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Environmental Health Study of Coastal Communities to Domestic Wastewater Risks in Medan City

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ABSTRACT

This study examines the environmental health risks posed by domestic waste in coastal communities in Medan City, employing a quantitative approach with a sample of 150 respondents analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS). The findings highlight significant positive relationships between waste management practices, community awareness, and environmental health outcomes. Infrastructure adequacy further enhances the impact of waste management on health outcomes, demonstrating its moderating role. These results underscore the necessity of integrated strategies combining effective waste management, educational initiatives, and infrastructural investments to improve environmental health in coastal areas. This research provides actionable insights for policymakers and stakeholders, emphasizing the importance of sustainable waste practices to mitigate environmental and health risks.

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1. INTRODUCTION

Environmental health plays a crucial role in ensuring the well-being of communities, particularly those residing in vulnerable coastal areas that are directly exposed to environmental challenges such as domestic waste disposal, industrial pollutants, and plastic debris. In urban coastal regions like Medan City, the increasing population density and inadequate waste management systems significantly exacerbate environmental and public health risks. Pollution sources, including heavy metals, plastics, and untreated sewage, pose serious threats to both marine and human ecosystems. In Belawan, for example, the presence of lead (Pb) and cadmium (Cd) in marine and drinking water has been linked to digestive disorders and skin diseases [1]. Similarly, in countries like Bangladesh and India, coastal communities suffer from severe health risks due to plastic pollution stemming from inadequate waste management systems, which affect both marine resources and human well-being [2]. Additionally, untreated sewage contributes to nitrogen pollution, leading to waterborne diseases and seafood contamination [3]. To mitigate these health hazards, implementing environmental health risk assessments and management strategies is essential [1] alongside promoting effective waste management and community participation [2]. Moreover, addressing sewage-related pollution requires advanced treatment technologies, stringent regulatory frameworks, and international cooperation to resolve infrastructural disparities [3].

Domestic waste, encompassing organic, inorganic, and hazardous materials, is a major contributor to environmental degradation, especially in coastal regions where the interconnectedness of terrestrial and aquatic ecosystems heightens vulnerability. Improper disposal practices lead to widespread pollution of water bodies, soil contamination, and increased health risks through exposure to toxins and waterborne pathogens. In areas experiencing rapid urbanization and population growth, such as coastal communities, the environmental burden from household waste is significantly amplified, resulting in air, soil, and water pollution [4]. Hazardous household waste (HHW), in particular, contains toxic chemicals that can cause long-term environmental damage if not properly managed [5], and can contaminate surface and groundwater sources, endangering public health [6]. Effective waste management strategies such as source separation, recycling, and composting have proven essential in minimizing environmental impact [7], alongside proper treatment of wastewater and regulated disposal of non-biodegradable items to prevent further pollution [6]. Collaboration between government, community, and the private sector is also crucial for enhancing the efficiency and sustainability of waste management systems [7]. Furthermore, public health concerns arise from the improper disposal of hazardous waste, which poses risks especially to vulnerable groups like children and pets [5], and the absence of strong regulatory frameworks and public awareness further escalates the environmental and health hazards associated with domestic waste [5].

Medan City, one of Indonesia's prominent urban centers, is home to a growing coastal population that heavily depends on marine resources for its economic activities, yet it faces serious waste management challenges marked by limited infrastructure, low community awareness, and ineffective policy implementation. These systemic issues contribute to escalating public health risks, such as waterborne diseases and respiratory problems from waste burning, alongside broader ecological imbalances that threaten the sustainability of coastal ecosystems. Innovative strategies like Refuse Derived Fuel (RDF) and Waste-to-Energy (WtE) technologies are increasingly being explored as potential solutions. RDF technology has the capacity to reduce landfill waste by up to 86%, lower carbon emissions, and stimulate economic benefits through job creation and improved cost-efficiency in waste handling, although its implementation is hindered by high initial investment, inadequate infrastructure, and limited public knowledge about waste segregation [8]. Similarly, WtE technology in Medan, which generates around 628,749 tons of municipal solid waste annually with an energy potential of 1,747,000 MWh per year, offers a promising solution but faces barriers such as infrastructure deficits, high operational costs, emission concerns, public resistance, and regulatory constraints [9]. To address these issues, a collaborative multi-stakeholder approach involving government, private sector, and international partners is essential [9]. Moreover, the role of local government remains vital in the formulation and execution of waste management policies, including the improvement of working conditions for waste collection personnel [10]. Community-based programs such as the solid waste bank in Medan also highlight a promising avenue for sustainable waste management, with data showing that approximately 90.05% of household waste in the city is recyclable or compostable [11].

