



Preliminary Study on Solid Waste Management In Small Islands: A Case Study of Penawar Rindu, Belakang Padang, Batam, Indonesia

1st Dian Prima Safitri
Department of Public Administration
Universitas Maritim Raja Ali Haji
Tanjungpinang, Indonesia
Dianprima@umrah.ac.id

4th Adi Syahputra Purba
Mechanical Engineering
Politeknik Batam
Batam, Indonesia
Adipurba@polibatam.ac.id

2nd Yosef Adicita
Environmental Engineering
Universitas Universal
Batam, Indonesia
yosef.adicita@uvers.ac.id

5th I Wayan Koko Suryawan
Environmental Engineering
Universitas Pertamina
Jakarta, Indonesia
i.suryawan@universitaspertamina.ac.id

3rd Nurul Ulfah
Mechanical Engineering
Politeknik Batam
Batam, Indonesia
nurululfah@polibatam.ac.id

Abstract—Penawar Rindu Island, nestled within Indonesia's Riau Islands province, presents a captivating and lesser-known allure to tourists seeking an escape to nature's tranquility. The Island's pristine beauty and rich cultural heritage have attracted local and regional visitors, making sustainable tourism a priority for preserving its authenticity and environmental integrity. However, the rise in tourism has also brought about solid waste management challenges, leading to concerns over environmental degradation and marine debris. To address this issue, a revitalization program was initiated for the Waste Processing Site (TPS) in 2021. Nevertheless, the absence of auxiliary facilities, such as garbage collection boats, and limited waste handling capacity pose unique challenges for an island location. To ensure a sustainable and healthy environment, a comprehensive waste management study is essential, considering waste generation patterns and waste treatment needs. By implementing responsible waste management practices and embracing sustainable tourism principles, Penawar Rindu Island can balance tourism development and environmental preservation, securing its allure as a sought-after destination within Indonesia and beyond while contributing to Indonesia's commitment to environmental conservation and reducing marine debris.

Keywords—Penawar Rindu Island, waste management, sustainable tourism, Riau Islands, marine debris

I. INTRODUCTION

Small islands are scattered across the globe, and their classification can vary depending on different criteria and regulations. In the context of Indonesian regulation no 14/2014 and UNESCO, a small island is defined as an area of 2000 square kilometers with a whole ecosystem. Besides Bali, which has earned global recognition as a stunning tourist destination, the Riau Islands are another region in Indonesia known for having numerous small islands. Penawar Rindu Island is another gem among the Riau Islands. As its name translates to "Cure for Longing," the Island promises a serene escape for travelers seeking solace in nature's embrace. With its pristine beaches and azure waters, Penawar Rindu offers an idyllic retreat for those looking to immerse themselves in a peaceful and natural setting. Like Bali, these small islands in the Riau Islands region require careful and responsible management to

protect their ecosystems, preserve their cultural heritage, and ensure sustainable tourism [1]. The coastal regions of Riau Islands possess a rich ecosystem and considerable potential to support sustainable livelihoods. However, escalating human activities and environmental stressors in these areas are notably impacting coastal systems. This surge of challenges in the utilization and advancement of coastal regions underscores the significance of examining policies for managing these areas [2].

Penawar Rindu Island, nestled off the coast of Belakang Padang in Indonesia's Riau Islands province, offers a distinctive and lesser-known allure to tourists from outside the region. However, it has garnered significant popularity among local tourists due to its renowned traditional coffee and culinary delights. The Island's unique appeal lies in its unspoiled natural beauty and tranquil ambiance, making it a perfect escape from more touristy destinations. It becomes imperative to strike a balance between tourism development and sustainable practices. Local authorities and stakeholders should work together to preserve the Island's natural beauty, protect its fragile ecosystems, and promote responsible tourism. As Penawar Rindu Island continues to captivate travelers with its cultural offerings and gastronomic delights, it is expected to gain more recognition both within Indonesia and beyond, while ensuring its authenticity and charm remain intact for future generations of locals and visitors alike [3].

