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ECOLOGICAL AND HEALTH RISKS OF MERCURY EXPOSURE (A Systematic Literature Review)

Ekawaty Prasetya[1], R. Susanti[1], *Eram Tunggul* Pawenang[1], *Yuni* Wijayanti[2]
[1] Public Health Science, Faculty of Medicine, Universitas Negeri Semarang
[2] Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang
Corresponding author: ekawaty8144@students.unnes.ac.id

Abstract. Mercury, also known as quicksilver, is a liquid metal that is silver in color, odorless, shiny, a good electrical conductor, with a freezing point in the range of -38.9°C and a boiling point in the range of 357°C. Mercury is a heavy metal that is highly toxic and easily mixes with enzymes in the human body, resulting in the loss of enzyme ability as a catalyst for important bodily functions. Mercury has the unique ability to combine with other elements to form organic and inorganic compounds. Exposure to increased levels of organic and inorganic mercury can damage the brain, kidneys, and developing fetus. Furthermore, higher levels of mercury exposure over a shorter period can cause damage to the lungs, increased heart rate, vomiting, diarrhea, nausea, and skin rashes. Metals are always found in both fresh and saltwater, although in small amounts. Some types of metals, whether light or heavy, are present in small quantities in water under normal conditions. Heavy metals in water are rarely in atomic form but are bound to other compounds, forming molecules. The objective of this literature study is to analyze the ecological and health risks of mercury exposure in order to obtain recommendations related to control and use efforts. The literature review used a comprehensive strategy in searching for journals both nationally and internationally. This literature review was written based on the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. The search strategy utilized electronic databases such as ScienceDirect, ResearchGate, Google Scholar, SemanticScholar, and Springerlink. The keywords used were "Hg pollution" for the search in international journals, and "Risk Exposure of Hg" and "environmental health" for the search in general. The search results were then filtered based on full text availability and publication date from 2016 to 2022, resulting in 1005 articles that were considered relevant. These articles will be further screened based on inclusion criteria for the systematic literature review.
Keywords: mercury, environmental health, health risks

1 INTRODUCTION

Mercury (Hg) is a metallic element that has many uses in various sectors, including in cosmetics, industry, and agriculture. However, the use of mercury has significant impacts on the environment and human health.

The effects of mercury on human health span various sectors, including cosmetics, industry, and agriculture. In cosmetics, mercury is often incorporated to expedite the achievement of a lighter and clearer facial complexion; however, its presence can instigate skin irritation, redness, and an artificial skin radiance. Moreover, adverse outcomes such as inhibited fetal growth, miscarriages, fetal demise, and infertility have been associated with mercury exposure [1]. Furthermore, prolonged exposure to mercury in cosmetics may escalate the risk of skin cancer and severe kidney failure [2]. In industrial settings, mercury finds application in diverse sectors such as streetlight production, battery manufacturing, and plastics production. However, its utilization in these industries can result in poisoning owing to air and water pollution. Similarly, in agriculture, mercury serves as a pesticide to combat fungi and pests in crops. Nonetheless, its agricultural use can lead to mercury accumulation in the food chain, thereby posing a poisoning risk for individuals who consume mercury-contaminated fish.

Mercury has a significant impact on the environment, particularly in terms of air and water pollution. Its presence in various industries can cause contamination of both air and water, which poses a threat to natural ecosystems. While inhaling mercury vapor can result in poisoning, ingestion usually does not have toxic effects unless there is an underlying fistula or gastrointestinal inflammatory disease [3]. Additionally, environmental pollution caused by mercury spills in industrial settings worsens the problem by contaminating water,

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soil, and air, ultimately leading to the poisoning of natural ecosystems. These spills pose a significant risk to environmental health and require strict measures for containment and cleanup.

The objective of this literature study is to analyze the ecological and health risks of mercury exposure in order to obtain recommendations related to control and use efforts. Ultimately, the goal of this investigation is to raise awareness about the dangers of mercury exposure and advocate for the implementation of comprehensive management and utilization strategies to protect both human health and the environment

2 METHOD

This literature review was written based on the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.

