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Impact of Mercury Pollution from Gold Mining Activities on Buru Island, Maluku: A Literature Review and Potential Health Risks to the Community

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Abstract: Artisanal gold mining (ASGM) in Buru Island, Maluku, particularly at Gunung Botak since 2011, has caused massive mercury (Hg) pollution in the environment, with concentrations in river sediments such as Patipulu River reaching 16 times the safe threshold and contamination up to Kayeli Bay, threatening aquatic ecosystems and food safety through bioaccumulation of methylmercury in the food chain. This literature study used a qualitative approach with systematic analysis of recent scientific sources from Scopus, ScienceDirect, and PubMed to identify environmental, health, and socio-economic impacts, as well as law enforcement challenges. The results show that Hg pollution not only causes environmental degradation such as deforestation and biodiversity decline, but also triggers public health disorders such as nerve damage, kidney, and skin diseases, while its social impacts include inflation, land conflicts, and livelihood shifts from agriculture to mining. The discussion underscored the need for holistic policies based on the Minamata Convention, public education, and adoption of alternative technologies to reduce reliance on mercury, as well as strengthening multisectoral law enforcement for long-term risk mitigation.

Keywords: Buru, gold mining, mercury

1. Introduction

Artisanal and small-scale gold mining (ASGM) is one of the main sources of anthropogenic mercury (Hg) emissions in the world that has a significant impact on the environment and public health (Agustiani et al., 2025). In Indonesia, especially in Buru Island, Maluku, ASGM activities began to grow rapidly since the discovery of gold reserves at Gunung Botak in 2011. The use of mercury in the amalgamation process for gold extraction results in massive mercury pollution in the surrounding environment, especially in adjacent rivers, estuaries and marine waters (Male et al., 2013; Yuliyanti & Aminuddin, 2023). This poses a serious contamination risk to aquatic ecosystems and local food chains that rely heavily on fisheries resources.

Previous research showed that total mercury (THg) concentrations in river and estuary sediments around mining sites on Buru Island exceeded the sedimentation quality limit set by the Indonesian government, even reaching 82 times in some spots. Mercury accumulated

in these sediments has the potential to methylate into methylmercury, a highly bioavailable and toxic compound that easily accumulates in the tissues of marine biota and impacts the food safety of people who consume seafood. This study emphasizes the need for urgent attention to risk mitigation and public education regarding mercury hazards (Reichelt-Brushett et al., 2017).

The public health impact of mercury exposure from ASGM has become a global issue, with an estimated 3.3 to 6.5 million miners worldwide experiencing mild chronic poisoning from mercury vapor (Yuliyanti & Aminuddin, 2023). In Indonesia, it is estimated that hundreds of thousands of people in rural areas involved in ASGM also face the same health risks. Mercury exposure can impair the central nervous system, kidneys, and cognitive function and poses long-term health risks to local communities, especially children and pregnant women (Agustiani et al., 2025).

In addition to health risks, ASGM activities on Buru Island also have complex social and economic impacts. Social changes due to gold mining, such as inflation in the price of basic necessities, decreased agricultural production, and changes in the social structure of the community, have been reported. These conditions exacerbate the community's vulnerability to health and environmental risks caused by mercury pollution, requiring a holistic and sustainable policy approach to address these issues (Rakuasa, Khromykh, et al., 2025).

The Indonesian government has ratified the Minamata Convention on Mercury as a global effort to reduce mercury use and emissions, including in the ASGM sector (Yuliyanti & Aminuddin, 2023). However, the implementation of regulations and supervision in the field still faces many challenges, mainly due to illegal mining activities and limitations of effective and environmentally friendly alternative technologies (Rakuasa et al., 2025). Therefore, a comprehensive literature study is essential to identify potential risks, mitigation strategies, and policies that can be implemented to protect public health and environmental sustainability in Buru Island.

Against this background, this study aims to assess in depth the impacts of mercury pollution from artisanal gold mining activities in Buru Island, Maluku, through a literature review integrating recent scientific findings. The main focus is on the potential public health and food safety risks, while providing evidence-based recommendations for more effective environmental management and health policies. This background incorporates data and findings from credible international and local studies, emphasizing the urgency of the problem and leading to clear and relevant research objectives.