While the rise in tourism has contributed positively to the local economy and cultural preservation, it has also resulted in a growing concern over the generation of solid waste and the strain on existing waste management infrastructure. To ensure sustainable tourism development in Penawar Rindu Island, responsible practices must be embraced to address the waste management issue and protect the Island's pristine environment. Marine debris is a problem that Indonesia will continue to face in the coming years (Nurhati & Cordova, 2020). Although the exact pathways of how this debris enters water bodies from land are not yet fully understood (Jambeck et al., 2015; Septiariva & Suryawan, 2021), data indicates that there are approximately 5.25 trillion plastic particles from 268,940 tons of floating waste in the ocean (Eriksen et al., 2014).

Indonesia is one of the largest contributors to marine debris and ranks as the second-largest producer of plastic waste in the ocean, just behind China (Jambeck et al., 2015).

In 2021, a revitalization program was initiated for the Waste Processing Site (TPS) on the Island, where waste was previously merely piled up in open areas, resembling an open dumping site (not yet considered an integrated landfill system). The solid waste issue extends beyond land and affects the Island's marine environment. Based on a study conducted by Sutarto and Muhammad in 2019, the primary issue with waste management on this Island is the absence of auxiliary facilities such as garbage collection boats. Additionally, the Island's capacity to handle waste from the local population and the incoming tourist waste is severely limited. Therefore, an initial study is essential to assess the waste management requirements on Penawar Rindu Island, considering the increasing popularity of the Island among both local visitors and tourists from outside Batam. By conducting this study, undesirable consequences such as health hazards can be prevented, ensuring a sustainable and healthy environment for both residents and visitors on the Island.

This article presents a preliminary study conducted on Pulau Penawar Rindu, focusing on solid waste management practices on the Island. The study employs a descriptive analysis methodology comprising observation and literature review. Observations were conducted in June 2023 to assess the current condition of solid waste in the Island's surrounding waters. Additionally, a comprehensive literature review was carried out to compare and review solid waste management practices implemented on small islands both in Indonesia and worldwide, emphasizing their crucial role in addressing solid waste challenges in island environments. The literature review aimed to comprehensively understand successful solid waste management practices adopted by small islands worldwide.

II. RESULT AND DISCUSSION

Indonesia, known as the world's largest archipelagic nation, is renowned for its remarkable marine biodiversity [5]. It is situated at the heart of the globally significant Coral Triangle, which is renowned for its high abundance and diversity of marine species. However, Indonesia also faces a significant challenge in managing marine debris with synthetic materials, such as plastic bags, food wrappers, footwear, fishing nets and lines, polystyrene, cans, plastic and glass bottles, polyethylene, and other plastic and glass items, dominating the marine litter [6]. According to the World Bank, disposable diapers (21%), plastic bags (16%), plastic packaging (5%), and other plastic items (9%), as well as glass and metal (4%) and plastic bottles (1%), are the major components of municipal waste in Indonesia [7]. While most published research has focused on densely populated coastal areas, a limited number of studies have revealed that plastic waste is prevalent in Indonesia [8].

Managing solid waste on small islands is a complex challenge requiring a well-planned and coordinated approach. Several studies have explored strategies to address solid waste management issues on small islands, considering various aspects such as rules, roles, involved organizations, and existing gaps (**Table 1**). Based on these considerations, several potential strategies can be proposed.

Firstly, the establishment and implementation of clear rules and regulations are essential. Local authorities should develop comprehensive waste management policies and enforce them effectively to ensure compliance among residents, businesses, and tourists. This may include waste segregation guidelines, recycling mandates, and penalties for improper disposal practices. Secondly, defining the roles and responsibilities of stakeholders is crucial for successful waste management. Engaging the local community, businesses, and tourism operators in waste reduction efforts can foster a sense of ownership and accountability. Local communities can play a pivotal role in waste collection and segregation, while businesses can adopt sustainable practices, such as reducing single-use plastics and promoting eco-friendly alternatives. Thirdly, the involvement of relevant organizations is paramount to achieving effective waste management on small islands. Collaboration between local governments, environmental agencies, non-governmental organizations, and private sector entities can facilitate sharing resources, expertise, and best practices.