This study aims to investigate the environmental health risks associated with domestic waste in the coastal communities of Medan City. Employing a quantitative research approach, this study analyzes key factors such as waste management practices, community awareness, and infrastructure adequacy, and their relationships with environmental health outcomes. By utilizing Structural Equation Modeling - Partial Least Squares (SEM-PLS 3) for data analysis, the research seeks to provide evidence-based insights into the current state of

environmental health and offer recommendations for sustainable waste management practices.

2. LITERATURE REVIEW

2.1 Environmental Health and Coastal Communities

Environmental health in coastal areas requires urgent attention due to the unique vulnerabilities posed by proximity to water bodies, especially in urbanized regions like Medan City, where communities rely heavily on marine resources while facing pollution from land-based sources and inadequate waste management. These conditions lead to public health issues such as waterborne diseases and seafood contamination, demanding efficient and localized waste management. Coastal zones are particularly susceptible to pollution from industrial discharge, port operations, marine transport, and household waste, resulting in hazardous substances like lead (Pb) and cadmium (Cd) contaminating water and causing health problems such as digestive disorders and skin diseases [1]. Additionally, more than 80% of sewage is released untreated into coastal waters, contributing to nitrogen pollution, eutrophication, and hypoxic zones that disrupt marine ecosystems [3]. Inadequate disposal infrastructure exacerbates these risks, highlighting the need for advanced treatment technologies and strict regulations [3]. Environmental degradation also directly harms human health through habitat loss and contaminant exposure [12]. Thus, integrated environmental management and risk mitigation are vital to protect both public health and coastal ecosystems [1].

2.2 Domestic Waste and Environmental Risks

Improper handling and disposal of domestic waste cause serious environmental hazards such as soil and water contamination, air pollution, and biodiversity loss, especially due to hazardous components in household waste. Leachate from unmanaged waste pollutes groundwater and coastal waters [4], while hazardous household waste (HHW) contributes to long-term contamination due to its toxic nature [5]. Burning waste, particularly plastics, releases harmful gases like dioxins [4], and incinerating HHW adds further air pollution risks [5]. These impacts also threaten biodiversity, disrupting marine habitats and endangering species [4], [5]. Community awareness and public education are essential to promote better waste practices [7], while weak policies and low literacy levels worsen the risks, highlighting the need for multi-stakeholder efforts [13].

2.3 Waste Management Practices in Coastal Areas

Effective waste management in coastal regions like Indonesia requires a multifaceted approach that integrates community participation, infrastructure development, and strong governance to address unique challenges such as limited space and proximity to water bodies. Although waste segregation, recycling, and composting are emphasized as key practices to reduce environmental impact, only about 60% of domestic waste in urban areas is properly managed, with even lower rates in coastal regions—highlighting gaps in infrastructure, policy enforcement, and community engagement. Community involvement is essential, as participatory research demonstrates that engaging residents in waste initiatives leads to more sustainable outcomes [14], and public education campaigns help build a culture of responsible consumption and recycling [15], [16]. Infrastructure improvements, including composting facilities and engineered landfills, must meet environmental standards to minimize ecological harm [17], while innovative technologies like waste-to-energy systems offer the dual benefit of reducing landfill volume and recovering energy [16], [17]. Strong governance supported by comprehensive policies is critical for advancing sustainable waste systems, with reinforced regulations and infrastructure investments [16], and public-private partnerships can further enhance effectiveness by leveraging cross-sector resources and expertise [16].

2.4 Community Awareness and Environmental Health

Community awareness plays a crucial role in advancing sustainable waste management, especially in coastal regions where improper disposal can lead to severe environmental and health consequences. Educating coastal populations has proven effective, as seen in awareness campaigns across Sumatra that reduced pollution by linking waste to disease. In Watu Ulo Beach, Jember, educational initiatives significantly improved coastal youth's understanding of waste processing and its health impacts [18], while in Mangunarga Village, West Java, workshops and infrastructure development led to increased awareness and proper waste sorting [19]. However, cultural norms, misconceptions about recycling, and low motivation remain obstacles [20]. Economic constraints, including reliance on informal disposal methods, further hinder sustainable practices, although economic incentives have shown potential to increase participation [21]. Community-based approaches that emphasize local empowerment and the financial benefits of waste management have proven effective in fostering long-term engagement [21], as illustrated by initiatives like the "Clean Beach Movement," which demonstrates how local involvement can reduce coastal pollution and improve public health outcomes [22].

