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Environmental Health Impacts and Risks of Domestic Wastewater Issues in Small Island

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Abstract

The problem of domestic wastewater on small islands poses a significant threat to the surrounding marine ecosystem. Generally, residents of small islands tend to overlook the sanitation aspects of domestic wastewater. The contents of domestic wastewater can harm environmental ecosystems and act as vectors for diseases within the community. This study aims to assess the sanitation risk index of domestic wastewater and its impact on ecological and public health. The research was conducted on Bungin Island in May 2024, using a mixed-methods approach with a Sequential Explanatory Design. The study involved 274 households as respondents and six key informants. Research instruments included questionnaires, observation sheets, and interview guides. Data collected were analyzed using Microsoft Excel 2013 and IBM SPSS version 29.0, while interview and observation data were processed using NVIVO version 14.0. The findings indicate that residents generally do not perceive domestic wastewater as a potential problem. Bungin Island falls into the high-risk category for sanitation, impacting fish ecosystems, and coral reefs, and contributing to marine pollution. Furthermore, it acts as a driving factor for diarrheal diseases and stunting in children. In conclusion, poor sanitation conditions have direct and indirect impacts on environmental ecosystems and public health. Integrated efforts are thus essential to address domestic wastewater issues on densely populated small islands.

Introduction

The problem of domestic wastewater on densely populated islands is one of the driving factors in the emergence of sanitation and environmental problems. Domestic wastewater constitutes a significant portion of the wastewater generated from human activities, with up to 90% of clean water consumption discharged as wastewater (Widyarani *et al*., 2022). Resource recovery and reuse from domestic wastewater have become crucial for the latest development of sanitation technologies and infrastructures (Firmansyah *et al*., 2021). Islands often lack land, freshwater resources, public finances, and technical personnel, leading to ineffective treatment of domestic wastewater and most pollution in surrounding sea areas (Sun *et al*., 2022).

Sanitation issues encompass solid waste management, access to clean water, proper treatment of domestic wastewater, and promotion of clean and healthy behaviors. Environmental factors have a significantly affect mortality, related to infectious diseases

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and pollution. Air pollution, unsafe water, and poor sanitation have numerous effects on human health and the environment (Liu *et al*., 2024). Domestic wastewater affects health and ecology because of its high organic concentration (Sabeen *et al*., 2018) In addition to organic matter, domestic wastewater contains bacteria and pathogens, which can directly impact human health. Many studies show that environmentally-based diseases are associated with poor hygiene and sanitation factors (Amirus *et al*., 2022).

Developing effective wastewater treatment is crucial for promoting public health and safeguarding environmental well-being. Domestic wastewater significantly affects ecological health, especially in small island ecosystems where resources are limited while the balance between human activity and nature is fragile. In small islands with limited land and water resources, releasing untreated or inadequately treated domestic wastewater can cause severe environmental damage (Silva, 2023). One of the most visible consequences is the contamination of coastal waters, where untreated wastewater from households often flows directly into the sea (Micella *et al*., 2024). It introduces high levels of organic matter, nutrients such as nitrogen and phosphorus, as well as pathogens into the marine environment (Brunetti *et al*., 2021). These pollutants can cause rapid eutrophication, leading to algal blooms that deplete oxygen levels in the water (Akinnawo, 2023). As a result, fish and other marine species struggle to survive, disrupting the local food chain and endangering biodiversity (Pfenning-Butterworth *et al*., 2024). The degradation of coral reefs, crucial to the island's marine ecosystem and economy, is also accelerated by wastewater pollution (Wear *et al*., 2021). Coral reefs are highly sensitive to changes in water quality, and the presence of excess nutrients and pathogens can lead to coral diseases and bleaching (Fattah *et al*., 2023).

Environment-based illnesses can stem from household wastewater, significantly impacting public health, particularly in regions with poor sanitation and water treatment facilities (Lin *et al*., 2022). The lack of sufficient sanitation for humans is a staggering problem (Muliana *et al*., 2021). The most prevalent illness brought on by water pollution is diarrhea, a typical indication of gastrointestinal disorders. In low-income nations, diarrhea is a primary cause of sickness and mortality among young children. In impoverished countries, diarrheal illnesses are responsible for 21% of the annual mortality of children under five (Lin *et al*., 2022). Problems related to sanitation need special attention considering the increasing population (Wulan *et al*., 2023). Thus, it is essential to research environmental health risks associated with domestic wastewater and its impact on the environment and human health. This study aimed to assess the ecological health risk index associated with household wastewater and its effect on the environment and human health.

