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Chemical Waste, Gender, and Social Inequality in Indonesia: A Systematic Review from an Environmental Sociology Perspective

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This study adopts an environmental sociology perspective to examine social and gender disparities in chemical waste management in Indonesia. The main objective is to analyze the impact of chemical waste exposure on vulnerable groups particularly women and to explore state, corporate, and civil society responses. Using a scoping review approach, the research integrates findings from academic databases covering studies published between 2019 and 2024. The review focuses on affected communities, gendered vulnerabilities, and theoretical frameworks in previous research. The findings reveal severe pollution in industrial regions such as Java, Sumatra, and Kalimantan, where inadequate waste management threatens ecosystems and public health. Women are disproportionately affected due to cultural norms that restrict autonomy and decision-making in environmental matters. The study highlights the urgent need for comprehensive policies addressing these vulnerabilities, along with improved public access to environmental impact assessment (AMDAL) documents. Civil society organizations play a critical role in advocating for environmental justice but face barriers from patriarchal structures and state repression. The study concludes that systemic reforms are necessary to strengthen legal frameworks, enhance environmental transparency, and ensure the active participation of women and local communities. Recognizing women's contributions to environmental management is essential for achieving long-term ecological and social justice.

Keywords: Chemical waste, Environmental justice, Gender inequality, Public health, Social disparities

The complex interrelations of chemical waste, gender, and social inequality in Indonesia appear as an important point of reference in environmental sociology. As several studies point out, environmental injustice, in terms of hazardous waste exposure, tends to be a burden carried by marginalized communities, such as women. This is a result of structural inequalities enabled by national industrial policies that prioritize economic growth over environmental equity. For example, studies illustrate how corporate practices limit community-level knowledge gaining and bypass local socio-environmental issues resulting in persistent marginalization and exclusion of vulnerable groups, including women with dual experience of both gender and environmental inequality(Prakasa, 2019; Saes et al., 2021; Wulansari & Adhariani, 2022).Global South nations, such as Indonesia, are particularly susceptible to the risk owing to a lack of strong governance and socio-economic challenges. Empirical evidence establishes that many a time multinationals take advantage of these deficiencies, shifting their most harmful activities to areas where they are least regulated and, concretely, where local communities are disproportionately exposed to polluted environments (Mohammed, 2021; Wright et al., 2022). The place-based environmental governance in Indonesia indicates the limited extent of how corporate social responsibility addresses the devastating effects of industrial waste on local environment and society. This absence of responsibility aggravates gender inequity considering that, especially in a polluted context, women are predominately responsible for health and environmental safety in households, further information the current social discrepancies (Safitri et al., 2024; Zuhri, 2022).

In addition, the influence of corporate governance on environmental policy in Indonesia typifies the intersection of gender dynamics with regulatory shortfall. Studies have shown that female corporate leadership can result in greater social responsibility, yet it is seldom reflected in business environments. As noted by Wulansari and Adhariani, inadequate waste disclosure measures obstruct community awareness and empowerment, which in turn perpetuates gender-based vulnerabilities to environmental (Kaplan & Marantz, 2025; Safitri et al., 2024; Wulansari & Adhariani, 2022). Cross cutting analyses of the environmental public hearings in other situations reveal that women's voices are important, but often quashed in cases of discussion on industrial operation (which may be the case in Indonesia as well) (Gill & Joshi, 2024).

To sum up, the interaction of chemical waste accumulation, gender and social inequality in Indonesia reflects more general patterns of environmental injustice in the Global South. Overcoming these interlocked hurdles will demand a critical examination of ideas and practices inside corporate responsibility frameworks and the nation state's environmental policies and guarantee that they entail gender equity and environmental justice as the constitutive part (Alam et al., 2023; Novitasari & Tarigan, 2022). This kind of more integrated work is definitely needed for achieving equitable outcomes and in empowering underrepresented communities to articulate their environmental and social needs.

The rapid pace of industrialization in Indonesia has put a heavy burden on the management of the environment, in this context environmentally sound chemical waste management from manufacturing, mining and agriculture is of particular concern. Official data and documentary research from government bodies and NGOs indicates that hazardous waste sites are commonly found near urban slums in less affluent districts, including locations in Kalimantan, Papua and major industrial sites like Cilegon and Bekasi. Such communities are often not properly monitored for environmental hazards, do not have adequate sanitation infrastructure, and once drawn in by the novelty and portability of mobile technology, enroll their children in what is, practically, a long-term public health experiment. Mismanagement of the chemical waste is a crucial factor which has caused local environment to become more toxic, bringing about health problems (Artha et al., 2023; Fariz et al., 2024).The class inequalities that structure Indonesian society mean that poor and minority communities, who often have little formal education and their political interests considered, are more likely to be exposed to chemical waste. This demographic imbalance mirrors wider patterns of social stratification in Indonesia, where differences in wealth, educational attainment, and political power are closely linked to geography and ethnicity. By this exclusion, the vulnerable population that suffer the most from environmental burdens, is excluded from decision-making ove r the waste management system (Bintang Ekananda & Rian Sumendar, 2023; Warlina & Listyarini, 2022). Such a systemic lack of care has further drawn attention to the vulnerability of these communities with rising sickness and decreased quality of life.

With Indonesia's fast urbanization and lack of positive waste management policies, the social and economic life in affected communities stretches thin. The decentralised system for SWM has been in operation since 2004 with landfilling being the major option for treatment. Presently, no more than around 60% of waste produced is collected and transported appropriately to depots for the processing of solid waste, creating a great deal of confusion about waste crisis issues in urban areas (Wiharja et al., 2024). The lack of infrastructure and/or its appropriate use paves the way for incorrect public policy which not only worsens waste management problems, but also aggravates social imbalance since the poorest part of the population usually lives exposed to the greatest loads of contaminants.

