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Coastal Sanitation Under Pressure: Evaluating the Failure of Septic Tank Implementation in Batu Merah Settlement

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Abstract
Coastal areas are residential regions where the lives of the community depend on the sea as the main source of livelihood. Coastal areas also have high ecosystem potential and tourist attractions, especially in archipelagic regions. These conditions encourage rapid settlement development, but it is often not accompanied by the provision of adequate basic facilities, especially environmental sanitation. This imbalance causes various problems, such as low environmental cleanliness quality and increased risk of health disturbances in the community. The coastal area of Batu Merah in Batam City is one of the regions experiencing sanitation problems. The sanitation issues that occur are not entirely caused by community behaviour but are influenced by the incompatibility of septic tank implementation with the physical conditions of the coastal area. Therefore, this study aims to evaluate the existing environmental sanitation conditions, analysing the factors behind the low use of septic tanks, and examining the mismatch of sanitation technology with the physical characteristics of the coast. The research method used qualitative through observation of the environment and society. The research results indicate that coastal physical conditions, the influence of tides, and limited infrastructure are the main factors causing sanitation problems in the Batu Merah coastal area, Batam. Therefore, an adaptive solution for sanitation system based on local conditions is needed to improve environmental quality and public health.

Keywords: Coastal; sanitation; septic tank; adaptive solution.

Introduction

Coastal areas experience rapid residential development, but this is often not accompanied by adequate sanitation facilities. This situation leads to various

environmental and public health problems, such as direct waste disposal into the sea and limited access to basic sanitation (Sembiring et al., 2020). Environmental sanitation in coastal areas plays a crucial role in maintaining the quality of life of the community, as it is related to the risk of disease caused by the surrounding environment (Nurhayati et al., 2024; Sapitri et al., 2025). In addition to limited facilities and infrastructure, sanitation issues in coastal settlements are also influenced by inherited customs and culture.

The practice of dumping household waste directly into the sea shows that low environmental awareness is very low and poor (Murtiono et al., 2021). In fact, open defecation is still practiced even though some communities have access to sanitation facilities (Sembiring & Safithri, 2020). This habit is influenced by public perceptions that the sea is a natural and convenient disposal site, leading to continued practice without considering the long-term impacts on health and the environment (Misdayanti, 2021). However, clean and healthy living practices play a crucial role in maintaining environmental quality, as environmental cleanliness is closely linked to public health (Nurhayati et al., 2024). Government efforts to provide sanitation solutions through the construction of septic tanks for domestic waste treatment have not been fully effective in coastal areas. Waste that should be treated has the potential to pollute groundwaters and the surrounding environment because it easily seeps in or overflows during high tide. As a result, many people no longer use the septic tanks provided and have returned to the practice of disposing of waste directly into the sea. This problem demonstrates that general technical approaches are not necessarily appropriate for the characteristics of coastal areas. Therefore, sanitation problems in coastal areas are not only caused by technical aspects such as limited infrastructure, but also by the mismatch of technology with environmental conditions and social and cultural factors that are difficult to change. A more adaptive approach, based on local conditions, coupled with behavioral changes and increased public awareness, is needed as part of the solution to sanitation management in coastal settlements.

Although several studies have addressed, most have focused on the technical aspects of sanitation infrastructure or environmental quality. Comprehensive research on the relationship between environmental conditions, community behavior, and the effectiveness of communal sanitation systems in coastal areas is still limited. Specifically, studies examining the coastal settlement of Batu Merah, Batam City are still rare. Therefore, this study fills this gap by analyzing the environmental characteristics and socio-cultural factors that influence sanitation management and the sustainability of existing sanitation facilities in Batu Merah. The Batu Merah coastal settlement was chosen as the study in the area because it's one of the coastal areas with the highest population density. This area is characterized by high groundwater levels, influences, limited land availability, and the presence of communal sanitation facilities that experience operational constraints. This makes Batu Merah a valuable area for evaluating the suitability of sanitation infrastructure and for understanding the interactions between environmental, social, and behavioral factors.