Furthermore, the support and guidance from higher government levels can help fund waste management infrastructure and capacity-building initiatives. Lastly, addressing existing gaps in waste management systems is critical. Identifying shortcomings in waste collection, transportation, and disposal processes and devising innovative solutions to overcome these challenges is imperative. Leveraging technology, such as waste-to-energy technologies or innovative recycling methods, can be explored to improve waste management efficiency and minimize environmental impacts. By formulating clear rules, defining roles, engaging relevant organizations, and addressing existing gaps, sustainable waste management strategies can be devised to preserve the pristine environments and promote the long-term well-being of small island communities.

Several gaps have been identified based on the literature study conducted on solid waste management in small islands. These gaps include the lack of adequate facilities due to limited funds and the low knowledge and awareness, particularly among the local residents, regarding proper waste management, especially household waste. Additionally, from the perspective of visitors or newcomers to the islands, they tend to dispose of waste properly if suitable facilities are provided. This observation aligns with research on education tourism related to mangroves and waste. To address these gaps and improve solid waste management in small islands, the following strategies can be implemented:

- a. Enhanced Education and Awareness: Implement educational programs and awareness campaigns targeting local communities. These initiatives should focus on the importance of effective waste management, the negative consequences of improper waste disposal, and the appropriate waste management and recycling methods. By providing education on the different types of waste, specifically distinguishing between organic and inorganic waste, communities can better understand the appropriate methods of waste disposal and recycling. As highlighted in previous

Tabel 1 Literature Study

Author	Island	Area	Region	Rules	Roles	Caps
[11]	Gili Trawangan	15 km ²	Indonesia	The regulation governing	Government, local neighborhood associations	Lack of established protocols, official guidelines, and suitable regulations regarding the creation and handling of waste; The efficiency of a Solid Waste Management (SWM) system relies on the level of emphasis and readiness demonstrated by the government; The allocated funds for waste management are insufficient for effectively handling the rising volume of waste produced; Deficiency in having the right facilities and infrastructure for gathering and processing waste, as well as an inadequate amount of land for its final disposal; There is a scarcity of knowledge, skills, and expertise in the field of waste management.
[12]	Puerto Rico	13.791 km ²	USA	1. Environmental Quality Board (EQB) has the ministerial responsibility to apply Act 41; 2. Environmental Protection Agency (EPA) The regulation governing	Government	Inadequate handling and improper disposal of nearly five million scrap tires (ST) produced each year on the island have led to adverse environmental, economic, and social consequences
[13]	Caribbean SIDS, Pacific SIDS and Atlantic, Indian Ocean, Mediterranean and South China (AIMS)	-	SIDS	The regulation governing	Government, local neighborhood associations	Lack of established protocols, policies, and suitable regulations regarding waste generation and management; The efficiency of a Solid Waste Management (SWM) system hinges on the government's prioritization and willingness; The allocated funds for waste management fall short in effectively handling the growing volume of generated waste; Insufficient possession of suitable facilities and infrastructure for waste collection, treatment, or ample land for final disposal; Limited expertise, skills, and knowledge in the realm of waste management.
[14]	Pacific Belakang Padang, Riau Island	- 68.11 km ²	SIDS Indonesia	The regulation governing The regulation governing solid waste management in Batam City is Regional Regulation No. 11 of 2013 concerning Waste Management. This regulation encompasses various waste management aspects, including sorting, collection, transportation, processing, and final disposal. For the purpose of this study, the focus is specifically on the issue of waste transportation.	Government, local neighborhood associations District office collaboration with the local neighbourhood associations	Inadequate government emphasis and political backing are crucial issues; Financial constraints are a major factor; Absence of extended or business-oriented planning; Subpar selection, design, organization, and oversight of landfill sites; Shortage of proficient staff; limited understanding of the repercussions of substandard waste management; constraints on establishing landfill sites; Inadequate management of medical waste; Insufficient recycling and repurposing, encompassing restricted reutilization of organic waste, septic and sewage sludge, and effluents. The region only possesses one waste disposal site (TPA) with a restricted area of 277 square meters, which is currently at full capacity. This necessitates the establishment of additional waste management facilities; The absence of functioning government-owned boats obstructs the collection of marine debris, exacerbating the issue of waste pollution in the sea. There is a lack of waste sorting at the household level, leading to insufficient efforts in waste separation and recycling; The acquisition of operational equipment, such as boats and vehicles, takes place on an annual basis, resulting in inefficiencies and delays in waste transportation; Vehicles, including motorized beacons, are in a state of disrepair and are poorly maintained, adding to the challenges in waste transportation.
[14]	Belakang Padang, Riau Island	68.11 km ²	Indonesia	The regulation governing solid waste management in Batam City is Regional Regulation No. 11 of 2013 concerning Waste Management. This regulation encompasses various waste management aspects, including sorting, collection, transportation, processing, and final disposal. For the purpose of this study, the focus is specifically on the issue of waste transportation.	District office collaboration with the local neighbourhood associations	The waste transportation team's contractual employment status affects their efficiency and consistency in executing waste management strategies; The custom of dumping wet waste into the sea persists within the local community, indicating a lack of understanding about proper waste disposal techniques; Careless blending of different kinds of waste complicates waste management endeavors and diminishes the feasibility of recycling initiatives; The shortage of boats for collecting marine waste worsens marine pollution, underscoring the necessity for well-planned waste collection methods in coastal regions; Local customs of discarding waste into the sea as a routine occurrence reveal a deficiency in knowledge and education regarding responsible waste disposal practices both on land and at sea; There is a need for extensive planning in waste management, increased investment in functional equipment, and educational initiatives to promote sustainable waste management practices and safeguard the environment from further harm; Cooperative initiatives involving the local government, communities, and non-governmental