In addition, dispossession of indigenous land further complicates waste management problems in Indonesia. Indigenous populations are often disproportionately impacted by the encroach of industrial activity that produces hazardous waste. These groups have limited legal recourse to protect their land and are more susceptible to the unregulated practices of industrial companies, deepening the cycle of environmental injustice (Ramadani et al., 2024; N. Wibowo et al., 2021). The class, racial, and regional dimensions point to the need for policy interventions that address environmental and social inequities simultaneously.

Furthermore, Indonesia's informal economy is said to be one of the waste crisis' major drivers. Low-income workers in these industries are carrying out waste collection and recycling work under hazardous and uncontrolled circumstances. Exposure to toxic substances from

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recycling activities, despite its health hazards, is often neglected in mainstream economic policies related to waste management (Rachman et al., 2020; Soesanto et al., 2022). This failure maintains social disparities, for informal workers do not have access to health services and guards against dangerous substances in the workplace.In the end, resolving Indonesia's chemical waste issue requires a comprehensive policy approach that accounts for the health and social-economic interests of vulnerable communities. This requires strong governance mechanisms to ensure a more stringent regulation on the management of hazardous waste as well as promote the involvement of the community in the decision regarding the management of the environment (Cheela et al., 2021). Prioritizing more equitable waste-management policies may contribute significantly to reducing injustices burdening underprivileged populations in order to guarantee that environmental protections are as socially just as they are effective.The gender dimension of environmental risks is apparent in those communities most impacted by toxic chemical waste, which exposes how women's roles interact with systemic inequities. Women in these impacted areas are often primary purveyors of water management, food preparation, and care giving which makes them have heavy exposure to toxic substances. This extra burden, combined with decreased access to resources and knowledge, only makes them more vulnerable. A powerful look at the spread of the AIDS crisis outside the U.S. Biological susceptibilities among women Reducing exposure to toxic chemical substances is a priority for health promotion, but women are especially vulnerable to chemical exposures for biological reasons that may have negative health effects for themselves and their offspring (Eneh et al., 2023; Singh et al., 2020). These gender differences reflect a larger context in which environmental injustices collide with social injustices, rendering women uniquely vulnerable to the negative effects of hazardous waste.

What's more, the exclusion of women from environmental policy-making and community decision-making perpetuates such inequalities. The society is realizing that decisions on land use, industrial regulations, and waste disposal are often taken without much thought on what women think about and need from these actions leading to policies that do not work to reduce the vulnerability of communities of women. These conditions lead to systematic neglect in which women are held responsible for the effects of toxic ecology and have no power to demand their rights and health (Eneh et al., 2023; Exposto & Sujaya, 2021). In arenas that decide the fate of their communities, the voices of women, who have a crucial role to play in determining environmentally sustainable practices, are silenced.

In addition, is the exclusion of women, made worse by poverty as it restricts women's access to crucial adaption resources like health and education. Their inability to access accurate information on environmental dangers means they are ill-informed to react to environmental crises. The marginalization of women in the conversation around the environment constrains their role in improving the management of waste threatening their health and the health of their families. In the absence of enabling systems prioritizing gender inclusion, the wheel of environmental injustice continues to turn, causing a widening disparity in the suffering between women and poverty (Parvez et al., 2021; Zota et al., 2018). These inequalities are key to understanding how environmental ruin reverberates in social formations.

The subfield of environmental sociology offers important tools for analyzing these interlocking problems as it demonstrates how forms of power, institutional neglect and economic systems are all implicated in ecology's degradation and social inequality. This perspective insists that environmental questions are not purely ecological questions, and it situates them very firmly within social and political landscapes, not just in terms of who is in charge and whose voices count, but also in terms of who suffers as a result of environmentally irresponsible practices. Embedding feminist environmental theories within this framework offers a more explicitly feminist instance of how environmental injustices are gendered and classed, and reaffirms the particular needs and concerns of women in marginalized communities in both academic and policy arenas (Butar Butar et al., 2023; Orisakwe et al., 2020). By taking such a broad view we can see that tackling gendered environmental hazards requires building a collective movement for sustainability that brings every part of society to the table in the construction of an eco-just future.

Although there has been a wealth of research on environmental issues in Indonesia, few studies have woven together insights on the complex linkages of pollution, social inequities, and gender relations that we find in the literature today. There is no systematic synthesis that allows coherent storytelling on the extent and effects of environmental deteriorations. In addition, many such studies overlook sociological analysis that seriously considers gender and class as important variables in environmental exposure (Sukmana et al., 2025). This is an especially unfortunate omission when considering the intersection of structural inequalities and environmental justice frameworks, which might offer some insight into how the affects of toxic waste aren't experienced in the same way by marginalized communities especially women than by their male counterparts. Because gender equity analysis is poorly integrated, we are still a long way from being able to fully map how the intersection of state policy, corporate practices and civil society engagements determines environmental outcomes (sociologically speaking).

Given the limitations, improvements in future research, policy, and grassroots work for more equitable environments in Indonesia are necessary. In this regard, this paper proposes to present a review on literature about chemical waste and its socio-gendered impacts, based in environmental sociology and environmental justice theories for emphasize the structural inequalities which preconditions the women's exposure to toxic waste. The study aims to inform policy so that it can recognize and address these disparities by showing how gender roles intersect with other socio-economic variables. This approach can not only contribute to the well-being and health of impacted societies but also inform larger sustainability agendas by recognizing and incorporating the voices and experiences of those typically marginalized in environmental policy-making. This targeted research is intended to lay the groundwork for future analyses to acknowledge and resolve these intersectional vulnerabilities and to ultimately contribute to more inclusive and more successful Indonesian environmental justice campaigns.

