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CONTEMPORARY ENVIRONMENTAL HEALTH LAW PARADIGM: COMPREHENSIVE ANALYSIS OF LITERATURE REVIEW ON POLLUTION REGULATION FRAMEWORK, HAZARDOUS WASTE CONTROL, AND OCCUPATIONAL SAFETY STANDARDS IN THE HEALTH SECTOR FOR THE PREVENTION OF EPIDEMIOLOGICAL AND ECOLOGICAL RISKS

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Abstract

This article presents a comprehensive analysis of the literature review on the contemporary environmental health law paradigm in Indonesia, focusing on the regulatory framework for pollution (Law No. 32/2009, Government Regulation No. 41/1999), the control of hazardous and toxic waste (Government Regulation No. 22/2021, Minister of Environment Regulation No. 6/2021), and occupational safety and health standards in the health sector (Minister of Health Regulation No. 66/2016, Ministry of Health Regulation No. 52/2018, Ministry of Manpower Regulation No. 5/2018), in order to prevent epidemiological risks such as nosocomial infections, antimicrobial resistance, and vector-borne outbreaks, as well as ecological risks in the form of water eutrophication, toxin bioaccumulation, and biodiversity degradation due to medical waste and emissions from health facilities. The normative juridical approach reveals the evolution of the paradigm from reactive anthropocentricity to proactive ecocentricity based on the polluter pays principle, the precautionary approach, and the OHS management system (ISO 45001). However, this is hampered by regional disparities, high processing costs (Rp10-15 million/tonne), as well as weak inter-agency supervision, which has resulted in only 60-70% of hospitals complying with hazardous waste quotas and 40% of workplace accidents occurring due to unsafe waste handling.ejournal. Reform recommendations include amending derivative regulations with AI-GIS monitoring, subsidising zero-waste technologies such as plasma pyrolysis, mandating a national P2K3RS committee, e-learning training, and harmonising ASEAN-PPP for synergistic dual risk prevention for a sustainable health ecosystem in line with SDGs 3, 6, 11, and 12.

Keywords: Environmental Health Law, Medical Hazardous Waste, Hospital Occupational Safety and Health, Pollution in the Health Sector, Epidemiological Risk, Ecosentric Paradigm, Indonesian Environmental Regulations.

Introduction

In the contemporary era marked by accelerated urbanisation, medical industrialisation, and increased hospital waste volumes due to recurring pandemics such as COVID-19, the environmental health law paradigm has become crucial as the main defence against ecosystem degradation and the explosion of interrelated epidemiological risks, (where hospitals, as centres of healthcare, often become primary sources of pollution through sterilisation gas emissions, infectious waste, and

hazardous chemicals that contaminate groundwater and surrounding air, thus creating a vicious cycle where environmental pollution exacerbates community vulnerability to infectious diseases such as drug-resistant tuberculosis or nosocomial infections that spread to wider communities, as highlighted in a WHO report noting that over 50% of global medical waste is not managed properly, triggering a public health crisis that burdens the economic systems of developing countries including Indonesia(Pramudya, 2023) .

The paradigm of environmental law has evolved from a classical anthropocentric approach that prioritises human interests alone to a contemporary ecocentric model that recognises the intrinsic right of nature to sustainability, especially in the field of health, where regulations are no longer merely reactive to pollution but proactive in preventing risks through the integration of the precautionary principle, the absolute responsibility of waste producers, and community participation, as adopted in the 1972 Stockholm Convention and the 1992 Rio Declaration, which form the basis for Indonesia's national legislation through Law No. 32 of 2009 concerning Environmental Protection and Management, in which the health sector as a producer of hazardous waste (Hazardous and Toxic Materials), is required to comply with processing standards that are in line with Sustainable Development Goals (SDGs) numbers 3, 6, and 11 to break the chain of pathogen transmission from medical facilities to residential environments.

In Indonesia, the health sector faces a double dilemma in which increased access to medical services following national health reforms has been accompanied by an escalation in medical waste production reaching millions of tonnes per year, (WHO; Prüss-Ustün, 2014) with data from the Ministry of Health showing that only 60% of hospitals have adequate waste treatment facilities, resulting in river and soil pollution from infectious waste, used syringes, and pharmaceutical residues, threatening the sustainability of natural resources and triggering outbreaks such as dengue fever, exacerbated by contamination of the Aedes aegypti vector through polluted hospital drainage systems. This calls for a contemporary legal paradigm that not only emphasises criminal sanctions but also incentivises technological innovation such as environmentally friendly incinerators and non-infectious waste recycling systems (.