Method

This research used mixed methods adapted from Creswell and Vicky (2018). The type of mixed methods research design used in this study is Sequential Explanatory Design. In this design, the research starts with quantitative data collection to see the sanitation risk value using the Environmental Health Risk Assessment (EHRA) method. It was followed by more in-depth qualitative data collection to find the environmental health and public health impacts of domestic wastewater problems. This research was conducted on Bungin Island, in Sumbawa Regency (shown in Fig. 1). Bungin Island is one of the most populated islands in Indonesia. This area is 8.5 ha and populated by 3.400 persons. As many as 274 households participated in the quantitative study. Questionnaires, EHRA instrument sheets, and observation sheets were employed as study tools. The impact of residential wastewater was then the subject of in-depth interviews with six key informants for the qualitative portion. A secondary data assessment was also carried out, specifically looking at disease data from the Alas Health facility in Sumbawa Regency, which serves as the Bungin Island health facility.

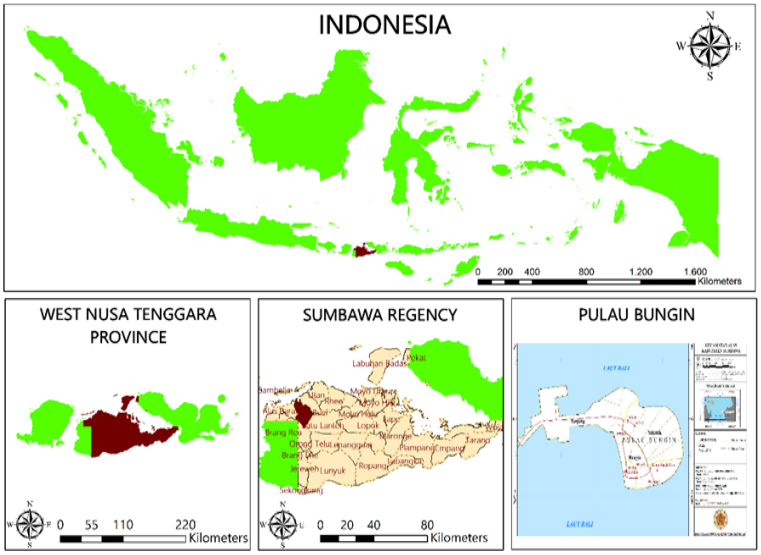

Fig. 1. Research Location

Result and Discussion

The quantitative research to find the sanitation risk index value involved 274 respondents, who had the following characteristics in Table 1,

Table 1 shows that the respondents are in the age range of 41 - 50 years old, most of whom are female. Most respondents have private home ownership status. Then, the primary type of family livelihood is as a fisherman. Most

Table 1. Characteristics of Respondents

Age Range (Years)	Frequency (n)	Precentage (%)
< 20	5	1.8
20 – 30	57	20.8
31 – 40	68	24.8
41 – 50	79	28.9
> 51	65	23.7
Gender	Frequency (n)	Precentage (%)
Man	15	5.5
Woman	259	94.5
House Ownership Status	Frequency (n)	Precentage (%)
Privately Owned	260	94.9
Family Sharing	8	2.9
Rent	6	2.2
Final Education	Frequency (n)	Precentage (%)
No School	18	6.6
Elementary	191	69.7
Junior High School	34	12.4
Senior High School	31	11.3
Occupation	Frequency (n)	Precentage (%)
Traders	24	8.7
Fisherman	195	71.2
Housewife	55	20.1