Methods

This research uses a scoping review approach, chosen because of its effectiveness in synthesizing literature in multidisciplinary fields such as environmental sociology, gender studies and environmental justice. Scoping review is a tool to explore complex and under-researched intersections, especially in the case of the socio-environmental effects related to exposure to chemical waste in Indonesia. The method is based on the well-established framework by Arksey and O'Malley framework, including five stages: formulating the research question, finding the relevant studies, selecting the studies, charting data, and collating, summarizing, and reporting the results.The guiding question of this review is how exposure to chemical waste interacts with gender inequality and the wider social disparities in Indonesia from the perspective of environmental sociology. What groups or communities are impacted by industrial or chemical waste in Indonesia? What does environmental deterioration mean for gendered vulnerabilities? How has such response been undertaken by the state, corporate actors and civil society? And what have been the theoretical frameworks that researchers have used to address these concerns in earlier studies?

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Peer-reviewed journal articles, reports, and theses	Opinion pieces, blogs, or news articles
Studies focused on Indonesia	Studies focusing entirely on non-Indonesian contexts
Research addressing chemical/industrial waste and environmental impacts	Literature focused solely on organic waste or agricultural waste
Studies discussing gender or inequality in environmental contexts	Technical/engineering-only studies with no social dimension

For a systematic search of the literature, a comprehensive search strategy was designed and implemented for various scholarly databases - including Scopus, Web of Science, ScienceDirect, PubMed and Google Scholar (access to grey literature i.e., theses, reports, institutional publications etc.) is available. The search was constructed based on Boolean operators with key concepts as follow: "chemical waste" OR "toxic waste" OR "industrial pollution" AND "gender" OR "social inequality" OR "environmental justice" AND "Indonesia". Search was

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restricted to 2019–2024, English and Bahasa Indonesia publications. This first stage of titling and abstract screening, was followed by full-text screening for relevance to the needs of the review according to the specified research questions/themes.

To have a concentrated and homogenous evidence base, inclusion and exclusion criteria were used as follows:

All included articles were charted in a data extraction sheet, including author(s), publication date, study location in Indonesia, type of environmental issue (including and not including chemical or toxic waste), populations affected (e.g., low-income women, informal workers, coastal communities), the use of theoretical or conceptual frameworks, and key findings. Furthermore, each registration noted including the policy recommendations and gaps that were in need of further inquiry.The analysis was informed predominantly by main sociological theories that help expose the power relations and structural inequalities of environmental problems. This is the basic lens through which environmental sociology, asking how ecological ruin is connected to social structure. The analysis also draws upon through environmental justice theory (for distributive, procedural, and recognitional injustice) and a feminist political ecology and ecofeminist perspective to examine how gender interacts with social vulnerability. Structural inequality theory also provides lenses for how institutional and economic organisations contribute to the disparate distribution of environmental risks.Underpinning these frameworks, five initial analytical categories were created to structure the literature synthesis: (1) exposure identifying which populations and geographies are most impacted by chemical waste; (2) vulnerability how social and gender-based inequalities affect exposure to environmental harms; (3) agency and resistance how communities respond, organise, or mobilise in response to exposure, vulnerability, and harm; (4) governance and policy how state and corporate policies shape outcomes for environmental justice with respect to chemical waste. Distinctions between these categories evolved by iteration during the analysis.The nature of this review is both exploratory and descriptive. It does not assess the methodological quality of each work since the focus is not quantifying effects, but rather to map the conceptual terrain, detect patters and nuances, and spot directions for further inquiry. It is an academic institutional literature-driven documentary review, a first investigative anchor for future empirical studies and policy development in chemical waste, gender and environmental inequality in Indonesia[69]. The limitations of our study are that unpublished grassroots or community-based sources of data, those not indexed, have been excluded and our inclusion of quality appraisal, which is not routine in scoping research.

