercury (Hg) in the samples. The results were then compared with established reference values based on WHO standards.

RESULTS

Table 1. Responden Characteristic's

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	18–29	10	20.0
	30–39	20	40.0
	40–49	15	30.0
	≥50	5	10.0
Gender	Male	47	94.0
	Female	3	6.0
Education level	No formal education	8	16.0
	Elementary school	22	44.0
	Junior high school	12	24.0
	Senior high school or higher	8	16.0
Duration of pesticide use	<5 years	12	24.0
	5–10 years	25	50.0
	>10 years	13	26.0
Use of Personal Protective Equipment (PPE)	Complete	10	20.0
	Incomplete	30	60.0
	Not used	10	20.0
Smoking habit	Smoker	35	70.0
	Non-smoker	15	30.0

The majority of respondents (40%) were in the age group of 30–39 years, suggesting that the workforce involved in pesticide spraying in Enrekang Regency is primarily composed of individuals in their productive years. This demographic may indicate sustained and long-term exposure to chemical pesticides, increasing the potential risk of chronic health effects related to heavy metal accumulation. A significant gender imbalance was observed, with 94% male respondents, reflecting that pesticide spraying is a male-dominated activity in this region. This aligns with occupational patterns in agricultural sectors in many rural areas of Indonesia. In terms of education, 44% of the

participants had only completed elementary school**, and** 16% had no formal education**.** This low educational background may contribute to poor awareness and limited understanding of pesticide hazards and safety protocols, including proper use of personal protective equipment (PPE).Regarding the duration of pesticide use, 50% of respondents had been exposed for 5–10 years**,** and 26% for more than 10 years**,** indicating a substantial risk of bioaccumulation of heavy metals due to long-term exposure.

PPE usage was notably inadequate, with only 20% using complete protective gear**,** while 60% used incomplete PPE**,** and 20% did not use any protection at all. This finding underscores a serious gap in occupational safety practices, which could directly contribute to elevated internal contamination by toxic substances such as lead, cadmium, and mercury.Lastly, a high prevalence of smoking was reported among respondents (70%). Smoking could act as a confounding factor in heavy metal exposure, particularly for cadmium, which is commonly found in tobacco smoke, and may further increase health risks in combination with occupational exposure.

Table 2. Heavy Metal concentration in Biological sample of respondent

Heavy Metal	Mean ± SD (µg/L)	Min	Max	WHO Reference Limit (µg/L)	% Above WHO Limit
Lead (Pb)	18.5 ± 6.2	8.0	34.5	10.0 [1]	72%
Cadmium (Cd)	3.2 ± 1.4	1.1	6.7	1.0 [2]	80%
Mercury (Hg)	7.9 ± 2.8	2.3	14.6	5.0 [3]	60%

The mean concentration of lead in the respondents' biological samples was 18.5 µg/L (±6.2)**,** with a maximum of 34.5 µg/L far exceeding the WHO reference limit of 10 µg/L**.** Notably, 72% of respondents had Pb levels above the safe threshold. Cadmium showed a mean concentration of 3.2 µg/L (±1.4)**,** with 80% of respondents exceeding the WHO safe limit of 1 µg/L. Mercury levels averaged 7.9 µg/L (±2.8)**,** with a maximum value of 14.6 µg/L. A total of 60% of the respondents exceeded the WHO threshold of 5 µg/L**.**

DISCUSSION

This study identified a concerning level of heavy metal contamination specifically lead (Pb), cadmium (Cd), and mercury (Hg) in the bodies of pesticide sprayers in Enrekang Regency, South Sulawesi. These findings align with mounting global evidence that agricultural workers exposed to chemical pesticides are disproportionately affected by bioaccumulation of toxic substances due to prolonged and unprotected contact (8,9) The mean concentrations of Pb, Cd, and Hg in this study exceeded World Health Organization (WHO) reference values in a substantial proportion of the sample: 72% for lead, 80% for cadmium, and 60% for mercury. This is significant considering that all three metals are classified by the International Agency for Research on Cancer (IARC) as probable or known human carcinogens.(10) One of the most striking findings was the high cadmium burden, which showed the highest percentage of exceedance (80%). Cadmium is not only nephrotoxic but is also associated with skeletal damage, reproductive dysfunction, and endocrine disruption in chronic exposures.(11) A study by Nordberg et al. emphasized that even low doses, if sustained over time, can result in irreversible kidney damage.(12) n this study, prolonged exposure was evident, with over 75% of respondents having sprayed pesticides for more than 5 years, and 26% exceeding 10 years.