Author	Island	Area	Region	Rules	Roles	Gaps
[15]	Setokok, Riau Island		Indonesia	The regulation governing solid waste management in Batam City is Regional Regulation No. 11 of 2013 concerning Waste Management. This regulation encompasses various aspects of waste management, including waste sorting, collection, transportation, processing, and final disposal. For the purpose of this study, the focus is specifically on the issue of waste transportation.	1. Kawan laut community; local neighbourhood associations 2.	organizations are pivotal in effectively addressing waste management issues and encouraging responsible waste disposal practices in the region. The area still grapples with insufficient waste management, with certain elements of waste disposal and recycling yet to be effectively managed. The absence of well-rounded waste management systems could lead to improper waste disposal, posing risks to both the environment and public health; There is a noticeable deficiency in community awareness and dedication to environmental cleanliness. This lack of a strong commitment to upholding a tidy and healthy environment may result in haphazard waste disposal, littering, and improper waste handling methods, ultimately contributing to environmental decline in the region.
[16]	Kangean, Madura	648,56 square km	Indonesia	Government Regulation (PP) 81/2012	local neighbourhood associations	Lack of proper waste disposal infrastructure and services; Illegal dumping; Dumping to the coastal area; Illegal burning
[17]	Saint Luca	617 square km	North America	The regulation governing	Government, local neighbourhood associations	The effectiveness of a SWM system depends on government priority and willingness
[1]	small island tourism	-	all	The regulation governing	Government, local neighbourhood associations	There is a lack of crucial government emphasis and political backing for action.; Financial resources are inadequate; There is an absence of extended or business-oriented planning; Landfill sites are poorly situated, designed, planned, and managed; There is a shortage of proficient staff; limited understanding of the repercussions of substandard waste management; constraints on establishing landfill sites; Clinical waste is handled inadequately; Recycling and repurposing efforts are insufficient, including the limited reuse of organic waste, septic and sewage sludge, and effluents
[18]	Pulo Aceh, Seribu, Karimun Jawa and Wakatobi	10,18 – 473,6 km ²	Indonesia	1. Government Regulation No. 19/1999 on Marine Pollution Control (Indonesia) 2. Law No 18/2008 on Solid Waste Management (Indonesia) 3. Ministry of Home Affairs Regulation No 33/2010 on Household Waste Management (Indonesia) 4. Presidential Regulation No. 97/2017 National Strategy and Policy for Solid Waste Management (Indonesia) 5. Presidential Regulation No. 83/2018 on the Handling of Marine Plastic Debris (Indonesia)	1. Government of Indonesia under the supervision of the Coordinating Ministry of Maritime Affairs and Investment 2. local neighbourhood associations 3. NGO	1. Lack of proper waste disposal infrastructure and services 2. Illegal dumping 3. Dumping to the coastal area 4. Illegal burning
[19]	Lengkang, Riau Island		Indonesia	The regulation governing solid waste management in Batam City is Regional Regulation No. 11 of 2013 concerning Waste Management. This regulation encompasses various aspects of waste management, including waste sorting, collection, transportation, processing, and final disposal. For the purpose of this study, the focus is specifically on the issue of waste transportation.	local neighbourhood associations	1. Lack of proper waste disposal infrastructure and services 2. Illegal dumping 3. Dumping to the coastal area 4. Illegal burning