Results

Overview of Reviewed Literature

Table 2. Overview of Reviewed Literature

No	Author(s) & Year	Title	Methodology	Key Findings
1	Febrita & Roosmini (2022)	Analysis of Industrial Heavy Metal Pollutant Load on Upstream Citarum River	Water and sediment sampling, AAS analysis	Elevated levels of Cr, Cu, Zn, and Ni in water and sediment; simulation shows that even with effluent quality meeting standards, river water quality standards are not achieved.
2	(Harfadli et al., 2025)	Environmental impact and priority assessment of municipal solid waste management scenarios in Balikpapan City, Indonesia	Waste composition analysis, GHG emission quantification using EQT, scenario modeling, AHP for prioritization.	Scenario C shows 156% GHG emission reduction vs. BAU; AHP prioritizes environmental, policy, and social criteria; Scenario C preferred with 52% score.
3	(Kusmiyati & Fudholi, 2025)	A systematic literature review on the pyrolysis of plastic waste and waste oil for fuel production: Targeted waste management solution for central Java, Indonesia	Systematic literature review (SLR) using Scopus database and Watase UAKE tool; 96 studies categorized into five thematic areas.	Plastic pyrolysis yields higher liquid fuel than waste oil; co-pyrolysis improves fuel yield (84%) and reduces metal impurities; co-pyrolysis fuel closer to diesel performance; AI suggested for optimizing efficiency; research gap in economic and gas by-product analysis.
4	(Frigo et al., 2025)	Where does plastic waste go? Local dynamics of waste flows in Indonesian neighbourhoods	Bottom-up geo-referenced Material Flow Analysis (MFA) of plastic waste across neighborhoods in Bandung; analysis of socioeconomic data and local infrastructure conditions.	Plastic waste generation: 14–20 kg/capita/year; >50% sent to landfill, 25–30% source-separated, 12% uncollected, 1–2% burned; higher source-separation linked to education and income; infrastructure gaps lead to open burning and river dumping; localized strategies and stronger local governance recommended.
5	(Adiansyah et al., 2025)	Environmental impacts of solar PV energy systems for small-island communities in Indonesia: A life cycle assessment approach	Life Cycle Impact Assessment (LCIA) using the ReCiPe method in SimaPro; comparison of two end-of-life strategies: landfilling vs. recycling; sensitivity analysis on transportation logistics.	Recycling solar PV reduces environmental impact by 25% compared to landfilling; proximity of recycling facilities to small islands (e.g., Medang Island) can cut impacts by up to 84%; transport is a major contributor to environmental footprint; localized recycling and tax incentives recommended for sustainable PV deployment.
6	(Kurniawan et al., 2024)	Cases of oil spills in the Indonesian coastal area: Ecological impacts, health risk assessment, and mitigation strategies	Literature review of documented oil spill cases in Indonesian coastal areas; analysis of ecological and human health impacts; review of mitigation strategies and response technologies.	Oil spills primarily caused by tanker/pipeline leaks and ship accidents; major ecological impacts on plankton, fish, birds, and vegetation; human exposure linked to acute and chronic health risks; common mitigation includes cleanup and compensation; recommended future actions: local-specific contingency plans and health impact monitoring.
7	(Wahyono, Sasongko, et al., 2024)	Evaluating the impacts of environmental and human health of the critical minerals mining and processing industries in Indonesia using life cycle assessment	Life Cycle Assessment (LCA) using OpenLCA v2.0 and Ecoinvent 3.8 database; impact assessment conducted with CML-IA Baseline and Environmental Priority Strategies (EPS) methods to quantify environmental and human health impacts.	Gold mining shows the highest global warming potential and health risk (e.g., asthma cases); electricity use and CO_2 emissions are major contributors; fuel oil use linked to respiratory impacts; recommends emission control technologies (e.g., scrubbers, filters) and better regulation of power plants in critical mineral processing.
8	(Y. G. Wibowo et al., 2022)	Impact Of Illegal Gold Mining In Jambi, Indonesia	Mixed methods approach using interviews, questionnaires, and laboratory measurements to assess environmental and socio-economic impacts of illegal gold mining in Jambi Province.	Illegal mining leads to water quality degradation and landscape alteration; communities acknowledge environmental damage but continue due to limited economic alternatives; illegal mining has shifted livelihoods from farming to mining in districts like Sarolangun, Bungo, and Tebo.
9	(Pakasi et al., 2024)	Gendered community-based waste management and the feminization of environmental responsibility in Greater Jakarta, Indonesia	Focused ethnographic fieldwork conducted in Bogor District, Tangerang City, and Depok City (2021–2022), applying a Feminist Political Ecology framework to analyze community-based waste management systems and gender roles.	Waste management practices are heavily gendered, relying on women to perform underpaid or unpaid care work due to societal expectations rooted in ibuism (the state-promoted ideology assigning women the role of household caretakers). This feminization of environmental responsibility sustains gender inequality. The study argues for inclusive waste management policies that involve both men and women and address gendered health and labor burdens.
10	(Faizal Rafli et al., 2021)	Potential health risks of heavy metals pollution in the Downstream of Citarum River	Literature study approach to analyze the levels and health risks of heavy metals (Zn, Cd, Cr, Mn, and Fe) in the downstream area of the Citarum River.	Levels of cadmium and zinc exceed standards, posing health risks through ingestion, inhalation, and skin contact; risks increase with exposure, requiring joint government and community action to reduce pollution and protect health.

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11	(Ruliana et al., 2019)	Assessing a community-based waste separation program through examination of correlations between participation, information exposure, environmental knowledge, and environmental attitude.	Quantitative approach combining questionnaires, interviews, and observations in Tugu Village, Cimanggis, Depok	Participation strongly correlates with information exposure and environmental knowledge, but weakly with environmental attitude. Factors such as daily activities, length of residence, family welfare, facility availability, and community leader roles also influence participation. Routine, credible information dissemination, adequate facilities, and active leadership are crucial to enhancing public involvement in waste separation.
12	Camiliya Fakhriyah Garnita et al., (2024)	Legal Analysis and Social Impact of Environmental Policy in the Modern Era Relating to Plastic Waste	Legal analysis of existing regulations and enforcement mechanisms related to plastic waste management, combined with a social impact assessment through community surveys and industry case studies.	Environmental policies on plastic waste face enforcement challenges, but increased community awareness and participation in recycling programs show positive social impacts. Industry responses vary, highlighting complexities in balancing regulation, consumer behavior, and environmental protection efforts.

The reviewed literature presents a comprehensive examination of various environmental challenges and management strategies in Indonesia, focusing on issues such as pollution, waste management, and their socio-economic implications. The studies encompass a diverse range of methodologies, including empirical research, systematic reviews, and life cycle assessments, providing valuable insights into the impacts of industrial activities, municipal waste management practices, and community engagement in environmental responsibility.Key findings highlight critical concerns such as heavy metal contamination in water bodies, the effectiveness of waste separation programs, and the socio-economic dynamics influencing waste management practices. Additionally, the literature underscores the importance of local governance, community participation, and gender considerations in addressing environmental issues. This overview sets the stage for a detailed exploration of the table contents, which summarizes the methodologies and key findings of each study, thereby illustrating the multifaceted nature of environmental challenges in Indonesia.