The regulatory framework for pollution in the health sector includes a series of norms governing air emissions from autoclave sterilisation processes, the disposal of liquid waste into water bodies, and the spread of particulate dust from the construction of medical facilities. Ministry of Health Regulation No. 7 of 2019 concerning Medical Waste Management sets emission quality standards that must be complied with to prevent the accumulation of mercury from broken thermometers or chlorine compounds from disinfectants that damage the ozone layer and trigger ocean acidification. with a contemporary paradigm emphasising an epidemiological risk-based approach where pollution is not viewed as an isolated incident but rather a systemic

threat that can trigger zoonotic pandemics through bioaccumulation in the food chain(Nugraha, 2021) .

The control of hazardous waste (B3) is a key pillar of the environmental health law paradigm, with Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management requiring a management chain from production in the operating room, segregation at the source, safe transportation using special containers, to final destruction through high-temperature incineration above 1,000°C. Failure in this control has led to pollution cases such as the Citarum River, which is polluted with antibiotic residues from hospital waste, causing global antimicrobial resistance ( ). thus a comprehensive literature review analysis is needed to identify gaps between regulation and implementation for evidence-based reform.

Occupational safety and health (OSH) standards in the health sector integrate contemporary paradigms through Minister of Manpower Regulation No. 5 of 2018 concerning OSH in the Workplace, which requires adequate ventilation, the use of complete PPE for cleaning staff, and monitoring of airborne pathogen exposure to prevent occupational infections such as hepatitis B among nurses. This integration with environmental law creates a dual risk prevention synergy, protecting both workers and the external ecosystem. ILO data shows that 40% of workplace accidents in hospitals stem from unsafe waste handling that has the potential to leak into the community (Santosa, 2018) .

The epidemiological risks of regulatory non-compliance include an increase in the incidence of vector-borne diseases, respiratory tract infections caused by VOC pollutants from medical waste, and nosocomial outbreaks spreading through outpatients, with case studies in India and Brazil showing a direct correlation between illegal hospital waste landfills and a surge in resistant malaria cases. thus contemporary legal paradigms demand predictive modelling for outbreak anticipation based on satellite monitoring data of pollution and integrated public health surveillance (Rahman, 2021) .

Ecologically, pollution from the health sector causes eutrophication of lakes due to nitrogen from liquid waste, a decline in fish biodiversity through synthetic oestrogen from used contraceptives, and soil degradation that affects surrounding agriculture. with an ecology-based paradigm supporting legally-based restoration such as payment for ecosystem services programmes for hospitals that achieve zero waste to landfill, as recommended in the IPBES report on the interconnection between human and planetary health (Kusumawardhani, 2021) .

Many studies discuss environmental law in general or industrial health and safety, but few integrate contemporary paradigms specific to the health sector with a comprehensive analysis of Indonesian regulations following the 2021 amendment to the Environmental Law. thus this article fills the gap with a normative legal approach that

compares national regulations with ASEAN best practices such as Thailand's Hospital Waste Management Act, to produce contextual recommendations for policymakers amid the green energy transition.

Research Methodology

A normative legal approach with literature review as the primary method, analysing primary documents such as Law No. 32/2009 on Environmental Protection, Government Regulation No. 18/1999 in conjunction with Government Regulation No. 85/1999 on Hazardous Waste, and Minister of Environment Regulation No. 18/2009 on Hazardous Waste Management. Secondary sources include environmental law journals, books such as Contemporary Health Law, and WHO reports on the epidemiological risks of health waste (Green et al., 2006) . The analysis technique uses a comprehensive-integral approach to integrate legal, health, and ecological aspects (Eliyah & Aslan, 2025) .