Fig. 2. Community Attitude Towards Domestic Wastewater

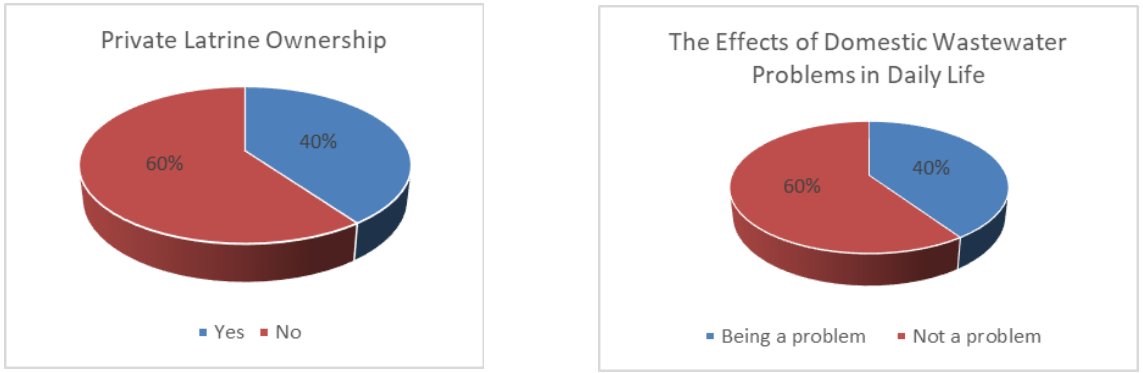

Fig. 3. Community Attitude towards Domestic Wastewater

respondents have lived on Bungin Island for more than 10 years.

The community mindset determines whether the issue of domestic wastewater affects life in the environmental and public health aspects. The results show that the community has a neutral attitude towards domestic wastewater management. In Figure 2(a), more than 50% of the community considers domestic wastewater a daily common. However, 43% of respondents agreed to domestic wastewater management. The perception evaluation on wastewater reuse was attempted to explore the level of awareness and knowledge of the beneficiary and functionary for its management (Huq *et al.*, 2024). It is essential to conduct a perception study to allow the establishment of indices and relevant elements about community water management and to match policy formulation with the conditions that already exist within the community. Because how people or groups perceive particular issues can affect planning, water management, and other matters about residential wastewater (Suksaroj *et al.*, 2024).)

Fig. 3 (a) showed that 60% of respondents have no private toilet. They rely on their neighbors' latrines and public toilets. Even still defecate directly in the sea. It is a primary challenge related to environmental sanitation issues. In urban stream systems, persistent populations of people living in open spaces have been a significant source of fecal pollution (Hinds *et al.*, 2024). In theory, this should be a problem. But for the community, it has become a habit. As many as 60% of respondents showed in Fig. 3 (b) stated that this does not lead to any problems. In addition to open defecation, a large number of anthropogenic activities specifically occur near water sources, which contributes to the contamination of their feces. Fecal pollution is related to unsanitary behaviors, including dumping waste in the waters (Okullo *et al.*, 2017). In addition to the water supply issue, the state and sufficiency of the restrooms are crucial since inadequate restrooms might promote open defecation (Odjegba *et al.*, 2024).