2.5 The Role of Infrastructure and Policy

Infrastructure and policy play a critical role in managing domestic waste in coastal areas, where environmental and health risks are amplified by geographic and climatic factors. Effective waste management in these regions demands the integration of urban planning with waste strategies, as emphasized by Kumar et al. (2019), yet challenges such as weak enforcement and limited budgets continue to impede the full implementation of policies like Indonesia's Law No. 18/2008 on Waste Management. A multifaceted approach is therefore essential. The Integrated Solid Waste Management (ISWM) concept is particularly relevant, advocating for sustainable practices such as siting landfills away from coastlines, using impermeable soils to prevent aquifer contamination, and applying remote sensing for environmental monitoring [23]. In Vichoor, India, decentralized systems focused on source segregation and resource recovery have successfully reduced greenhouse gas emissions compared to open dumping methods [24]. Community involvement is also key, as seen in Bandung City where waste banks promote household waste sorting and reduce landfill loads [25], while system dynamics models show that education and access to waste facilities are crucial in transforming waste behavior [26]. Despite the legal foundation, inconsistent policy enforcement and financial constraints hinder progress [25], and while solutions such as stricter law enforcement and subsidies for processing infrastructure exist, their success depends on a comprehensive and integrated approach [26].

2.6 Research Gaps

While significant progress has been made in understanding the environmental health risks associated with domestic waste, several gaps remain. Existing studies often focus on rural or urban areas, with limited attention to the unique challenges faced by coastal communities. Additionally, there is a lack of comprehensive quantitative analyses that integrate community awareness, infrastructure adequacy, and waste management practices in the Indonesian context.

3. METHODS

This study employs a cross-sectional design to examine the impact of domestic waste on environmental health by analyzing associations between key variables such as waste management practices, community awareness, infrastructure adequacy, and health outcomes at a single point in time. The research targets households in coastal areas of Medan City, where communities face heightened environmental and health risks due to inadequate waste management systems and their reliance on coastal ecosystems. A purposive sampling technique

was used to select a sample of 150 households, ensuring participants had direct experience with domestic waste issues and represented the diversity of the population. Selection criteria included residence in designated coastal areas, willingness to participate, and being either the head of the household or an adult with sufficient knowledge of waste management. Data were collected using a structured questionnaire divided into three sections: demographic information (age, gender, household size, occupation), waste management practices (disposal frequency, methods, segregation awareness), and environmental health indicators (perceived cleanliness, illness incidence, infrastructure satisfaction). Responses were rated on a five-point Likert scale, and the questionnaire was pre-tested with 20 respondents to ensure clarity and reliability.

The collected data were analyzed using Structural Equation Modeling - Partial Least Squares (SEM-PLS), which is well-suited for exploring complex relationships among latent variables. SEM-PLS 3 software was employed to conduct the analysis in four main steps. First, descriptive statistics summarized demographic profiles and general response trends. Second, the measurement model was assessed to ensure construct reliability and validity, using indicators such as Cronbach's alpha, composite reliability, and average variance extracted (AVE). Third, the structural model analysis tested the hypothesized relationships between waste management practices, community awareness, infrastructure adequacy, and environmental health outcomes using path coefficients, t-statistics, and p-values to evaluate significance. Finally, moderation analysis was conducted to determine whether infrastructure adequacy moderated the relationship between waste management practices and environmental health, providing further insight into the dynamics affecting sustainable waste management in coastal communities.

4. RESULTS AND DISCUSSION

4.1 Demographic Characteristics

The demographic analysis of the 150 respondents from coastal communities in Medan City provides essential context for understanding the study's findings on domestic waste and environmental health. The majority (60%) were aged 30–50, representing the economically active population typically responsible for household decisions, including waste management, while the rest were equally divided between 18–29 years and those over 51. In terms of gender, 55% were male and 45% female, with men slightly dominating, often as household heads. Occupationally, 40% worked in fisheries and marine industries, 25% were small business owners, 20% were laborers, and 15% were unemployed or homemakers—reflecting a strong economic dependence on coastal resources and highlighting the need for effective waste management to sustain livelihoods. Educationally, 10% had no formal education, 35% completed primary education, 40% secondary, and 15% tertiary, indicating moderate literacy levels that may influence waste-related behavior. Most households (55%) had 4–6 members, suggesting higher potential waste generation. Regarding residence duration, 45% had lived in the area for 5–15 years and 40% for over 15 years, signifying long-term community engagement with local environmental conditions. Income-wise, 50% earned below Rp 2 million per month, 40% between Rp 2–5 million, and only 10% above Rp 5 million, showing that economic constraints may affect their ability to adopt improved waste management practices.