2.1 The Search Strategy

The method used in this literature review search employs a comprehensive strategy such as searching for journals both nationally and internationally. The search strategy utilizes electronic databases such as ScienceDirect, ResearchGate, Google Scholar, Semantic Scholar, and SpringerLink. The keywords used are (Hg Pollution) while the search in international journals includes (Risk Exposure of Hg, environmental health). The search results are then filtered based on full text and publication date 2010-2023, where 1005 articles were found to be relevant and further screened based on inclusion criteria to be used for the literature review. Subsequently, these 1005 articles were reselected based on their relevance to the aim of this study by reading the title and abstract of each article, resulting in a total of 10 articles analyzed (Figure 1).

2.2 Data extraction

After the articles have been selected, they are analyzed and relevant information is extracted. This relevant information includes the study, year, title, method, research results, and recommendations. The results obtained are then reviewed for their relevance to the risks of Hg exposure to health and the environment, as well as efforts for control and use.

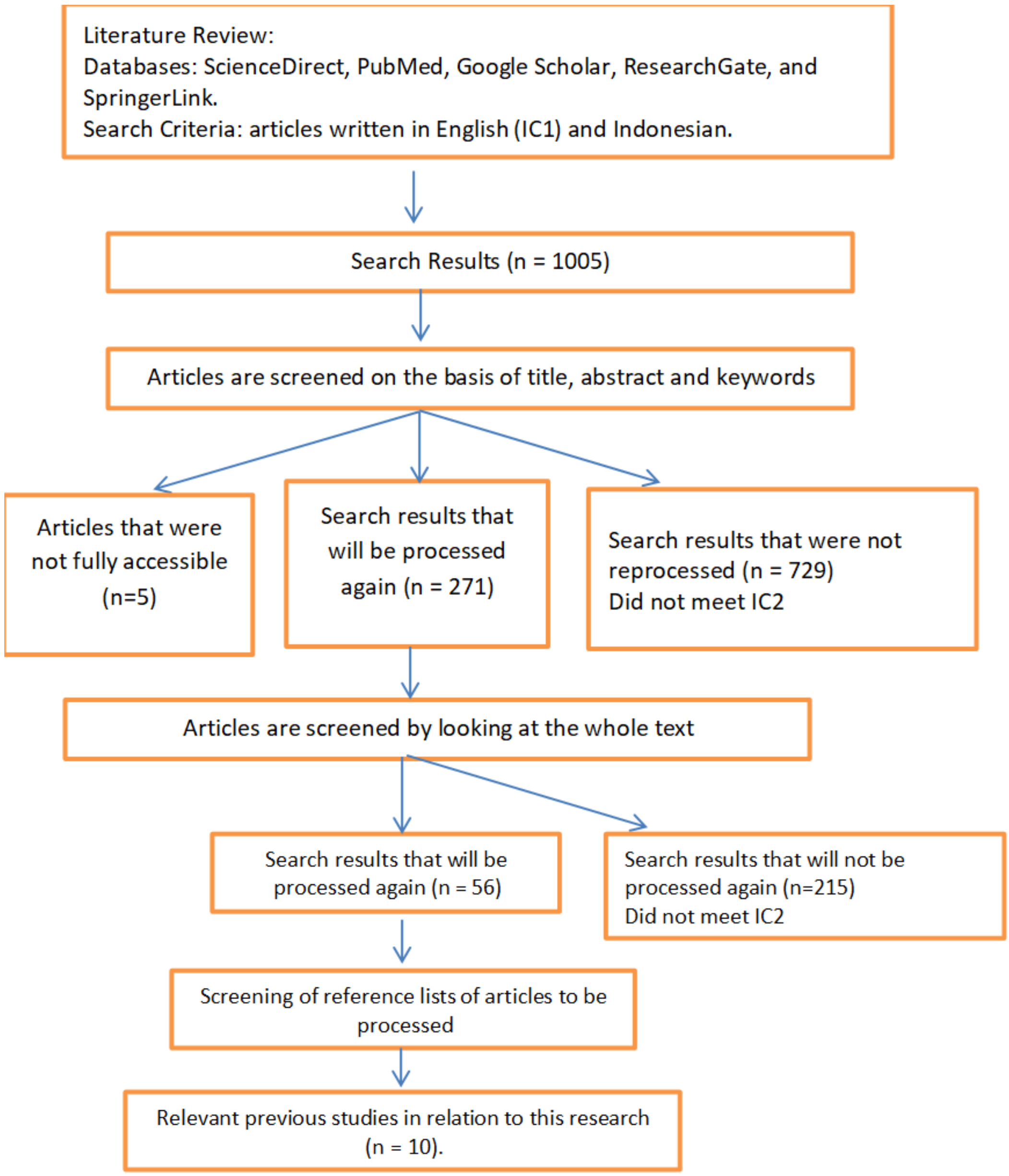

Figure 1. Research flowchart

3. RESULTS AND DISCUSSION

Table 1. Related Journals / Research Articles "Ecological and Health Risks of Mercury Exposure" (A LITERATURE STUDY)

No	Title, Researcher/Year	Subject	Location	Method	Results	Recommendation
1	Konsentrasi merkuri pada ikan di perairan laut Sulawesi akibat penambangan emas tradisional Buladu Kabupaten Gorontalo Utara (Mahmud et al., 2018 [4])	The fish that live in the depths of the water and on the coral reefs and rocks in the Sulawesi Sea. The types of fish used as samples are white snapper, red snapper, and grouper.	