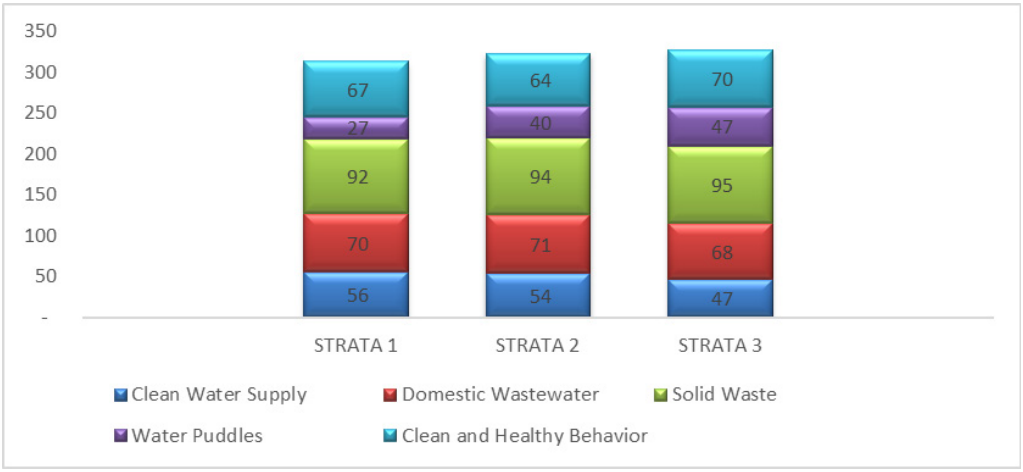

Fig. 4. Risk Sanitation Index

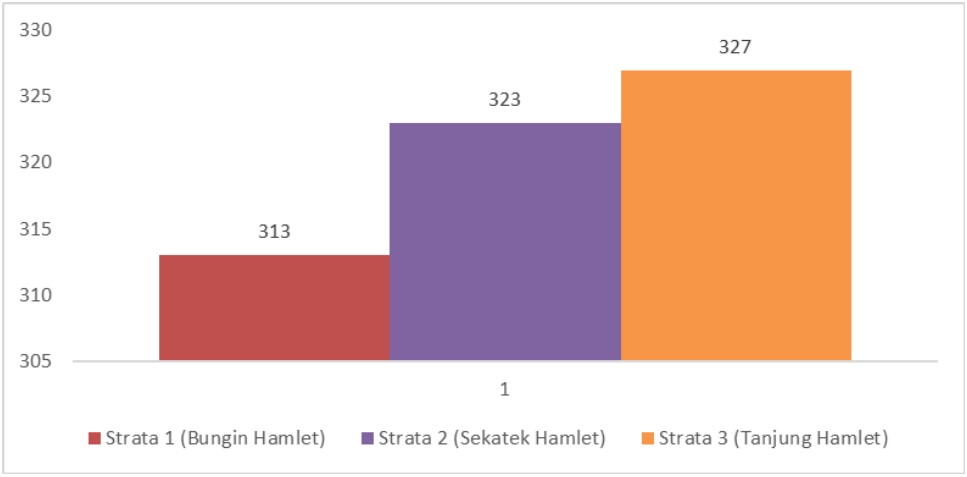

Fig. 5. Risk Sanitation Index Cumulative

In this study the sanitation risk index was measured using the EHRA method. The clustering process of the Bungin Island area is divided into 3 strata areas based on population density, poverty, tidal flooding, and drainage flow through the sea flow. Figure 4 shows that domestic wastewater is still a problem because it does not have proper management. So, it is still discharged directly into the environment. It has a very high risk after solid waste. If examined further, the sanitation indicator shows the average risk value, which results in a total value in each stratum, as shown in Figure 5.

Figure 5 shows that the cumulative sanitation risk index value in both Strata 1, 2, and 3 has a high cumulative index value. The calculation results show that the cumulative index value makes Bungin Island fall into the high-risk category. High sanitation risk in an area will affect the transmission process of environment-based disease vectors (Amirus *et al.*, 2022b). In addition, high sanitation risk will affect poor environmental ecosystems, which will ultimately have an impact on exceeding the carrying capacity of the environment (Howard *et al.*, 2016). The high risk of sanitation impacted on potential for diarrhea, trachoma, child growth, and intestinal infection (Kanda *et al.*, 2021). The projection of the results of the sanitation index calculation is followed by the creation of a sanitation risk map as in Figure 6 below,