Results and Discussion

Regulatory Framework for Pollution and Hazardous Waste Control

The regulatory framework for pollution in Indonesia's health sector is based on Law No. 32 of 2009 concerning Environmental Protection and Management, which defines pollution as the entry or introduction of living organisms, substances, energy, and other components into the environment through human activities that exceed quality standards, particularly from health facilities that produce air emissions from sterilisation processes, liquid waste from laundries and laboratories, and solid waste such as gypsum plaster containing mercury. The contemporary paradigm emphasises the polluter pays principle and the precautionary principle to prevent epidemiological impacts such as the spread of pathogens through contaminated aerosols and ecological impacts such as water eutrophication due to phosphates from medical detergents, as outlined in contemporary health law documents that integrate aspects of dual risk prevention.siladikti(Sutarno, 2019) .

Air pollution regulations are stipulated in Government Regulation No. 41 of 1999 concerning Air Pollution Control, which requires hospitals to install HEPA filters on waste incinerator chimneys and monitor NOx and SOx emissions from emergency generators, with quality standards in accordance with Appendix to Minister of Environment Decree No. 12 of 1995, which limits particulates to 230 mg/Nm³, where non-compliance often occurs in small private hospitals, causing medical smog to contribute to chronic respiratory diseases in urban areas such as Jakarta. thus contemporary legal paradigms are driving the transition to low-emission plasma pyrolysis technology as an alternative to conventional incinerators to align with the Net Zero Emission 2060 target.(, 2020) .

Water and soil pollution from the health sector is regulated by Government Regulation No. 22 of 2021 Article 58, which prohibits the direct discharge of liquid waste into public channels without IPTL (Wastewater Treatment Plant) treatment, with BOD and COD quality standards in accordance with Ministry of Environment Regulation No. 5 of 2014, which limits COD to 100 mg/L for hospital waste, where the case of pollution of the Code River in Yogyakarta by hospital waste demonstrates ecological risks such as mass fish deaths and epidemiological risks such as acute diarrhoea among riparian residents, necessitating a risk assessment-based paradigm for periodic audits by the Ministry of Environment and Forestry (Smith, 2024) .

The control of hazardous waste in the health sector is based on Law No. 32/2009 Article 1 paragraph 3, which classifies medical waste as B3 if it contains infectious, cytotoxic, or radioactive substances such as used needles, bacterial cultures, and iodine-131 isotopes (Government Regulation No. 101 of 2014 in conjunction with Government Regulation No. 22/2021 regulates the management chain from waste code identification (e.g., 18 01 01 for infectious waste) to annual reporting to the hazardous waste database, where the contemporary paradigm adds the dimension of the circular economy to minimise volume through source segregation and recycling of non-hazardous waste.

Hospitals as producers must have a B3 business licence in accordance with Minister of Environment Regulation No. 6 of 2021, including a waste management plan (RPPL) that covers monthly inventory and contracts with licensed transporters such as private incineration companies, where violations are subject to administrative sanctions of up to 3 years imprisonment under Article 98 of the Environmental Law. with 2023 Ministry of Environment and Forestry data showing that 30% of Type C hospitals failed to meet processing quotas, necessitating a digital tracking-based enforcement paradigm via blockchain for transparency (Hidayat, 2022) .

Medical hazardous waste must be processed using autoclave, microwave, or incineration methods at a minimum temperature of 850°C in accordance with SNI 04-6999-2003, where regulations require ash residue testing for dioxin content below 0.1 ng TEQ/Nm³ to prevent environmental carcinogens, with the contemporary paradigm adopting zero waste to landfill through biogas conversion from organic waste, reducing methane emissions that contribute 25% to global warming from medical landfills (Wijaya, 2017) .

Supervision is carried out by a joint team from the Environment Agency and Health Agency on a quarterly basis, accompanied by progressive sanctions ranging from warnings to revocation of hospital operating licences (SIROL). The case of Hermina Hospital in 2022, which was fined Rp500 million for illegal waste disposal, emphasises the restorative justice paradigm with a river remediation programme as an alternative to criminal punishment, supported by a GIS-based information system for pollution hotspot monitoring(Rumokoy, 2022) .

National regulations are in line with the 1989 Basel Convention on the control of transboundary movements of hazardous wastes and the Stockholm Convention on POPs from incomplete incineration, whereby Indonesia, as a ratifying party, requires radioactive waste to be exported only to authorised countries. with a contemporary paradigm promoting the harmonisation of the ASEAN Medical Waste Framework for regional standards to prevent cross-border dumping that triggers transnational epidemiological risks (Ellen MacArthur Foundation, 2023) .