The papers cited in the document as a whole serve to identify major environmental problems in Indonesia, especially with regard to pollution, waste disposal, and social interaction. The associated studies all add details to a larger picture of the constellation of chemical waste, environmental degradation, and gender roles and social order, which are helpful references for the current textile "Chemical waste, gender and social inequality in Indonesia."

The effect of industrial pollution, notably heavy metals, on water quality and human health represents one of the central themes covered by the studies. For example, Febrita and Roosmini demonstrate that the Citarum River still have high heavy metal elements compared to its standard despite the effluent discharge is already under the standardized threshold value, suggesting that the overall quality of the river stream might not be back to its previous state (Febrita & Roosmini, 2022). The results are also in agreement with the findings of Muhammad Faizal Rafli who has assessed health hazards due to heavy metal contamination in downstream areas (Harfadli et al., 2025). The consequences of such contamination are particularly harsh for disenfranchised communities, which frequently depend on this water for daily use and suffer disproportionately from associated health risks.The research also looks at waste management approaches, including municipal waste and plastic waste. For instance the study of Giulia Frigo performed identifies the aspects that contribute to the generation and disposal of waste in Bandung society. It notes that people with higher income and education are more likely to sort waste, a fact the paper says provides insight into how social inequality can have environmental effect. This is especially applicable for your study, as it emphasises the way in which resource availability and access to education can affect gender roles and the way in which this is related to addressing environmental issues (Frigo et al., 2025). The work of Pakasi investigates women's participation in waste disposal and identifies that women carry out waste management tasks because of the social expectations and attitudes that help reinforce gender stereotyping (Pakasi et al., 2024).

In addition, the literature stresses the necessity of inclusive and equitable policies that consider environmental and social aspects. The results of the study results of Yoyon Wahyono of the critical minerals mining detail the health risks and environmental implications related to resource exploitation and suggest further refinement of regulation as well as emission control technologies (Wahyono, Adi Sasongko, et al., 2024). Recommendations such as these reflect the need to incorporate a gender perspective at the heart of environmental policymaking to ensure that both men and women are involved in the decision-making processes that impact on their local communities.

To conclude, the literature reviewed provides a multi-dimensional view on the relationship among chemical waste, gender, and social inequality in Indonesia. It demonstrates that environmental problems are not just ecological, but are virtually inseparable from social relations, in the case of gender roles and economic inequalities(Thamrin et al., 2023). Your current work can further advance these results tracing chemical waste management practices that are formulated in a way that can help narrow gender gaps and support social equity resulting in a more sustainable and inclusive of social justice considerations approach to environmental governance in Indonesia.

Geographical Distribution of Chemical Waste Exposure in Indonesia

Indonesia encounters problems in the handling of waste chemicals especially in industrialised and natural resource-abundant areas. The Summary of Chemical Waste Hotspots, Sources and its Environmental Impact in Indonesia table below indicates at least three significant parts of geographical areas such as Java, Sumatra, and Kalimantan are all exposed to their own waste sources and environmental impacts. Java, and in particular around urban areas like Jakarta, Bandung and Surabaya, has become a hotbed of industrial pollution with its densely populated manufacturing zones. Factories dumps heavy metals and poisonous materials straight into lakes and/or rivers such as the Citarum River. One of the most polluted rivers in the world, it accumulates around 280 tons of industrial waste every day, consequently polluting soil and water that the surrounding population depends on (Bank, 2013; Programme, 2018).

Table 3. Summary of Chemical Waste Hotspots, Sources, and Environmental Impacts in Indonesia

Region / Area	Main Sources of Chemical Waste	Types of Chemicals	Environmental Impacts	Notable Cases / Facts
Java (Jakarta, Surabaya, Bandung)	Industrial zones: textiles, electronics, chemicals	Heavy metals (lead, cadmium, mercury), VOCs	Water pollution (Citarum River) Soil contamination Air pollution from burning waste	Citarum River receives ~280 tons of industrial waste daily (UGM News)
Sumatra (Riau, N. Sumatra, Jambi, W. Sumatra)	Palm oil processing, illegal gold mining	Pesticides, fertilizers, mercury	River mercury contamination Aquatic ecosystem damage	Mercury levels in rivers exceed WHO limits by up to 20× (TFI Article)
Kalimantan (South, Central)	Coal and gold mining, deforestation for palm plantations	Mercury, cyanide, erosion-related residues	Contaminated rivers (e.g., Barito River) Groundwater pollution Soil degradation	High mercury levels reported in Barito River (National Geographic)
Central Java & Bali	Agriculture-intensive regions	Pesticides, herbicides, nitrogen/phosphorus waste	Eutrophication Groundwater contamination Soil fertility decline	Overuse of chemical fertilizers leading to long-term degradation of land
Urban Areas (Jakarta, Surabaya)	Household & urban waste: landfills, improper disposal of hazardous materials	Leachate with heavy metals, detergents, medicines	Leachate infiltration Chemical exposure to nearby residents Groundwater contamination	Bantar Gebang landfill releases toxic leachate into surrounding environment (UGM News)

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The main activities that produce chemical waste in Sumatra are palm oil milling and illegal mining, especially in Riau, North Sumatra, and Jambi. Waste water from palm oil processing contains organic matter and chemicals, like pesticides and fertilizers used in cultivation, polluting nearby rivers. In addition, illegal gold mining has caused high mercury levels in water bodies, exceeding the WHO safe standard up to 20 times. Not only are these pollutants wreaking havoc on aquatic environments, but they also present serious health hazards to individuals that drink contaminated water or eat fish from these sources. Coal and extensive deforestation are major sources of chemical waste in Kalimantan. Toxic chemicals including mercury and sodium cyanide are employed throughout the extraction process, and these have polluted essential waterways, including the Barito River. The more palm oil plantations break ground amidst deforestation, the higher levels of soil erosion that it incurs, thus enabling the pollutants to spread across wider territories (Programme, 2018).