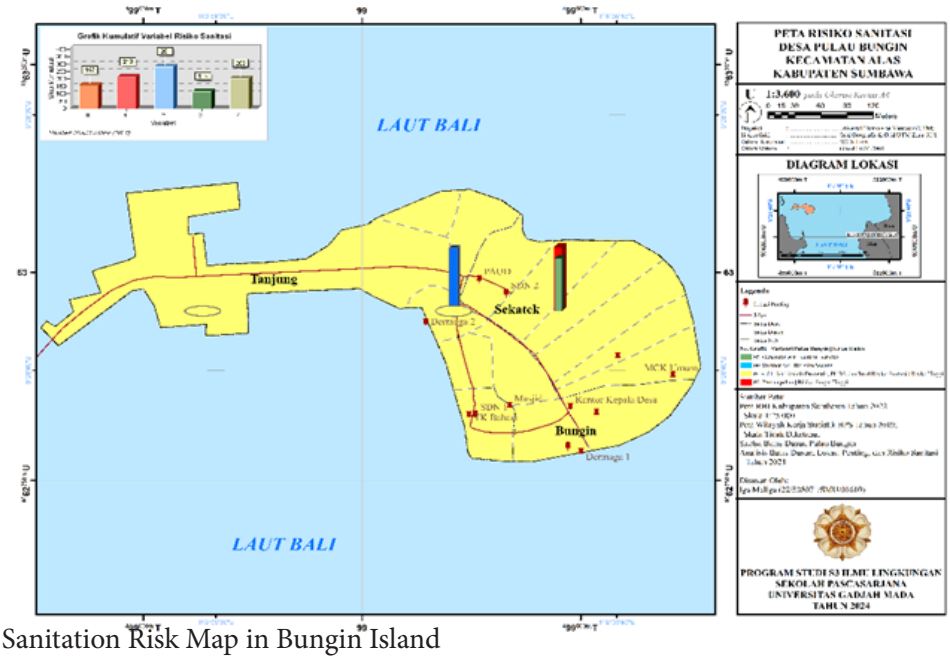

Fig. 6. Sanitation Risk Map in Bungin Island

Then, to find the impacts felt directly, in-depth interviews were conducted with residents and village policymakers related to the health and environmental impacts felt by residents due to sanitation problems and domestic wastewater in particular. Respondents and informants stated some impacts felt due to sanitation problems, as shown in Table 2.

The results of this study point to several theoretically connected effects. The longer this sanitation issue is neglected, the more detrimental effects it will have on the environment and human health in the future. It may have negative effects. Research by (Freeman *et al.*, 2017), showed that sanitation conditions impact on infectious disease and nutritional status. It is in line with the findings in the field, which show that diarrheal disease in children is high on Bungin Island. It was also validated by data from the Alas Community Health Center, which is the working area for Bungin Island. The results of the interview mentioned that stunting conditions were also suffered by having many children. Although the cause of stunting due to environmental sanitation factors cannot be known for certain. It can be a concern in the future.

Fish populations, coral reefs, and general marine health are significantly and frequently negatively impacted when untreated household wastewater is released into marine settings (Zhou *et al.*, 2022). Numerous contaminants, including nutrients, organic debris, heavy metals, and pathogens, are carried by wastewater as it flows to the ocean (Micella *et al.*, 2024). These contaminants upset the natural equilibrium of marine environments, frequently leading to detrimental effects. In fish environments, eutrophication—which encourages excessive algal growth—can

Table 2. Impact of High-Risk Sanitation in Bungin Island

Impact Category	Impact
Environmental Health	Fish ecosystem reduced
	Coral reef damage
	Potential marine pollution
Human Health	Malaria outbreaks have occurred
	High rate of diarrhea
	High rate of stunting

result from an overabundance of nutrients like phosphorus and nitrogen (Akinnawo, 2023). Hypoxic, or oxygen-depleted, zones are produced when the dead algae break down and consume dissolved oxygen (Bergland *et al*., 2019).

Wastewater pollutants can weaken coral resilience, promote the spread of coral illnesses, and induce coral bleaching (Nurdjaman *et al*., 2023). Wastewater high in nutrients encourages the growth of toxic algae on coral reefs, which suffocates these essential ecosystems by competing with corals for sunlight and space. The additional stress from wastewater pollution speeds up the destruction of coral reefs, which are already threatened by rising ocean temperatures and acidification (Pendleton *et al*., 2019). In addition to affecting biodiversity, damage to coral reefs also affects local fisheries stability and the livelihood of populations that depend on them. The effects of inadequate sanitation extend to long-term growth and development problems, particularly for young children(Ugboko *et al*., 2020). Frequent intestinal infections are caused by repeated exposure to tainted water and unsanitary settings, which hinder the absorption of nutrients. Children eventually experience stunted growth as a result of not getting the nutrients their bodies require for proper growth and development (Cumming & Cairncross, 2016). This disorder, called stunting, has long-term effects on cognitive development and physical health.

Conclusion

This research can conclude that the high sanitation risk conditions on Bungin Island impact environmental and human health conditions. The high sanitation risk that occurs is not only the result of poor domestic wastewater management but also clean water and solid waste problems. The condition of people who still do not have direct access to toilets also further increases sanitation risks due to the habits of people who do not fully care about sanitation conditions. The impacts felt by residents and the results of observations in the field show that environmental impacts such as a decrease in fish catches, coral reef problems, and potential sea water pollution also occur due to poor environmental sanitation. Sanitation and domestic wastewater problems are also driving factors for diarrhea and stunting problems in the community. Further efforts are needed to address domestic wastewater problems in Bungin

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