The main challenges include high processing costs (Rp10-15 million/tonne), a lack of trained human resources, and regional disparities, with hospitals in Papua only 20% compliant compared to 70% in Java. Therefore, the legal paradigm requires fiscal subsidies and mandatory e-learning-based training to bridge the gap, as recommended by Neliti's study on the environmental protection paradigm(Pramudya, 2023) . Regulatory non-compliance triggers epidemiological risks such as antimicrobial resistance from antibiotic residues in groundwater, causing superbugs like MRSA to spread to communities. A UNSRAT study shows a 2.5-fold increase in infections near hospital waste landfills, demanding an integrated predictive epidemiology paradigm with environmental monitoring (WHO; Prüss-Ustün, 2014)).

Ecological impacts include the bioaccumulation of heavy metals such as lead from hospital UPS batteries in scavenger birds, disrupting the trophic chain and biodiversity, where the contemporary ecocentric paradigm encourages Life Cycle Assessment (LCA) for every medical procedure to minimise the carbon footprint, in line with SDG 12 (WHO; Prüss-Ustün, 2014) .

Reform is needed through amendments to Government Regulation B3, including AI monitoring and green tax incentives for zero B3 discharge hospitals, along with PPP collaboration for regional processing centre infrastructure, so that the contemporary environmental health legal paradigm is not only normative but effective in preventing sustainable epidemiological-ecological risks in Indonesia.

Occupational Safety Standards in the Health Sector

Occupational safety and health (OSH) standards in the Indonesian health sector are regulated within a contemporary paradigm that integrates the protection of health workers, patients, and visitors against physical, chemical, biological, and ergonomic risks in service facilities such as hospitals and clinics, based on Law No. 1 of 1970 on Occupational Safety, which requires employers to provide a safe environment, reinforced by Law No. 44 of 2009 on Hospitals, Article 8, which emphasises K3RS (Hospital Occupational Safety and Health) as an integral part of management, so that the prevention of epidemiological risks such as nosocomial and ecological infections through safe waste management becomes a top priority (Boxall, 2020) .

Government Regulation No. 88 of 2019 concerning Occupational Health Article 2 stipulates the integrated responsibilities of the central government, regional

governments, and the community in prevention, promotion, health checks, and surveillance efforts, with standards covering the fulfilment of occupational health, reproductive protection, high-risk immunisation, and standard precautions for healthcare workers, where the contemporary paradigm has shifted to a risk-based management system to minimise workplace accidents, which account for 40% of hospital incidents due to waste management. Regulation(Nugraha, 2021) .

Ministry of Health Regulation No. 66 of 2016 comprehensively regulates K3RS, including hazard identification from service processes such as needle injections to sterilisation, with the obligation to form a K3RS Advisory Committee (P2K3RS) for annual internal audits, where risks are not only from clinical activities but also from infrastructure such as poor ventilation that triggers airborne tuberculosis, in line with the integrated prevention paradigm to protect the internal ecosystem of hospitals. Regulation (Santosa, 2018) .

Ministry of Health Regulation No. 52 of 2018 specifically regulates safety in health care facilities, requiring an occupational health and safety management system with policies, planning, implementation, evaluation, and management review, including emergency evacuation training and infection control, where the contemporary paradigm emphasises a safety-first culture to reduce the incidence of needlestick injuries that pose a risk of hepatitis B/C in nurses .

Permenaker No. 5 of 2018 concerning Occupational Safety and Health in the Workplace stipulates physical quality standards such as lighting of 300-500 lux in operating rooms, noise <50 dB in ICUs, and ventilation of 10 air changes per hour to prevent pathogenic aerosols, with routine measurements by OSH experts, thus integrating with environmental laws to prevent secondary pollution from dirty air conditioning systems that trigger respiratory allergies.

PPE standards are regulated by Minister of Manpower Regulation No. 8 of 2020, which requires nitrile gloves, N95 masks for aerosol-generating procedures, protective goggles, and hazmat suits for handling hazardous waste, with employers fully responsible for the costs and training in their use, where the zero harm paradigm targets 100% compliance to protect health workers from exposure to carcinogenic cytostatic drugs (Kusumawardhani, 2021) .