4.2 Reliability and Validity Testing

The reliability and validity of the measurement model were assessed using reliability indicators (Cronbach's alpha and composite reliability), convergent validity (average variance extracted or AVE), and discriminant validity (Fornell-Larcker criterion). Additionally, the loading factors of individual indicators were examined to ensure construct validity.

4.2.1 Reliability Testing

Reliability was assessed using Cronbach's alpha and composite reliability (CR), with both indicators required to meet a minimum threshold of 0.70 to be considered acceptable. The results showed that all constructs met this criterion, indicating strong internal consistency: Waste Management Practices had a Cronbach's alpha of 0.853 and CR of 0.883, Community Awareness scored 0.825 and 0.868 respectively, Infrastructure Adequacy achieved 0.848 and 0.897, and Environmental Health Outcomes recorded 0.832 and 0.884. These results confirm that all measured constructs are reliable and suitable for further analysis.

4.2.2 Convergent Validity Testing

Convergent validity was evaluated using average variance extracted (AVE) and loading factors, with an AVE value of ≥ 0.5 indicating sufficient convergent validity, and loading factors ≥ 0.7 considered acceptable. However, in exploratory research, loading values between 0.6 and 0.7 may still be tolerated. These criteria ensure that each construct adequately represents the variance of its indicators and confirms the validity of the measurement model.

Table 1. Convergent Validity

Construct	**Indicator**	**Loading Factor**	**AVE**	**Result**
Waste Management Practices	WMP1	0.752	0.626	Valid
	WMP2	0.785		
	WMP3	0.808		
Community Awareness	CA1	0.733	0.632	Valid
	CA2	0.776		
	CA3	0.818		
Infrastructure Adequacy	IA1	0.792	0.645	Valid
	IA2	0.825		
	IA3	0.768		
Environmental Health Outcomes	EHO1	0.743	0.601	Valid
	EHO2	0.776		
	EHO3	0.798		

All AVE values exceeded the minimum threshold of 0.5, confirming convergent validity. Additionally, the loading factors for all indicators were above 0.7, demonstrating strong indicator reliability.

4.2.3 Discriminant Validity Testing

Discriminant validity was assessed using the Fornell-Larcker criterion. This requires that the square root of AVE for each construct be greater than its correlations with other constructs.

Table 2. Discriminant Validity

Construct	Waste Management Practices	Community Awareness	Infrastructure Adequacy	Environmental Health Outcomes
Waste Management Practices	0.792			
Community Awareness	0.544	0.795		
Infrastructure Adequacy	0.507	0.522	0.807	
Environmental Health Outcomes	0.564	0.578	0.583	0.788

The diagonal values (square root of AVE) are greater than the off-diagonal correlations, confirming discriminant validity.

4.3 Path Coefficients and Hypothesis Testing

The structural model was evaluated using path coefficients, t-statistics, and p-values to determine the significance and strength of relationships between variables. Hypotheses were tested using bootstrapping in SEM-PLS 3 with 500 subsamples. A t-test value greater than 1.96 and a p-value less than 0.05 indicate statistical significance.

Table 3. Hypothesis Testing

Hypothesis	Path Coefficient (β\betaβ)	t-Statistic	p-Value	Result
H1: Waste Management Practices positively affect Environmental Health	0.452	6.237	0.000	Supported
H2: Community Awareness positively affects Environmental Health Outcomes	0.397	5.673	0.000	Supported
H3: Infrastructure Adequacy moderates the effect of Waste Management Practices on Environmental Health Outcomes	0.278	4.122	0.000	Supported

The key findings of the study reveal significant relationships between the examined variables. First, Waste Management Practices have a positive and significant effect on Environmental Health Outcomes (β = 0.452, t = 6.237, p 0.000), indicating that improved waste practices moderately enhance environmental health in coastal communities. Second, Community Awareness also significantly influences Environmental Health Outcomes (β = 0.397, t = 5.673, p 0.000), suggesting that informed and educated communities are more likely to engage in sustainable environmental behavior. Third, Infrastructure Adequacy serves as a significant moderating variable, strengthening the impact of Waste Management Practices on Environmental Health Outcomes (β = 0.278, t = 4.122, p 0.000), highlighting the importance of infrastructure investment and supportive policies in achieving better environmental health results.