North Gorontalo Regency	Sampling was conducted randomly. Mercury sample analysis in fish using Flameless AAS.	• The research findings indicate that the highest mercury concentration in white snapper fish (Chrysaphrys urata) is 2.2977 mg/kg with a weight of 380 grams. The second highest is found in red snapper fish (Lutjanus russeli) with a mercury concentration of 2.0071 mg/kg and a fish weight of 310 grams. The lowest concentration is in grouper fish at 0.3154 mg/kg with a fish weight of 140 grams. Fish weighing between 220 - 700 grams, both red and white snapper fish from the Lutjanidae family, have mercury concentrations ranging from 1.1201 - 2.2977 mg/kg. These results are above the quality standard set according to the Decree of the Director General of POM No. 03725/B/SK/VII/89, where mercury should not exceed 0.5 mg/kg. For fish weighing between 120 - 180 grams, mercury concentrations range from 0.3154 - 0.9080 mg/kg. Based on these results, the mercury concentration tends to be above the established quality standard.	• Waste treatment is necessary to reduce pollution to the surrounding environment, such as phytoremediation.
2.	Heavy Metals in Water of Stream Near an Amalgamation Tailing Ponds in Talawaan – Tatelu Gold Mining, North Sulawesi, Indonesia	The concentration of heavy metals in the water sample.	North Sulawesi	The Inductive Coupled Plasma/Mass Spectrometry method (ICP/MS, APHA–3125–B,	The levels of arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn), and mercury (Hg) in the small river near the tailing pond amalgamation in the Talawaan-Tatelu PESK activity are higher compared to other PESK mining activities in Indonesia and the average global metal content	• The technique of amalgamation still produces relatively higher gold content, thus necessitating the use of alternative techniques.