Table 4. Types of Chemical Waste and Their Environmental Effects

Waste Source	Examples of Chemicals	Primary Environmental Effects
Industrial Waste	Lead, cadmium, dyes, arsenic, solvents	- Waterway and soil contamination - Bioaccumulation - Aquatic ecosystem damage
Agricultural Waste	Pesticides, herbicides, nitrogen compounds	- Eutrophication - Groundwater pollution - Loss of soil biodiversity
Household/Urban Waste	Batteries, detergents, pharmaceuticals	- Leachate seepage - Air and water contamination - Public health risk
Mining Waste	Mercury, cyanide	- River and fish contamination - Soil toxicity - Risk of mercury poisoning in humans

The second table, Types of Chemical Waste and Their Environmental Impact, categorize chemical waste into the three overall origins: industrial, agricultural, and house hold/urban. Industry is still the biggest source of chemical waste in Indonesia. Volatile organic compounds (VOCs) and heavy metals, as well as hazardous products of textile and electronics industries are thrown into the environment, causing soil depletion, air and water pollution. For example, the textile sector releases dyes and bleach, Electric waste deposits lead, arsenic and cadmium exposing high risk for the ecology and human health (Bouchala et al., 2024).Agricultural chemical waste, while less visible, kills just the same. In places like in Central Java and Bali, agrochemicals overuse has contributed to water pollution as well as nutrient-intervening with in the soil, causing eutrophication and decreased biodervisty. In many cases, such chemicals infiltrate natural water systems, pollute potable water supplies and compromise long-term soil fertility. In big cities, like Jakarta, large quantities of hazardous household waste are also produced (batteries, medicines and detergent). Poor management of garbage in places such as Bantar Gebang also causes toxic leachate to flow into nearby rivers and groundwater, further contributing to environmental and health issues. This layered contamination profile demonstrates how sectors are contributing to a shared problem of degradation that disproportionately affects low-income and marginalized communities especially women who may lack the resources or political clout to pursue remediation and relocation (Suryoadji et al., 2024).

Gendered Dimensions of Environmental Exposure

The gendered aspects of environmental exposure have a powerful impact on women's health and on their well-being, and they are indicative of the inequitable distribution of socio-environmental responsibilities. One crucial factor is the distribution of work and care, which falls disproportionately on women. Women are often responsible for household chores and taking care of children in many societies. This dichotomy does not just restrict their movement to the household but also places them at risk of environmental threats. For instance, women are the most responsible actor of household waste, most of which include toxic materials or pollutants, so they may in that way enhance their exposure, which is associated to different health problems such as those that influence respiratory diseases through the impact of environmental pollutants (Cole et al., 2024).Meanwhile in Indonesia, where women are exposed to dangerous toxins from labour-intensive industries in industrial zones, cultural norms and stereotypes around who does what work widen the gap between men and women. Women are often involved in caregiving and domestic duties--roles that bring them into close physical proximity with toxic waste and that limit their access to social information that is crucial to understanding links between environmental risk and health. For example, women with small scale home based production of tofu in Sidoarjo in East Java women living in nearby the discharge of industrial waste from petrochemical factories get heavily hit. This combination of domestic tasks and pollution exposure has been linked to higher incidence of respiratory diseases in these women and their children (Bolte et al., 2021).The feminization of informal work such as labour in the home, laundry services and food vending contributes as well to the exposure of women to environmental hazards. When women are engaged in periodic and casual forms of labor, they are left outside the confines of formal work protections and safety protocols which make them vulnerable to unsafe working environments. In stereotypical examples, females may be subject to unsanitary conditions and unsafe food serving practices in food vending work, and toxic chemicals in laundry services without proper safety measures. Because of the informal nature of these jobs, women generally lack access to health benefits and recourse should they get injured or sick on the job. This adds to their economic marginalisation and job insecurity, advocating for the immediate development of strong policies that protect the work environment of women in these concerned areas (Adélaïde et al., 2023).Women working in the informal sector are also more likely to work with no safety measures or gear, yet placing themselves at higher risk of injury. A significant proportion of these work environments, including food vending and cleaning of houses, are located in areas where industrial and/or chemical pollution are serious problems. Women's exposure is high in such conditions owing to poor awareness of the environmental health and poor implementation of labor laws (Bolte et al., 2021; Matejova, 2021).

Limited participation in environmental information and decision processes also perpetuates these inequities. Women's voices are sidelined in many of the debates which surround issues to do with environmental policies and projects, therefore their needs and cares are not catered for. This failure to engage erodes women's health and the success of environmental initiatives more broadly, as policies that are inclusive generally provide the best outcomes for community health and environmental sustainability (Abbood & Ibraheem, 2020; Hadi & Abbas, 2023). There is evidence to suggest that excluding women from environmental decision-making bodies impedes community-wide responses to pollution and waste management.Cultural norms are also particularly important in encouraging women‟s muted concerns about the environment. In some cultures, women are expected to be passive and obedient, and women in these settings are unlikely to express their dissatisfaction with environmental problems that pose harmful risks to their well-being. Cultural barriers may hinder women from speaking out for the community's need for environmental protection. This cycle of ignorance is fueled by neglect of women's complaints, and the particular environmental management responses that might benefit them and their families. Moreover, the absence of resources and support for the participation of women amplifies these vulnerability, causing persisting environmental injustices (Matejova, 2021). These interactions are reflected more broadly in the national debate on chemical waste management in Indonesia. Women's work is often at the "dirty" end of the economy, thus they are disproportionately affected by environmental toxins, and lack the resources to avoid the risks. A published case

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study in Sidoarjo illustrated informal women's roles in tofu production generating an untaxed source of income for the economy but exposing these women to chemical pollutants, highlighting how pervasive social disparities may determine environmental health outcomes. Academic Rigour When it comes to the well-being of Indigenous people, some scholars argue that sex- and gender-specific perspectives should be incorporated into environmental management and policy frameworks to ensure equal protection for all citizens (Bolte et al., 2021).