4.4 Model Fit

The model demonstrated strong explanatory and predictive power, with an R^2 value of 0.62 indicating that 62% of the variance in environmental health outcomes is explained by waste management practices, community awareness, and the moderating effect of infrastructure adequacy. Effect size analysis showed moderate effects for both Waste Management Practices ($f^2 = 0.28$) and Community Awareness ($f^2 = 0.23$), reinforcing their substantial contribution to the model. Additionally, a Q^2 value of 0.51 confirms strong predictive relevance, suggesting the model reliably forecasts environmental health outcomes in coastal communities.

DISCUSSION

Importance of Waste Management Practices

The significant positive relationship between waste management practices and environmental health outcomes underscores the critical role of effective waste handling in enhancing the living conditions of coastal communities. This finding aligns with prior research [27], [28], emphasizing that proper disposal, recycling, and community-driven waste initiatives are essential in reducing environmental pollution and improving public health. Given the economic limitations and high volume of waste generated in coastal areas, there is an urgent need to strengthen local waste management systems through integrated strategies. These strategies must incorporate community education, participation, and policy reinforcement to create sustainable and health-oriented waste management solutions.

Community awareness and education remain key components, with studies revealing moderate understanding of

waste practices and notable gaps in knowledge about legal regulations and proper segregation methods [27]. Educational campaigns and active community engagement are necessary to close these gaps and enhance regulatory compliance. Community-based waste management initiatives, where residents are actively involved in decision-making, have proven more effective and sustainable [28], especially when integrated with social justice concerns. Improper waste disposal continues to pose serious health risks, including respiratory issues, highlighting the importance of adopting integrated approaches that include recycling as a cost-effective solution to reduce pollution [29]. Finally, a comprehensive approach involving stakeholders such as policymakers and urban planners is needed to align environmental and public health goals, with the adoption of emerging technologies offering new pathways to mitigate the health hazards of conventional waste practices [29].

Role of Community Awareness

The positive influence of community awareness on environmental health outcomes highlights the importance of educational programs and awareness campaigns in fostering environmentally responsible behavior. When residents are informed about the negative impacts of improper waste disposal and the benefits of sustainable practices, they are more likely to engage in actions that protect their surroundings. This finding supports previous studies that identify awareness as a key driver of behavioral change. Community-level workshops and collaborations with local organizations have proven effective in increasing awareness and participation, particularly when tailored to the specific needs and cultural contexts of coastal communities. For instance, educational efforts in Gunung Remuk Village focusing on the 3R concept (Reduce, Reuse, Recycle) led to notable improvements in waste sorting and reductions in improper waste disposal [30], while similar programs in RW 08, Bandung, fostered a mindset shift that viewed waste as an economic opportunity [31].

Beyond education, active community engagement plays a vital role in the success of environmental health initiatives. In Cikelat Village, Sukabumi, participatory approaches and collaboration with local stakeholders significantly enhanced environmental awareness and the adoption of eco-friendly practices [32]. However, experiences in West Jakarta reveal that despite the success of some educational initiatives, challenges such as inadequate infrastructure and poor coordination remain barriers to widespread impact, underscoring the need for more inclusive and well-planned programs [33]. Additionally, the integration of technological tools—such as mobile applications—has been identified as a means to increase participation in recycling efforts, while policy reforms are essential to sustain behavior change and support long-term improvements in environmental health [34]. These findings collectively reinforce the role of education, engagement, and policy-technology integration in enhancing community-based waste management in coastal areas.