No	Title, Researcher/Year	Subject	Location	Method	Results	Recommendation
	(Palapa & Maramis, 2015 [5])			2005) is employed.	in river water, but lower than the water quality standards in Indonesia.	
3.	Analisa Potensi Pencemaran Merkuri Pada Sungai Ongkag Dumoga Akibat Kegiatan Pertambangan Emas Tanpa Izin (PETI) (Bouty et al., 2022 [6])	Mercury, BOD, pH, COD, and DO.	Dumoga District, Bolaang Mongondow Regency, North Sulawesi.	Mercury Pollution Load Analysis.	Based on the analyzed data, it is evident that the mercury content in the surface water of Sungai Ongkag Dumoga is still considered safe as it does not exceed the threshold set in Government Regulation No. 82 of 2001, Class II.	• Efforts that can be made to minimize the potential pollution caused by mercury can include the use of phytoremediation methods and the establishment of communal wastewater treatment plants. These strategies are highly effective for any activities carried out by the community. • River water quality monitoring should be conducted at least once every 6 months.
4	Assesing The Risks of Mercury Contamination In Terrestrial Systems At Artisanal Buladu Gold Mine In Gorontalo Province (Mallongi et al., 2014 [7])	The amount of mercury in dry deposition, soil surface, and food materials.	Gold mining in the village of Dembe, Buladu, Bone Bolango Regency, Gorontalo Province	THg using AAS (Atomic Absorption Spectrometry) Ecological Risk Analysis Health Risk Analysis.	• The dry deposition HQs for soil and surface water are 10 and 1.7 respectively, posing risks. On the other hand, the THQs for chocolate, coconut, and corn are all below 1, with values of 0.2, 0.2, and 0.1 respectively, indicating no risks. • The terrestrial environmental status in the Buladu gold mine and its surroundings is considered threatened, while local food sources remain safe for consumption.	• It is necessary to have integrated research management and the issuance of regional regulations regarding efforts to control mining activities at research sites.

No	Title, Researcher/Year	Subject	Location	Method	Results	Recommendation
5	Potensi Pencemaran MerkuriI (Hg) pada Tanah Sawah Akibat Pengolahan Emas Dengan Teknik Gelondong (Intania et al., 2019 [8])	Land, sediment, and water.	The district of North Lebong, Lebong Regency, Bengkulu Province..	Laboratory testing is performed on soil, sediment, water, and plant samples.	• The research findings indicate that all samples contain mercury and exceed the threshold value. The highest total Hg in water is 0.44 ppm, in sediment is 58.19 ppm, in soil is 15.44 ppm, and in plants is 16.85 ppm.	• It is essential to conduct an evaluation of the techniques used and continuous monitoring of mercury concentration at the mining site.
6	Human Health Risk Assessment of Artisanal Miners Exposed to Toxic Chemicals in Water and Sediments in the Prestea Huni Valley District of Ghana. (Obiri et al., 2016 [9])	In water and sediment samples, there are As, Cd, Hg, and Pb.	The gold mining area around the Prestea Huni Valley in the region of Ghana	1. Analysis of human health risks.	• The average concentrations of As, Cd, Hg, and Pb in the water samples range from 15 µg/L to 325 µg/L (As), 0.17 µg/L to 340 µg/L (Cd), 0.17 µg/L to 122 µg/L (Pb), and 132 µg/L to 866 µg/L (Hg), respectively. • The average sediment concentrations are below the standard threshold. • The non-cancer human health risk assessment results are 0.04 (Cd), 1.45 (Pb), 4.60 (Hg), and 1.98 (As); HQ > 1 for Pb, Hg, and As.	This outcome necessitates an epidemiological study with case control to establish the association between exposure to toxic chemicals and related diseases, as identified in other studies conducted in various countries, as a basis for developing policy interventions to address the safety issues of small-scale gold mining (PESK) in other countries.
7	Human Health Risk Assessment of Mercury Vapor Around Artisanal Small-Scale Gold Mining Area, Palu city, Central Sulawesi, Indonesia. (Nakazawa et al., 2016	Mercury (0) present in the surrounding air.	Small-scale gold mining in Poboya, Palu City, Central Sulawesi	• Hg (0) is measured using a portable handheld mercury analyzer, which is a mercury	• The average Hg (0) sample point during the day in the city ranges from 2,096-3,299 ng/m^{-3}. Meanwhile, the average daytime Hg (0) in the Poboya gold processing area is 12,782 ng/m^{-3}. • The research findings indicate that 93% of the overall sample population is at risk (hazard quotient ratio ≥1 population sample).	A more advanced mercury recovery system and an environmental education program will be necessary to mitigate the human health risks associated with mining activities.