2. Methods

The research method used in this study is a qualitative approach with a literature study method, which aims to collect, analyze, and synthesize information from various written sources relevant to the topic of mercury pollution due to gold mining activities in Buru Island, Maluku. The data collection process was conducted through systematic searches in several reputable academic databases, such as Scopus, ScienceDirect, PubMed, and Google Scholar, using specific keywords related to mercury, artisanal gold mining, environmental impacts, and public health risks. Inclusion criteria included international journal articles and scientific reports published within the last 10 years to ensure relevance and currency of the data. Furthermore, the literature obtained was analyzed descriptively and critically to identify patterns, knowledge gaps, and potential health risks arising from mercury pollution in the study area. This method allows researchers to present a comprehensive picture based on

existing scientific findings while providing evidence-based recommendations for mitigating the impacts of mercury pollution in Buru Island.

3. Results and Discussion

3.1. Level of Mercury Pollution in the Environment of Buru Island

Artisanal gold mining (ASGM) on Buru Island, which began following the discovery of gold at Gunung Botak in 2011, has led to large-scale releases of mercury into the environment (Male et al., 2013). Studies show that drum waste from this mining activity has very high mercury concentrations, reaching 22 ppm, or 22 times the acceptable standard (Male et al., 2013). This released mercury contaminated local rivers, including the Patipulu River and Waiapu River, where mercury concentrations in river sediments were found to be 16-fold above the permissible limit (Male et al., 2013).

The impact of this pollution extends to the estuary and Kayeli Bay, where the rivers estuary (Male et al., 2013). Total mercury concentrations in sediments at the mouths of local rivers and tributaries reached more than 3.00 mg/kg and 7.66 mg/kg, respectively, indicating significant contamination of the aquatic ecosystem (Male et al., 2013). The finding of mercury in sediments at the mouths of some rivers such as Suket (1.62 mg/kg), Wailata (8.27 mg/kg), and Anahoni (4.99 mg/kg) far exceeds the standard set by the US EPA of 0.2 mg/kg, confirming the serious level of pollution in the region (Mariwy et al., 2019).

Water-soluble and sediment-bound mercury is stable and can easily accumulate in the body tissues of aquatic organisms through bioaccumulation and biomagnification processes in the food chain (Male & Sahuburua, 2021). Further studies revealed that river, estuary, and marine ecosystems downstream of ASGM operations on Buru Island are exposed to very high concentrations of Hg, posing serious concerns for food safety, especially for communities dependent on local fishery resources (Reichelt-Brushett et al., 2017). Data from the Ambon Environmental Health Engineering Center in 2012 also showed mercury concentrations in water samples ranging from 0.0049 to 0.0529 mg/L in the region (Mallongi et al., 2020).

3.2. Ecological Impacts and Environmental Degradation

Illegal gold mining activities in Buru Island, Maluku, have caused significant mercury pollution in the environment, particularly in water and soil. Studies show that mercury was detected in various aquatic biota such as crabs and mangrove snails in the estuary, indicating pollution due to unlicensed mining activities at Gunung Botak and Anahoni sites (Irsan et al., 2023). This pollution not only threatens the quality of aquatic ecosystems but also has widespread impacts on river ecosystem damage, deforestation, erosion, and decreased biodiversity on Buru Island (Ashri et al., 2023).

The ecological impact of mercury pollution is very serious, especially because mercury can accumulate in the food chain and threaten the sustainability of ecosystems and the sustainability of biological resources (Male et al., 2013). The decline in fish populations and other aquatic organisms reported by local fishermen shows a direct impact on the welfare of coastal communities who depend on fish catches as a source of livelihood

[9]. In addition, mercury pollution that exceeds the tolerance threshold can cause severe environmental degradation, including river sediment contamination and potential groundwater contamination, risking long-term public health problems [13].

The results of another study also revealed the presence of mercury-resistant bacteria in gold mining waste in Buru Regency, which opens up opportunities for the development of

bioremediation as a pollution mitigation solution. However, pollution control efforts must be supported by strict policies and law enforcement against illegal mining activities, given that the resulting ecological and health impacts are very complex and potentially harmful to the wider community.

3.3. Public Health Risks from Mercury Exposure

Mercury exposure from gold mining activities in Buru Island, Maluku, has caused serious public health risks (Lain et al., 2016). Literature studies show that exposure to mercury through inhalation of vapors and consumption of contaminated fish or aquatic biota can cause neurological disorders, kidney damage, and risks to the reproductive health of local communities (Esdaile & Chalker, 2018). In addition, chronic exposure to mercury can trigger chronic diseases such as liver dysfunction, decreased leukocytes, tremors (Parkinson's-like), numbness, and psychological disorders such as sleeplessness and anxiety, as found in illegal gold miners in various regions (Bose-O'Reilly et al., 2008). This condition is exacerbated by the lack of use of personal protective equipment and lack of awareness of the dangers of mercury among miners and surrounding communities (Rumatoras et al., 2016).