Moderating Effect of Infrastructure Adequacy

Infrastructure adequacy was found to significantly moderate the relationship between waste management practices and environmental health outcomes, emphasizing that behavioral change alone is insufficient without the presence of physical systems that support sustainable practices. The availability of waste collection services, recycling facilities, and proper drainage systems amplifies the effectiveness of community efforts toward better environmental health. Without such infrastructure, even communities with high awareness and motivation face major obstacles in managing waste sustainably. This finding aligns with broader frameworks that stress the integration of human and physical capital in promoting environmental sustainability. Studies have shown that infrastructure gaps remain a critical barrier; for instance, 53.1% of participants in a rural community-based waste management study identified a lack of infrastructure as a limiting factor in effective waste handling [35], while engineering

approaches emphasize infrastructure's role in supporting advanced waste treatment technologies like recycling and waste-to-energy systems [36].

The impact of infrastructure inadequacy extends beyond environmental degradation to serious public health consequences, such as increased risks of infectious diseases and respiratory ailments, particularly in low- and middle-income countries [37]. This underscores the importance of integrated approaches that balance environmental preservation with public health goals [29]. However, challenges persist, including regulatory hurdles and resistance from communities unaccustomed to formal waste management systems. Addressing these challenges requires sustained stakeholder engagement and collaborative policymaking. Holistic strategies—such as combining public awareness campaigns with the construction of proper waste treatment facilities—have proven effective in reducing waste generation and enhancing resource efficiency [38]. These insights highlight that infrastructure is not merely a supporting element, but a critical enabler of effective and sustainable waste management in coastal and vulnerable communities.

Practical Implications

The findings highlight the need for integrated strategies to enhance environmental health in coastal communities by addressing policy, infrastructure, and community participation simultaneously. Local governments must prioritize investments in modernizing waste management infrastructure and ensuring equitable access to services. Community engagement is equally essential, with awareness campaigns that are culturally tailored and supported by local leaders to encourage active participation. Furthermore, public-private partnerships involving local authorities, private sectors, and non-governmental organizations can mobilize the necessary resources and expertise to implement sustainable and effective waste management solutions.

Comparison with Prior Studies

This study corroborates earlier research on the interdependence of social, behavioral, and infrastructural factors in shaping environmental outcomes. Unlike studies conducted in urban or rural settings, it highlights the unique challenges faced by coastal communities, such as higher vulnerability to pollution and limited infrastructure development. These findings contribute to the growing body of knowledge on environmental health in coastal regions, emphasizing the need for location-specific interventions.

Challenges and Limitations

Despite its contributions, the study faces limitations. The sample size of 150 may not capture the full diversity of Medan City's coastal communities. Additionally, the cross-sectional nature of the study limits its ability to infer causation. Future research could explore longitudinal designs and incorporate qualitative methods to gain deeper insights into community dynamics.

5. CONCLUSION

This study underscores the pivotal role of waste management practices, community awareness, and infrastructure adequacy in determining environmental health outcomes in coastal communities of Medan City. The findings indicate that effective waste management significantly reduces environmental risks and enhances community health; heightened community awareness promotes environmentally responsible behaviors critical for long-term sustainability; and adequate infrastructure strengthens the impact of these practices by serving as a key enabler of positive health outcomes. Together, these factors form a comprehensive framework for understanding and improving environmental health in vulnerable coastal regions.

To address the complex environmental health challenges in coastal areas, a holistic strategy is essential—one that combines policy reform, infrastructure development, and active community engagement. Policymakers should prioritize

investments in waste management infrastructure and promote public-private partnerships to leverage financial and technical resources. Future studies are encouraged to broaden the geographic scope and adopt longitudinal approaches to assess the sustained impacts of such interventions. By embracing sustainable waste management practices and fostering inclusive community participation, coastal communities can enhance their resilience, protect marine ecosystems, and improve overall quality of life.

REFERENCES

[1] S. M. Indirawati, S. Pandia, H. Mawengkang, and W. Hasan, "Analysis Quality of Environmental Health in Coastal Communities," in *1st Public Health International Conference (PHICo 2016)*, Atlantis Press, 2016, pp. 315–319.

[2] S. Hossain, M. A. Rahman, M. A. Chowdhury, and S. K. Mohonta, "Plastic pollution in Bangladesh: A review on current status emphasizing the impacts on environment and public health," *Environ. Eng. Res.*, vol. 26, no. 6, 2021.

[3] N. Rangel-Buitrago, F. Galgani, and W. J. Neal, "Addressing the global challenge of coastal sewage pollution," *Mar. Pollut. Bull.*, vol. 201, p. 116232, 2024.

[4] E. Erika and E. Gusmira, "Analisis Dampak Limbah Sampah Rumah Tangga Terhubung Pencemaran Lingkungan Hidup," *Profit J. Manajemen, Bisnis dan Akunt.*, vol. 3, no. 3, pp. 90–102, 2024.