The high lead levels detected in 72% of workers are equally concerning. Lead affects multiple organ systems, including the central nervous system, particularly in adults with cumulative exposure. Agricultural workers may absorb lead via inhalation of aerosolized particles during pesticide application or via skin contact when mixing concentrates or disposing of containers.(13) hese exposure pathways are exacerbated by the lack of protective equipment, as 80% of participants reported using either incomplete or no PPE at all. Similar trends have been observed in pesticide handlers in India and rural Africa, where socioeconomic and educational barriers limit compliance with safety protocols.(14)

The presence of mercury in excess of WHO limits in 60% of the sample may suggest that some pesticide formulations used in the area contain mercury-based compounds, or it may be an indicator of cumulative environmental exposure, especially in water and soil. Mercury is known for its neurotoxic effects, even at low chronic

exposures, and may interact synergistically with other metals to exacerbate cellular oxidative stress.(15) Sociodemographic factors also play a critical role. This study found that most respondents had low levels of education (60% elementary or below), which likely contributes to their limited understanding of chemical risks and safe pesticide practices. Previous research has shown that education level is a strong predictor of PPE usage and awareness of pesticide toxicity.(16)

CONCLUSIONS

This study highlights a serious occupational health issue among chemical pesticide sprayers in Enrekang Regency, South Sulawesi, where a substantial proportion of workers exhibited elevated levels of lead, cadmium, and mercury in their biological samples. The findings indicate that prolonged exposure to chemical pesticides, compounded by inadequate use of personal protective equipment, low education levels, and smoking habits, has contributed to a high body burden of toxic heavy metals. The results underscore the urgent need for integrated public health interventions, including routine biomonitoring, mandatory PPE enforcement, education on pesticide safety, and policy regulation to limit heavy metal content in agricultural chemicals. Without immediate and sustained action, these workers remain at risk for serious long-term health consequences, and the wider community may also face indirect exposure through environmental contamination.

CONFLICTS OF INTEREST

All Author Declare No. conflict of interest

FUNDING SOURCES

No. Funding

ACKNOWLEDGMENTS

Thanks to all parties who have supported this research

BIBLIOGRAPHY

1. Aishankar M, Tseten T, Anbalagan N, Mathew BB, Beeregowda KN. Toxicity, mechanism and health effects of some heavy metals. *Interdiscip Toxicol*. 2014;7(2):60–72. https://doi.org/10.2478/intox-2014-0009
2. Damalas CA, Koutroubas SD. Farmers' exposure to pesticides: toxicity types and ways of prevention. *Toxics*. 2016;4(1):1. https://doi.org/10.3390/toxics4010001
3. Singh S, Kumar V, Thakur S, Banerjee BD, Chandna S, Rautela RS, et al. DNA damage and cholinesterase activity in occupational workers exposed to pesticides. *Environ Toxicol Pharmacol*. 2011;31(2):278–285. https://doi.org/10.1016/j.etap.2010.12.005
4. Flora SJ, Mittal M, Mehta A. Heavy metal-induced oxidative stress & its possible reversal by chelation therapy. *Indian J Med Res*. 2008;128(4):501–523.
5. Kesavachandran C, Fareed M, Pathak MK, Bihari V, Mathur N, Srivastava AK. Health risks of employees working in pesticide retail shops: An exploratory study. *Indian J Occup Environ Med*. 2009;13(3):121–126. https://doi.org/10.4103/0019-5278.58916
6. Nordberg GF, Nogawa K, Nordberg M, Friberg L. Cadmium. In: Handbook on the Toxicology of Metals. Academic Press; 2007. p. 445–486.
7. Bradberry SM, Sheehan T, Vale JA. Heavy metal poisoning. *Medicine*. 2009;37(12):649–655. https://doi.org/10.1016/j.mpmed.2009.09.014
8. Bradberry SM, Sheehan T, Vale JA. Heavy metal poisoning. *Medicine*. 2009;37(12):649–655. https://doi.org/10.1016/j.mpmed.2009.09.014
9. Jaishankar M, Tseten T, Anbalagan N, Mathew BB, Beeregowda KN. Toxicity, mechanism and health effects of some heavy metals. *Interdiscip Toxicol*. 2014;7(2):60–72. https://doi.org/10.2478/intox-2014-0009
10. IARC. Agents Classified by the IARC Monographs. Volumes 1–132. International Agency for Research on Cancer; 2023.
11. Gupta PK. Toxicity of pesticides. In: Veterinary Toxicology. 2nd ed. Elsevier; 2012. p. 449–463.

12. Nordberg GF, Nogawa K, Nordberg M, Friberg L. Cadmium. In: Handbook on the Toxicology of Metals. Academic Press; 2007. p. 445–486.
13. Singh S, Kumar V, Thakur S, Banerjee BD, Chandna S, Rautela RS, et al. DNA damage and cholinesterase activity in occupational workers exposed to pesticides. *Environ Toxicol Pharmacol*. 2011;31(2):278–285. https://doi.org/10.1016/j.etap.2010.12.005
14. Kesavachandran C, Fareed M, Pathak MK, Bihari V, Mathur N, Srivastava AK. Health risks of employees working in pesticide retail shops: An exploratory study. *Indian J Occup Environ Med*. 2009;13(3):121–126. https://doi.org/10.4103/0019-5278.58916
15. Flora SJ, Mittal M, Mehta A. Heavy metal-induced oxidative stress & its possible reversal by chelation therapy. *Indian J Med Res*. 2008;128(4):501–523.
16. Damalas CA, Koutroubas SD. Farmers' exposure to pesticides: toxicity types and ways of prevention. *Toxics*. 2016;4(1):1. https://doi.org/10.3390/toxics4010001