No	Title, Researcher/Year	Subject	Location	Method	Results	Recommendation
	[10])			analyzer. • Human health risk analysis.		
8	Atmospheric Deposition: Sampling Procedures, Analytical Methods, and Main Recent Findings from the Scientific Literature (Amodio et al., 2014 [11])	Mercury in wet deposition and dry deposition of ambient air	The industrial zone in Taranto, Italy.	cold vapour atomic absorption spectrophotometry	• Simulation models demonstrate that rainfall plays a role in the deposition of mercury from anthropogenic sources in China, which is transported all the way to Taranto, Italy.	An ongoing assessment of the environmental impact of pollutants on the environment is necessary.
9	Spatial Distribution and Ecological Risk Assessment of Trace Metals in Urban Soils in Wuhan, Central China. (Zhang et al., 2015 [12])	Heavy metals (Mercury, Lead, Zinc, Copper, Chromium, and Cadmium).	Urban areas in Wuhan, central China	The Milestone DMA-80 Atomic Absorption Spectrophotometer (AAS) is utilized for the analysis of soil samples using the ordinary kriging spatial analysis method.	Nearly all urban areas in Wuhan are facing a significant ecological risk due to heavy metal contamination in the soil.	Immediate actions need to be taken to address Cd enrichment, and the presence of other metals in the soil should also be reduced, in order to protect human health at the research site.

No	**Title, Researcher/Year**	**Subject**	**Location**	**Method**	**Results**	**Recommendation**
10	Environmental Mercury and Its Toxic Effects (Rice et al., 2014 [13])	Methylmercury	United States	Research on the pathophysiology of specific organ systems associated with mercury toxicity has been explored.	Systemic effects of mercury on cellular, cardiovascular, hematological, pulmonary, renal, immunological, neurological, endocrine, reproductive, and embryonic development.	Taking appropriate measures in the field of public health and prevention to reduce mercury exposure and raise public awareness of the dangers of mercury exposure.

3 DISCUSSION

Based on the study on the risks of mercury exposure to the environment and human health, several articles recommend the following important points:

Prevention and Control of Mercury Use

1. Use Limitation: Due to its negative impacts, the use of mercury is being increasingly restricted. In the 1980s, the understanding and awareness of the health and environmental hazards of mercury led to a sharp decline in its use. By 1992, the use of mercury in batteries had decreased to less than 5% compared to 1988, and the use of mercury in electrical devices and light bulbs had decreased by 50% during the same period [2].
2. Regulations and Laws: Worldwide, mercury production is limited to a few countries with lax environmental laws. The voluntary use of mercury in glass production has been discontinued, and the use of mercury in fungicides and pesticides has been banned in the United States.
3. Prevention of mercury bioaccumulation requires actions such as reducing mercury emissions from industrial sources, monitoring mercury concentrations in the environment, and educating the public about the health and environmental risks of mercury exposure [14].
4. Other efforts that can be undertaken based on the aforementioned article include minimizing the potential for mercury pollution through phytoremediation methods and the establishment of communal wastewater treatment plants.
5. Attention from relevant agencies, such as local governments, is needed regarding the issuance of local regulations on mercury restrictions and efforts to replace mercury with alternative substances such as borax and cyanide solutions in traditional gold mining.
6. Regular monitoring of river water quality at least once every 6 months and integrated research management on the presence of mercury due to mining activities are necessary.

4 CONCLUSION

In conclusion, the presence of mercury has a considerable effect on both health and the environment, underscoring the necessity of implementing preventive measures and regulating its usage.

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