The health impacts of mercury pollution are also evident from the increase in cases of infectious diseases such as ARI, diarrhea, dengue hemorrhagic fever (DHF), and skin disorders indicated by the perception survey of health officials in Buru Regency (Rumatoras et al., 2016). Mercury waste disposed of without adequate treatment pollutes soil and water, causing contamination that has a direct impact on public health. Skin diseases such as reddish patches, thickened skin, and eczema are common complaints in the affected areas. Population mobility and migration due to mining activities also worsen social and health conditions, expanding exposure risks and reducing overall quality of life.

Addressing the health risks of mercury exposure requires a multidisciplinary approach that includes controlling sources of pollution, educating communities, and improving health facilities (Rumatoras et al., 2016). The use of environmentally friendly technologies such as activated carbon to absorb mercury in the gold processing process can reduce the release of mercury into the environment. In addition, strengthening regulation and supervision as well as raising awareness of the dangers of mercury are essential to protect public health and prevent more severe long-term impacts.

3.4. Social and Economic Impacts

Gold mining on Buru Island, Maluku, has brought significant socioeconomic impacts to local communities. One of the main changes is the shift in community livelihoods from agriculture to gold mining, which offers higher incomes in a short period of time. This shift has led to a decline in agricultural labor, threatening local food security and creating competition for access to food resources (Riry et al., 2024; Rohayati, 2018). In addition, the increase in income from gold mining also raises the standard of labor wages, making it difficult for farmers to find cheap labor, which in turn worsens the economic conditions of the agricultural sector.

The social impacts of gold mining activities also include social conflicts arising from struggles over mining land and unclear boundaries of customary land ownership. These conflicts create tensions between mining communities and local indigenous peoples, worsening social stability in the region (Riry et al., 2024. In addition, the price inflation of basic necessities that occurs due to increased demand in mining areas causes additional economic

burdens for communities that are not directly involved in mining. This widened the social and economic gap between communities on Buru Island.

The environmental crisis caused by illegal gold mining has also exacerbated poverty and social instability on Buru Island. Environmental degradation such as deforestation, water pollution, and air quality degradation has led to the loss of traditional livelihoods, especially for farmers and fishermen, resulting in a 15% increase in the poverty rate (Kahfi Maftukhah, 2024). This widespread environmental damage not only impacts economic conditions but also poses public health risks that further threaten the social and economic sustainability of the region (Hehanussa et al., 2023). Addressing the socioeconomic impacts of gold mining on Buru Island therefore requires a holistic approach involving sustainable environmental management and inclusive social conflict resolution (Latue & Rakuasa, 2032).

3.4. Management and Law Enforcement Challenges

Law enforcement against illegal gold mining activities in Buru Island, Maluku, still faces significant obstacles (La Ode Angga & Suat, 2019). Recent studies have shown that weak law enforcement is a major factor causing mercury pollution and environmental damage to continue unchecked. This is exacerbated by the lack of resources of law enforcement officers and the possibility of collaboration between illegal miners and government officials, making enforcement efforts ineffective (Anwar, 2024). These conditions lead to serious environmental impacts and high public health risks due to mercury exposure from these mining activities (Manakane et al., 2023).

In addition to challenges in law enforcement, the limitations of environmentally friendly alternative technologies are also a major obstacle in reducing mercury use in the artisanal gold mining sector. Efficient and affordable mercury-free gold processing technologies are still not widely adopted by mining communities, most of whom still rely on dangerous traditional methods. Lack of education and public awareness regarding the negative health and environmental impacts of mercury also exacerbate this situation, so educational interventions and training on alternative technologies are needed to reduce dependence on mercury (Anwar, 2024).

In terms of policy, law enforcement must be supported by a comprehensive and sustainable approach involving various stakeholders, including central and local governments, law enforcement officials, and local communities (Lumowa et al., 2022). Strict measures such as the crackdown on illegal mining that has been carried out by police officers in Maluku are appreciated, but it is necessary to ensure that these actions are followed by guidance and the provision of viable economic alternatives for mining communities. This multisectoral approach is important to address the root of the problem while minimizing the public health risks of ongoing mercury pollution.

Conclusions

Illegal artisanal gold mining on Buru Island since 2011 has caused very serious mercury pollution in the environment, with mercury concentrations in sewage and river sediments far exceeding safe standards, including in Patipulu River, Waiapu, and Kayeli Bay. This pollution has major ecological impacts, threatening biodiversity, causing declines in fish populations, and damaging aquatic and terrestrial ecosystems through deforestation and erosion. In terms of public health, exposure to mercury through the air and consumption of contaminated aquatic biota causes neurological disorders, organ damage, and increased

infectious and skin diseases in the affected areas. Socio-economic impacts are also significant, including livelihood shifts, land-related social conflicts, and increased poverty due to environmental degradation and inflation of basic needs prices. Law enforcement against illegal mining activities remains weak, exacerbated by a lack of environmentally friendly technologies and public awareness, so pollution control requires a comprehensive multi-sectoral approach, including education, alternative technologies, and policies that have the heart of the community.