Research Method

This research was conducted in Batu Merah Village, Batu Ampar District, Batam City, Riau Islands Province. These areas a residential area located in a coastal area with a high area population density and has various environmental sanitation problems, especially related to the domestic waste disposal system. Based on regional data, Batu Merah is one of the villages in Batam City with an area of approximately **3.79 km². Although several studies have addressed sanitation conditions in coastal settlements, most have focused on the technical aspects of sanitation infrastructure or environmental conditions, community behavior, and the effectiveness of communal sanitation systems in coastal areas is still limited. Specifically. Studies examining the coastal settlement of Batu Merah, Batam City, are still rare. Therefore, this study fills the gap in the research by analyzing how environmental characteristics and socio-cultural factors influence sanitation management and the sustainability of existing sanitation facilities in Batu Merah.**



Figure 1. *Location of Batu Merah, Batam City (source: google earth)*

This study employed a descriptive qualitative method, conducting environmental observations after identifying problems and conducting in-depth interviews with the community using narrative qualitative questions to facilitate respondents' understanding of the research questions and objectives. This study utilized a very limited number of respondents, making it impossible to provide a general reference.

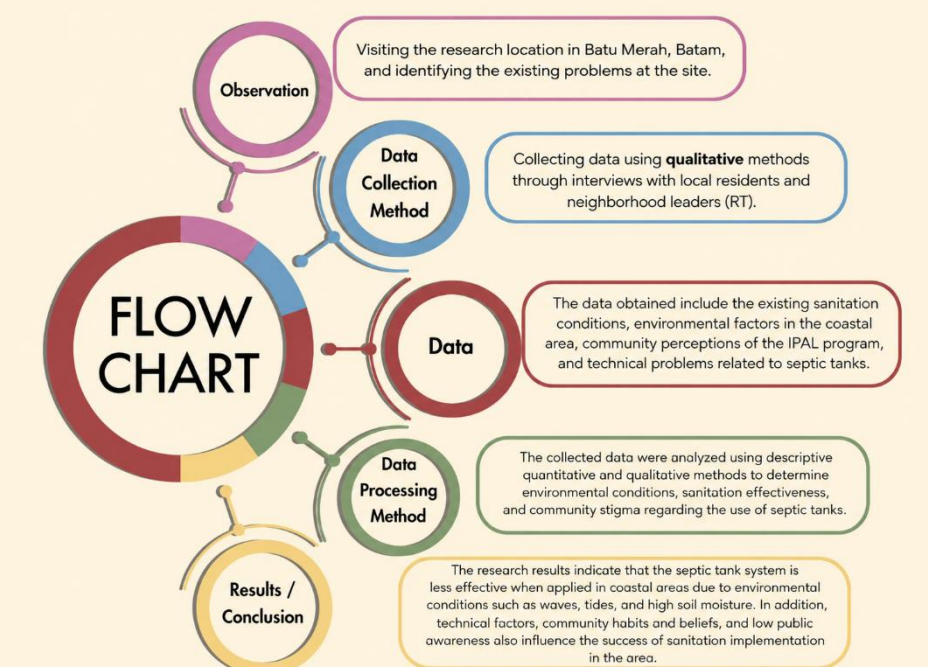


Figure 2. *Research Method design*

Results and Discussions

Based on the observations and interview with the Head of RT 07, several main issues were identified:

Table 1. *Key Sanitation Issues Identified in Batu Merah, Batam*

SANITATION PROBLEMS
Incompatibility of the IPAL System with Environmental Conditions
Technical Elevation (Leveling) Problems
Construction and Sustainability Constraints
Economic and Social Aspects
Existing Sanitation Practices (Flying Toilet)
Community Preferences

Based on field observations and interviews with the Head of RT 07, several major sanitation issues were identified in the Batu Merah coastal settlement. The findings indicate that the existing sanitation system is strongly influenced by environmental, technical, and socio-economic conditions characteristic of coastal areas. One major problem with wastewater treatment systems in areas is that they do not work well with the environment. These systems are always exposed to the oceans tides, seawater, waves and unstable soil, which causes the pipes and tanks to break down faster and not work properly. This is what Fanggi and others found out in 2015. They said that sanitation systems in areas need to be able to handle the stresses of the environment and need special infrastructure that can deal with the conditions in coastal areas. Another big issue is the problem of elevation and wastewater flow.

When the houses are at heights and the land is not even it can disrupt the flow of wastewater which can cause blockages and sewage to back up into people's toilets. This is what Saputri and others found out in 2021. When it comes to building and maintaining sanitation systems the study found that they need to be fixed because of problems like leaks and corrosion which are caused by the seawater and the age of the system. This increases the cost of running the system. It affects how well it works in the long run. This is what Sembiring and Safithri found out in 2023.