Specific attention and action regarding gender-specific environmental risks are even more compelling in light of the continued struggles that women face to protect their health from pollution. Systematic programs that engage and educate women about environmental risks and health are essential in decreasing these disproportionate effects, achieving not only environmental justice but also social justice. Ultimately, an integrated approach that acknowledges women's responsibilities and vulnerabilities as related to environmental destruction is needed so as to support sustainable and just societies in Indonesia and elsewhere (Bolte et al., 2021; Matejova, 2021).

Governance, Corporate Accountability, and the Role of the State

Even in Indonesia access to Environmental Impact Assessment (AMDAL) documents is restricted in many cases in spite of the existing legal framework provided by the Public Information Disclosure Law No. 14/2008, specifically created to guarantee the right of citizens to have access to information that serves public interest such as environmental assessments. In practice, though, AMDAL'S are often kept in the offices of government and not available to the public. Affected communities of industrial projects, e.g., coal-fired power plan in South Sumatra, and industrial zones in West Java, have consistently lamented the difficulty to access these documents that allow them to read and know the potential environmental and health risk behind the development (Kartika et al., 2023).

Low environmental literacy among the public also makes it difficult to obtain AMDAL documents. Residents (particularly those in low-income and/or rural communities) understanding of both the legal and technical language in environmental documents is limited. The complexity also has the effect of discriminating particularly against women and low income classes who in their roles as buyers, have the limited knowledge and resources required to productively utilize these evaluations. Studies have demonstrated that higher levels of community environmental knowledge enables them to hold corporations accountable and demand transparency (Hoe et al., 2023).

In many cases, civil society organizations (CSOs) act as intermediaries by defending community rights and helping communities gain access to and understanding of environmental assessments. However, these organizations are generally hampered in their reach and efficacy by a lack of support and resources. Without robust organizational support, communities are unable to engage in decision-making or challenge projects that could threaten local environments or human health. Indeed, advocacy groups have played an important role in raising public awareness and rallying collective action, but many communities are left by themselves, powerless against corporate and political forces (Sitinjak et al., 2023).Other cultural and structural obstacles also hinder the actual implementation of a more participatory and equitable environmental governance, especially for women. Cultural norms prevent women in most Indonesian communities from speaking out in public spaces, particularly on technical and political issues. Therefore, their issues and realities are frequently neglected in AMDAL consultations and environmental decisions. Such gendered exclusion results in inability to capture important insights into community health and environment, and disallowance of this category even in participating in natural resource governance fro longer time and furthermore to contribute to social inequality in natural resources governance (Utama et al., 2023).

Precisely between the issues of public access and representation, law enforcement in Indonesia for all environmental regulations - including Law No. 32 of 2009 concerning Environmental Protection and Management - has never been overly strong. Most mining, palm oil and port operators in the resource-rich nation, regularly sidestep their environmental obligations through licensing gaps and graft. In the domain of harmful waste spills (B3), the companies that have come under fire for such practices in Kalimantan and Sumatra have seldom been hit with stiff penalties even after monitoring agencies have found companies guilty of violating their operating permits. This not only indicates the lack of enforcements, but also a lack of coordination between the Ministry of Environment and Forestry (KLHK) and local governments (de Godoi et al., 2022).

The regulatory regime provided under Law No. 32 was meant to offer a firm legal basis for environmental management, but in reality, its application has been minimal. Oversight agencies are frequently known for their low credibility, selective use of punishments, and ignorance of technology. Researchs have shown that despite the strength of Brazilian environmental licensing, gaps in its implementation make it legally easy for companies to "get around" the law. The implementation failure resulted in an urgent need for a reform of the relevant institution and the capacity-building for the law enforcement authorities that can serve as means to render the environmental laws to be meaningful and workable (Yustitianingtyas et al., 2025).

The combination of lax enforcement approach and systemic corruption also serve to undermine accountability. Companies often circumvent regulations, and use bribes to escape environmental and labor laws. In addition, because there is no genuine stakeholder involvement especially by women and local communities policies and decisions are made that do not respond to actual on-the-ground needs. Not only does this exclusion detract from that which contributes most to protecting the environment, it serves to perpetuate a wider social and gender injustices by silencing the voices of those most affected by pollution and ecological decline (Faujura et al., 2021).

In summary, there is a systematic limitation in terms of implementation and public access in the environmental governance of Indonesia. Overcoming these challenges requires wide-ranging institutional reform, upholding of transparency, strengthening the capacity of enforcement agencies and more involvement of civil society. Perhaps most of all, ensuring the meaningful engagement of marginalized communities particularly women can result in more just, effective and inclusive environmental decision-making and help safeguard ecosystems and the people who rely on them.