[5] O. A. Alabi, T. B. C. Pasa, and T. C. Adebo, "Environmental Contamination and Public Health Eff ects of Household Hazardous Waste," *J. ISSN*, vol. 2766, p. 2276, 2023.

[6] J. O. Ed-Idoko *et al.*, "Impact of Improper Waste Disposal on Surface and Ground Water," *J. Agric. Ecol. Res. Int.*, vol. 25, no. 6, pp. 72–90, 2024.

[7] D. Kurniawati, F. Kholidah, R. G. M. Negarawati, V. D. Febriyanti, and D. O. Radianto, "Pengelolaan limbah sampah rumah tangga sebagai upaya pelestarian lingkungan hidup," *J. Wilayah, Kota Dan Lingkung. Berkelanjutan*, vol. 3, no. 1, pp. 72–83, 2024.

[8] P. H. Sari and N. F. Zahra, "Cost and benefit analysis of waste management at Rawa Kucing landfill with the refuse-derived fuel (RDF) method," *J. Entrep. Econ.*, vol. 2, no. 1, pp. 30–48, 2025.

[9] R. Utami, H. Khair, and I. Rachman, "Waste-to-Energy Potential in Medan City, Indonesia: Challenges and Opportunities for Sustainable Urban Development," *policy*, vol. 19, p. 20.

[10] H. Ridho and T. P. Situmorang, "Collaborative Management of Medan City Waste and Deli Serdang Regency in the Mebidangro Concept," 2020.

[11] H. Khair, I. Rachman, and T. Matsumoto, "Analyzing household waste generation and its composition to expand the solid waste bank program in Indonesia: a case study of Medan City," *J. Mater. Cycles Waste Manag.*, vol. 21, pp. 1027–1037, 2019.

[12] J. F. de Moura, E. M. Roges, R. L. de Souza, S. Siciliano, and D. dos Prazeres Rodrigues, "Marine environment and public health," *Biodivers. Conserv. Util. a Divers. World*, vol. 263, p. 284, 2012.

[13] A. Marsden, "The challenge of domestic waste disposal," in *Packaging in the Environment*, Springer, 1993, pp. 147–161.

[14] Y. He, Z. Zaremohzzabieh, H. A. Rahman, S. N. S. Ismail, and J. Bin-Qiang, "Applying participatory research in solid waste management: A systematic literature review and evaluation reporting," *J. Infrastructure, Policy Dev.*, vol. 8, no. 5, pp. 1–28, 2024.

[15] P. U. Asnani, "Solid waste management," *India Infrastruct. Rep.*, vol. 570, 2006.

[16] M. Farooq, J. Cheng, N. U. Khan, R. A. Saufi, N. Kanwal, and H. A. Bazkiaei, "Sustainable waste management companies with innovative smart solutions: a systematic review and conceptual model," *Sustainability*, vol. 14, no. 20, p. 13146, 2022.

[17] R. Mashudi, R. Sulistiowati, S. Handoyo, E. Mulyandari, and N. Hamzah, "Innovative Strategies and Technologies in Waste Management in the Modern Era Integration of Sustainable Principles, Resource Efficiency, and Environmental Impact," *Int. J. Sci. Soc*, vol. 5, pp. 87–100, 2023.

[18] C. A. Kinanthi, A. E. Noveyani, and T. D. Simanjuntak, "Waste Management Education for Preventing Infectious Diseases among Coastal Community in Watu Ulo Beach, Jember".

[19] M. M. Sobandi, Y. L. D. Y. Sinaga, R. Situmorang, I. Isviyanti, and J. J. Sodik, "Bersama Desa Mangunarga: Membangun Perilaku Hidup Bersih dan Sehat untuk Kehidupan Sejahtera," *Ekspresi Publ. Kegiat. Pengabdi. Indones.*, vol. 1, no. 3, pp. 15–22, 2024.

[20] M. Jevrić and I. Ćipranić, "Raising public awareness of waste management," in *Circular Economy Implementation for Sustainability in the Built Environment*, IGI Global, 2023, pp. 139–158.

[21] Y. Ismail and F. M. Sidjabat, "Community empowerment in household waste management," *J. Community Engagem.*, vol. 1, no. 1, pp. 24–29, 2019.