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Conflicts of Interest
The authors declare no conflict of interest

References
Abdullah Fikri Ashri, Raynard Kristian Bonanio Pardede, Mohamad Final Daeng, F. P. H. (2023). *Bahaya Mengintai dari Penambangan Emas Ilegal di Pulau Buru*. Kompas.Com. https://www.kompas.id/baca/nusantara/2023/11/07/bahaya-mengintai-dari-penambangan-emas-ilegal-di-pulau-buru

Agustiani, T., Sulistia, S., Sudaryanto, A., Kurniawan, B., Poku, P. A., Elwaleed, A., Kobayashi, J., Ishibashi, Y., Anan, Y., & Agusa, T. (2025). Mercury Contamination and Human Health Risk by Artisanal Small-Scale Gold Mining (ASGM) Activity in Gunung Pongkor, West Java, Indonesia. *Earth*, *6*(3), 67. https://doi.org/10.3390/earth6030067

Anwar, A. (2024). Dinamika Negosiasi Dan Membangun Kepercayaan Pasca Penutupan Tambang Emas Gunung Botak Di Kabupaten Buru. *Bina Hukum Lingkungan*, *1*(1 SE-Articles), 19–35. http://bhl-jurnal.or.id/index.php/bhl/article/view/44

Bose-O'Reilly, S., Lettmeier, B., Matteucci Gothe, R., Beinhoff, C., Siebert, U., & Drasch, G. (2008). Mercury as a serious health hazard for children in gold mining areas. *Environmental Research*, *107*(1), 89–97. https://doi.org/10.1016/j.envres.2008.01.009

Esdaile, L. J., & Chalker, J. M. (2018). The Mercury Problem in Artisanal and Small-Scale Gold Mining. *Chemistry – A European Journal*, *24*(27), 6905–6916. https://doi.org/10.1002/chem.201704840

Hehanussa, F. S., Sumunar, D. R. S., & Rakuasa, H. (2023). Pemanfaatan Geogle Earth Engine Untuk Identifikasi Perubahan Suhu Permukaan Daratan Kabupaten Buru Selatan Berbasis Cloud Computing. *Gudang Jurnal Multidisiplin Ilmu*, *1*(1), 37–45.

Irsan, I., Koto, S., Ismail, I., Dahlan, R., & Mangesa, R. (2023). Dampak Penambangan Emas Ilegal Di Kabupaten Buru Terhadap Konsentrasi Merkuri (Hg) Pada Kepiting Bakau (Scylla Serrata) Dan Keong Bakau (Telescopium telescopium). *BIOPENDIX: Jurnal Biologi, Pendidikan Dan Terapan*, *10*(1 SE-Articles). https://doi.org/10.30598/biopendixvol10issue1page80-90

Kahfi Maftukhah. (2024). Krisis Lingkungan di Pulau Buru: Penegakan Hukum Terhadap Tambang Emas Ilegal. *Sovereignty*, *3*(2 SE-Articles), 108–113. https://journal.uns.ac.id/index.php/sovereignty/article/view/1540

La Ode Angga, L. O. A., & Suat, H. (2019). Legal Responsibility in the Pollution and Environmental Destruction Due to Gold Mining Exploitation in Botak Mountain of Buru Regency. *FIAT JUSTISIA:Jurnal Ilmu Hukum*, *13*(4), 381. https://doi.org/10.25041/fiatjustisia.v13no3.1695

Lain, B., Danudianti, Y. H., & Joko, T. (2016). Analisis Risiko Kesehatan Lingkungan Pajanan Merkuri pada Masyarakat di Area Penambangan Emas tanpa Ijin (Peti) Desa Kayeli Kabupaten Buru Provinsi Maluku. *Jurnal Kesehatan Masyarakat Universitas Diponegoro*, *4*(2).