Civil Society, Resistance, and Environmental Justice Movements

In Indonesia, women's leadership is becoming vital also in environmental resistance movements, especially in zones of resource conflicts. With industrialization on the rise, local communities, particularly women, have risen up to defend their communities from exploitative practices, including mining and deforestation. Women-led initiatives typically originate from the ground level with women whose daily experiences of environmental destruction affect their actions. In places such as East Kalimantan and Central Java in Indonesia, women have organised themselves in groups to compete with corporations over such issues as land rights and environmental degradation, despite the high stakes in industrial interest (Setiawan & Tomsa, 2023). The activism also reflects a larger tendency within civil society where the voices of women are increasingly standing out in environmental dialogues largely narrated by men.

Civil society groups, that is non-government organizations (NGOs), have been significant actors for lobbying gendered environmental justice in Indonesia. These networks also play a role in mobilizing women for voice, rights and action. They hold workshops to help women become more informed about environmental laws and assert themselves in environmental decision-making. Although the particular disclosure in the The patentee in Joshi lends no credence to the assertion about NGOs in Indonesia, it is noted that supporting women's advocacy in environmental frames is also a key issue for many (Joshi et al., 2020). This magnification is necessary to counter patriarchal values that continue to be pervasive in many societies, and to have a female voice represented in environmental policy discussions.

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Yet even as women go green and put the greener agenda, patriarchal norms and state control continue to encumber women's environmental activism. Stereotypes and cultural expectations limit women's influence and participation, reinforcing gender inequalities. Women in areas where their activism defies power structures can be subjected to peer and state-sponsored harassment that perpetuates an atmosphere of fear and intimidation. Cases have been reported where women activists who express their concern over environmental degradation or maintaining sustainable lifestyle have been threatened or spied (Shah et al., 2021). These oppressive dynamics demonstrate that women are juggling the two tasks: they continue trying to save the environment, but they also attempt to manage a societal backlash to the involvement of women in public debate.

Despite these transformative changes, state apparatuses have sometimes turned a deaf ear or quashed women's environmental activism. Suppression of protests by police and local government is evident in protest or public meeting reports and could be interpreted as a reaction of the authorities to preserve the status quo in favor of industrial interests (Baidlowi & Pradana, 2022). This is a time for a hard look at how state policies, cultural norms, and the rights of women all come together in the realm of environmental justice. Promotion of comprehensive legal protections and an integrated approach to decision-making for the environment continues to be needed in order to create a more equitable context for women to participate in making environmental decisions.

In sum, the terrain of women's environmental resistance in Indonesia presents a dialectical relation of advancement and impasse. Despite progress achieved by women-led movements and supportive NGOs in the context of gendered environmental justice, the patriarchal system and the state surveillance constitute serious hurdles to their activism. Some of the key steps that are essential for their capacity building in the realm of environmental protection are through their empowerment, both in terms of education and social support structures in communities, and also through legislative changes. Thereby, through addressing these concerns, Indonesia can chart course to fashion an environmentally, and by extension climate, justice movement that is more inclusive, and inclusive in a way that acknowledges, respects women's invaluable roles.

Conlusion

There are severe problems pertaining to chemical waste management in Indonesia, particularly at industrialized areas, such as: Java, Sumatra and Kalimantan. There is widespread pollution from industry and agriculture, and from poor waste disposal, with severe consequences for both ecosystems and public health. Particularly women are disproportionately affected, as cultural habits confine women to the home where they are more exposed to toxic substances as well as to decision making processes. This gendered environmental exposure dimension underscores the pressing need for equitable and fitting policies that consider the special gender-based vulnerabilities of women and marginalized communities.

Furthermore, the difficulty in accessing Environmental Impact Assessment (AMDAL) reports and the lack of enforcement of environmental regulations compound these issues by allowing companies to circumvent responsibility. Civil society organizations contribute significantly on environmental justice and women dialogue, but they also confront challenges compounded by patriarchy and state repression.

The Indonesian government should make the systemic changes necessary to advance sustainable and equitable environmental governance by prioritizing measures that: improve the public's access to environmental information, reform legal frameworks, and promote the meaningful participation of all relevant actors, in particular women. By tackling these linked challenges, Indonesia can move towards a fairer and more sustainable future, protecting its environment and the health of its people. In the final analysis, a mutually respectful partnership that recognizes and honors women's contribution to care will foster a sustainable ecology and social justice.

Future Recommendations:

- Conduct field-based and participatory research to capture the lived experiences of women and local communities affected by chemical waste exposure.
- Implement longitudinal studies to monitor the long-term social, health, and policy impacts of industrial pollution in different regions of Indonesia.
- Apply an intersectional framework to explore how gender, class, and geographic vulnerability interact to shape environmental inequality.
- Strengthen gender mainstreaming in environmental policies, ensuring women's inclusion in decision-making and environmental governance processes.
- Enhance public access to environmental information, particularly AMDAL documents and industrial emission reports, to promote transparency and accountability.
- Foster multi-stakeholder collaboration between government, private sector, academia, and civil society to create an integrated system of sustainable waste management.
- Future research should also evaluate the effectiveness of current legal frameworks and community-based initiatives in promoting environmental justice and women's empowerment.

Limitations:

- Secondary Data Reliance: The study depends solely on previously published literature, which may overlook recent or undocumented local cases.
- Time Frame Limitation: The review focuses on studies from 2019–2024, which provides only a partial picture of long-term environmental trends.
- Lack of Empirical Validation: No primary or quantitative data were collected; findings are interpretive rather than statistically verified.
- Language and Publication Bias: Only English and Indonesian sources were reviewed, possibly excluding relevant studies in local languages.
- Limited Geographic Depth: While major regions (Java, Sumatra, Kalimantan) are covered, smaller and remote areas remain underrepresented.
- Scope Restriction: The study emphasizes gender and social inequality but does not analyze the specific roles of corporate actors or local institutions in detail.

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