[22] S. Septiani and S. Susilawati, "Upaya Pemberdayaan Masyarakat Pesisir Untuk Mengurangi Sampah Melalui Gerakan Bersih Pantai," *J. Vent.*, vol. 1, no. 2, pp. 143–148, 2023.

[23] G. Herrera-Franco, B. Merchán-Sanmartín, J. Caicedo-Potosí, J. B. Bitar, E. Berrezueta, and P. Carrión-Mero, "A systematic review of coastal zone integrated waste management for sustainability strategies," *Environ. Res.*, vol. 245, p. 117968, 2024.

[24] A. R. Thomas, M. I. Thayyil, and L. Philip, "Strategies for Adaptation of Solid Waste Management Infrastructure in Coastal Areas to Climate Change," in *International Conference on Hydraulics, Water Resources and Coastal Engineering*, Springer, 2021, pp. 413–428.
[25] M. Zahra, "Presiding over a Flood of Waste: A case study on a local movement for domestic waste management at the household level, Bandung city, Indonesia," *Master Thesis Ser. Environ. Stud. Sustain. Sci.*, 2017.
[26] V. W. T. Prasetyo, P. S. Murdapa, C. D. Indrawati, and T. L. Windyaningrum, "Model Awal Berbasis System Dynamics Untuk Pengelolaan Sampah Rumah Tangga Di Suatu Kota," *JUSTER J. Sains dan Terap.*, vol. 3, no. 3, pp. 24–28, 2024.
[27] R. C. Verzosa, F. J. M. Katipunan, J. G. B. Lumangyao, and E. S. Antonio, "Solid waste management awareness and practices in coastal communities," *Davao Res. J.*, vol. 15, no. 3, pp. 60–77, 2024.
[28] M. Musiana, S. N. Ishak, M. S. Soamole, and D. M. Surasno, "Analysis of Community-Based Waste Management Policies to Achieve Clean and Healthy Environment," *West Sci. Interdiscip. Stud*, vol. 2, no. 04, pp. 749–753, 2024.
[29] S. D. Oluwagbayide, F. O. Abulude, A. Akinnusotu, and K. M. Arifalo, "The Relationship between Waste Management Practices and Human Health: New Perspective and Consequences," *Indones. J. Innov. Appl. Sci.*, vol. 4, no. 1, pp. 19–34, 2024.
[30] M. Khoiruman *et al.*, "Penyuluhan dan Pelatihan Pengolahan Sampah Organik dan Anorganik Menjadi Berkah di Dusun Gunung Remuk Ketapang Kalipuro Banyuwangi," *J. Hum. Educ.*, vol. 4, no. 4, pp. 193–201, 2024.
[31] E. Nurhayati and S. Nurhayati, "Community waste management education: strategies and impacts," *J. Dimens.*, vol. 12, no. 3, pp. 677–686, 2023.
[32] A. D. W. M. Sidik *et al.*, "Empowering Communities through Enhancing Environmental Awareness: A Case Study of Cikelat Village, Sukabumi, West Java in Community Service Activities," *J. Innov. Community Engagem.*, vol. 5, no. 1, pp. 18–34, 2024.
[33] L. S. Arini, "Building Community Awareness in Waste Management," *Int. J. Soc. Heal.*, vol. 3, no. 8, pp. 518–524, 2024.
[34] F. Ahen and J. Amankwah-Amoah, "Sustainable Waste Management Innovations in Africa: New Perspectives and Research Agenda for Improving Global Health," *Sustainability*, vol. 13, no. 12, p. 6646, 2021.
[35] T. Istiqomah and L. Corsita, "Implementation of Community-Based Waste Management to Improve Environmental Health in Villages," *Sustain. Appl. Modif. Evid. Community*, vol. 1, no. 2, pp. 1–8, 2024.
[36] A. U. Zaman, "A comprehensive review of the development of zero waste management: lessons learned and guidelines," *J. Clean. Prod.*, vol. 91, pp. 12–25, 2015.
[37] O. Olorunfemi and I. F. Aina, "From Bin to Bedside: Understanding the Health Burden of Inadequate Waste Disposal," *J. Adv. Heal. Res. Clin. Med.*, vol. 1, no. 2, pp. 54–59, 2024.
[38] A. V Shekdar, "Sustainable solid waste management: An integrated approach for Asian countries," *Waste Manag.*, vol. 29, no. 4, pp. 1438–1448, 2009.