Latue, P. C., & Rakuasa, H. (2032). Identification of Flood-Prone Areas Using the Topographic Wetness Index Method in Fena Leisela District, Buru Regency. *Journal Basic Science and Technology*, *12*(2). https://doi.org/https://doi.org/10.35335/jbst.v12i1.3673

Lumowa, R., Utomo, S. W., Soesilo, T. E. B., & Hariyadi, H. (2022). Promote Social Order to Achieve Social and Ecological Justice for Communities to Prevent Illegal Artisanal Small-Scale Gold Mining. *Sustainability*, *14*(15), 9530. https://doi.org/10.3390/su14159530

Male, Y. T., Reichelt-Brushett, A. J., Pocock, M., & Nanlohy, A. (2013). Recent mercury contamination from artisanal gold mining on Buru Island, Indonesia – Potential future risks to environmental health and food safety. *Marine Pollution Bulletin*, *77*(1–2), 428–433. https://doi.org/10.1016/j.marpolbul.2013.09.011

Male, Y. T., & Sahuburua, L. F. (2021). Analysis of mercury (Hg) levels in the Patipulu River ecosystem, Kaiely Village, Buru Island. *INTERNATIONAL CONFERENCE ON ENERGY AND ENVIRONMENT (ICEE 2021)*, 1–6. https://doi.org/10.1063/5.0059520

Mallongi, A., Limbong, E., Naiem, F., Ishak, H., Basri, S., Saleh, M., Syam, A., & Asrul, L. (2020). Health risk analysis of exposure to mercury (Hg) and cyanide (CN) in Kayeli village communities Teluk Kayeli district Buru regency. *Enfermería Clínica*, *30*, 427–430. https://doi.org/10.1016/j.enfcli.2020.03.007

Manakane, S. E., Latue, P. C., Somae, G., & Rakuasa, H. (2023). Flood Risk Modeling in Buru Island, Maluku Province, Indonesia using Google Earth Engine: Pemodelan Risiko Banjir di Pulau Buru, Provinsi Maluku, Indonesia dengan menggunakan Mesin Google Earth. *MULTIPLE: Journal of Global and Multidisciplinary*, *1*(2), 80–87.

Mariwy, A., Tuasamu, Y., & Warinah, W. (2019). Mercury (Hg) Distribution in Body of Water at Some Point Waiapu River Buru Island. *The 3rd International Seminar on Education*, 179–186.

Rakuasa, H., Ahmat Rifai, A. R., Latulanit, A. K., Amahoru, A. H., Laitupa, R. A., Diaz Astiza, D. A., & Rajani, L. M. (2025). Detection of Land Cover Change in Nickel Mining Areas, in Weda Tengah Sub-district, Halmahera Island, Indonesia using Planet-Scope Satellite Images. *Frontiers in Sustainable Science and Technology*, *2*(1), 41–50. https://doi.org/10.69930/fsst.v2i1.379

Rakuasa, H., Khromykh, V. V., & Rifai, A. (2025). Spatio-Temporal Analysis of Forest Cover Change in Halmahera and Obi Islands, Indonesia using Hansen Global Forest Change Data on Google Earth Engine. *Journal of Scientific Insights*, *2*(3), 281–291. https://doi.org/10.69930/jsi.v2i3.417

Reichelt-Brushett, A. J., Stone, J., Howe, P., Thomas, B., Clark, M., Male, Y., Nanlohy, A., & Butcher, P. (2017). Geochemistry and mercury contamination in receiving environments of artisanal mining wastes and identified concerns for food safety. *Environmental Research*, *152*, 407–418. https://doi.org/10.1016/j.envres.2016.07.007

Riry, Y., Pinoa, W. S., & Salakory, M. (2024). Socio-Economic Impact of Gold Mining on the Community of Wamsaid Hamlet, Dava Village, Waelata District, Buru Regency. *Jurnal Pendidikan Geografi Unpatti*, *3*(1), 34–43. https://doi.org/10.30598/jpguvol3iss1pp34-43

Rohayati, I. (2018). Illegal Mining Pertambangan Emas Illegal Di Gunung Botak Maluku. *Logika : Journal of Multidisciplinary Studies*, *9*(02). https://doi.org/10.25134/logika.v9i02.2511

Rumatoras, H., Taipabu, M. I., Lesiela, L., & Male, Y. T. (2016). Analisis Kadar Merkuri (Hg) Pada Rambut Penduduk Desa Kayeli, Akibat Penambangan Emas Tanpa Ijin di Areal Gunung Botak , Kab. Buru-Provinsi Maluku. *Indonesian Journal of Chemical Research*, *3*(2), 290–294. https://doi.org/10.30598/ijcr.2016.3-had

Yuliyanti, A., & Aminuddin, A. (2023). Mercury Contamination in Artisanal Gold Mining Sites in Indonesia and the Remediation. *Proceedings of the 3rd Sriwijaya International Conference on Environmental Issues, SRICOENV 2022, October 5th, 2022, Palembang, South Sumatera, Indonesia*. https://doi.org/10.4108/eai.5-10-2022.2328332