Government Regulation No. 88/2019 Article 4 mandates pre-employment health examinations, annual periodic examinations, and special post-exposure examinations such as rapid HIV tests for needlestick injuries, along with occupational health and safety surveillance for early detection of occupational diseases (PAK) such as contact dermatitis from disinfectants, with a data-driven paradigm for timely intervention and prevention of ecological epidemics. 's regulations .

The identification of chemical risks such as formaldehyde and ethylene oxide is regulated in the SMK3 (Occupational Health and Safety Management System) based on Government Regulation No. 50 of 2012, with substitution, engineering, administrative,

and multi-level PPE controls, while biological hazards are addressed by WHO hand hygiene protocols and hepatitis vaccinations, integrating nosocomial prevention that leaks into the external environment(Sutarno, 2019) .

Ergonomic standards include workstation design to prevent musculoskeletal disorders (MSDs) in nurses lifting patients, with adjustable chairs and treadmill desks, plus psychosocial stress management through an Employee Assistance Programme (EAP), where the contemporary holistic paradigm recognises fatigue as a trigger for medical errors posing an epidemic risk(Suryadi, 2020) .

Ministry of Health Regulation No. 66/2016 Chapter VI regulates emergency response plans for fires, earthquakes, or chemical spills, with quarterly drills and clear evacuation routes, in line with OHSAS 18001/ISO 45001, which is recommended for certification, preventing emergencies from escalating into ecological disasters such as chemical waste spills. The contemporary paradigm adopts ISO 45001:2018 as a global framework for SMK3K (Occupational Health and Safety Management System) which includes the PDCA cycle for risk identification, external audits, and continual improvement, in line with ILO Convention No. 155, for Indonesian hospitals to achieve international accreditation while protecting the work ecosystem (Smith, 2024) .

Challenges include underreporting of occupational safety and health incidents, budget constraints at type D hospitals, and a lack of certified auditors, with administrative and criminal sanctions under Law No. 1/1970, so the reform paradigm requires the digitisation of SMK3 via app reporting and certification incentives to improve national compliance (Faure, 2022) .

Recommendations include integrating K3RS with hazardous waste management for synergistic dual risk prevention, mandating P2K3RS in all facilities, subsidising imported PPE, and collaboration between the Ministry of Health and the Ministry of Manpower for national training, so that the contemporary legal paradigm realises hospitals as models of sustainable safe work environments.

Conclusion

The contemporary paradigm of environmental health law in Indonesia, as analysed through a comprehensive literature review, shows an evolution from a reactive anthropocentric approach towards a proactive ecocentric model that integrates the regulatory framework for pollution (Law No. 32/2009 and Government Regulation No. 41/1999), hazardous waste control (Government Regulation No. 22/2021 and Minister of Environment Regulation No. 6/2021), and occupational safety standards (Minister of Health Regulation No. 66/2016, Minister of Health Regulation No. 52/2018, and Minister of Manpower Regulation No. 5/2018), thus forming a synergy for the prevention of epidemiological risks such as nosocomial infections, antimicrobial resistance, and vector-borne outbreaks due to contaminated medical waste, as well as ecological risks in the form of water eutrophication, toxin bioaccumulation, and

biodiversity degradation from emissions and residues of hazardous waste from the health sector.siladikti.

However, the effectiveness of this paradigm is hampered by regional disparities in implementation, high waste treatment costs (Rp10-15 million/tonne), weak inter-agency supervision, underreporting of occupational safety and health incidents, and a lack of harmonisation with international standards such as the Basel Convention, ISO 45001, and SDG 3-12. Data shows that only 60-70% of hospitals comply with hazardous waste processing quotas and 40% of workplace accidents stem from unsafe waste handling, creating systemic gaps that trigger a vicious cycle between ecosystem damage and public health risks.

Therefore, contemporary legal paradigm reform requires amendments to derivative regulations with the inclusion of AI-GIS monitoring, fiscal subsidies for plasma pyrolysis technology and zero waste infrastructure, a national P2K3RS mandate along with e-learning training, a restorative justice approach to progressive sanctions, and ASEAN PPP collaboration for regional harmonisation, in order to realise health facilities as a sustainable ecosystem model that not only protects health workers and patients but also the planet from long-term epidemiological-ecological threats.

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