It is hard to set up sanitation systems because they are expensive to build and the coastal environment is unpredictable. Previous research by Lisafitri and others in 2021 found the thing. They said that not having sanitation in crowded coastal areas can lead to pollution, bad smells and a decline in the quality of the environment. In Batu Merah the sanitation problems are not just because of a lack of infrastructure. Also, because the usual ways of dealing with sanitation do not work well in coastal environments. Things like the tides, waves, unstable soil and differences in elevation all reduce how well the sanitation systems work in the run.

Sanitation systems are a problem. Also not having money and people not trusting the systems make it even harder to set up communal sanitation programs. So, we need sanitation systems that can adapt to the environment are community-based and work well with the environment to improve how sanitation works and the quality of the environment in coastal areas.

The main things we found out about sanitation problems in our research, in the Batu Merah area of Batam are as follows:

Table 2. *Detailed Findings on Sanitation Conditions in Batu Merah, Batam*

ASPECT	INDICATOR	DESCRIPTION
Existing Santiation System	Type of Disposal	Flying Toilet
	Physical Condition of the System	Leaking and Damaged
	Frequency of maintenance	WC suction
Environmental Factors	Ocean Waves	Intensity and Impact on the System
	Elevation (Leveling)	Difference in Height of House to Land
	Soil Conditions	Stable
Socio-Economic Factors	Construction costs	Covered
	Public Perception	Disagreement with IPAL
	System Preferences	Individual
Impact of Sanitation	Comfort	Odor and Blockage
	Environmental Health	Polluted
	System effectiveness	Ineffective

This study found that the sanitation issues in the Batu Merah coastal area are caused by technical, environmental, and socio-economic factors. The current sanitation system still uses flying toilets, broken pipes, and septic tanks, needs frequent cleaning, and the shared IPAL system doesn't work well. Coastal environmental conditions like ocean waves, changing tides, differences in height between homes and the ground, and unstable soil can greatly impact how long and well sanitation systems last. These conditions usually lead to blocked wastewater, leaks, bad smells, and pollution that make the community less comfortable and less effective at keeping things clean. Fanggi et al.(2015) also found similar results, explaining that sanitation systems in coastal communities are very sensitive to tides and unstable ground. Sembiring and Safithri (2023) said that traditional community sanitation systems usually don't work well in coastal areas because the infrastructure gets damaged easily from seawater and needs a lot of money to maintain. Socially, interviews showed that some residents don't trust the shared IPAL systems because they think they don't work well and are costly to keep running. So, many families choose their own septic tanks, but these systems still release waste that is affected by the movement of seawater and can keep causing pollution. This result agrees with the study by Susilawati et al.(2022), which showed that how people feel about sanitation and how much they accept the system depends a lot on what they think, how much money they have, and how much they work together in their community. Based on these findings, the early results of this study show that the sanitation issues in Batu Merah are not just because there are not enough facilities, but also because traditional sanitation systems do not work well in coastal areas.This suggests that better, more flexible, and community-focused sanitation solutions are needed for coastal communities.

Conclusion

The findings indicate that sanitation problems in the Batu Merah coastal area are influenced by more than just the lack of sanitation facilities. Another major issue is that existing septic tank systems are not well suited to the environmental characteristics of coastal regions. Conditions such as rising sea levels, wave activity, elevation differences, and unstable soil reduce the efficiency of sanitation systems and may result in leakage, unpleasant odors, and environmental contamination. Social and cultural factors also play an important role in limiting the success of sanitation programs. Long-standing habits of disposing of waste directly into the sea, along with decreasing public confidence government sanitation initiatives, make sustainable sanitation management difficult to achieve. Therefore, several solutions are recommended, including designing sanitation systems that can adapt to high groundwater levels and tidal conditions, regularly maintaining communal sanitation facilities, and increasing community awareness through educational programs. This study is limited because it only focused on RT 07 in Batu Merah Village and relied on observations and interviews without conducting detailed technical assessments. Future studies should cover a wider range of coastal settlements in Batam and incorporate water quality analysis, environmental

impact assessments, and evaluations of sanitation technologies that are suitable for coastal environments.

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Competing Interest

There is no conflict of interest in the publication of this article.

Generative AI Statement

During the preparation of this manuscript, the author(s) used GPT.ai to refine language and improve readability. Following this process, the author(s) critically reviewed, edited, and validated the output to ensure accuracy and scientific integrity. The author(s) maintain full accountability for the final content. AI was used solely as a supportive tool and is not credited with authorship. No original data analysis or interpretations were performed by the AI without human oversight.