research different types of waste require different waste management processes [9], [10]. For instance, organic waste can be composted or used for biogas production, while inorganic waste might need to be recycled or properly disposed of in landfills or waste-to-energy facilities. By raising awareness about these distinctions, local communities can make informed decisions regarding waste management practices that are more suitable for their specific needs, especially in coastal areas. To further enhance waste management efforts, subsequent research can focus on the following aspects:

- Waste Generation Studies: Conduct studies to determine the amount and types of waste generated in different areas of the Island. This data will help identify the most significant sources of waste and aid in tailoring waste management plans accordingly.
 - Waste Characterization: Characterize the composition of waste produced on the Island, considering local community and tourist waste. Understanding the specific waste composition can guide recycling efforts and identify potential opportunities for waste reduction.
 - Awareness and Behavior Analysis: Assess the level of awareness and waste disposal behavior among local residents and tourists. This analysis can highlight areas where education and awareness campaigns need improvement and help target specific audiences with tailored messages.
 - Waste Hotspots: Identify locations on the Island where waste accumulates or is disposed of improperly. Implement measures to address these waste hotspots through increased waste collection points, educational signage, or community engagement.
 - Tourist Involvement: Engage tourists and visitors in waste management practices through educational materials, awareness programs, or sustainable tourism initiatives. Encouraging responsible waste behavior among tourists can significantly contribute to maintaining the cleanliness of the Island.
- b. Community Involvement: Encourage active participation from the local community in waste management efforts. This can involve organizing community clean-up events, waste separation initiatives, and other community-driven waste reduction programs.
 - c. Infrastructure Development: Despite limited funds, seek support from government agencies, non-governmental organizations, or international bodies to invest in essential waste management infrastructure. Adequate waste collection points, recycling facilities, and waste treatment systems are crucial for proper waste disposal.
 - d. Tourist Engagement: Engage with tourists and visitors to raise awareness about responsible waste disposal during their stay on the islands. Implement educational

materials, signages, or interactive displays at popular tourist spots to encourage responsible waste behavior.

- e. Public-Private Partnerships: Foster collaborations between local authorities and private sectors to improve waste management. Private businesses can contribute resources, knowledge, and funding to support waste reduction and recycling initiatives.
- f. Waste Reduction Policies: Develop and implement policies that promote waste reduction, such as plastic bag bans, single-use item regulations, or waste reduction targets.
- g. Monitoring and Evaluation: Establish a monitoring and evaluation system to assess the effectiveness of waste management strategies over time. This data-driven approach can help refine existing initiatives and identify areas for improvement.

III. CONCLUSION

Penawar Rindu Island, possesses a unique charm that has attracted local and regional tourists seeking a serene escape from bustling destinations. However, the rapid tourism growth has brought about challenges, particularly in solid waste management, posing a threat to the Island's pristine environment and marine ecosystems. To ensure sustainable tourism development on Penawar Rindu Island, it is crucial to address the waste management issue and protect its fragile ecosystems. Marine debris and plastic waste in the surrounding waters necessitates urgent action to prevent further environmental degradation. The revitalization program for the Waste Processing Site (TPS) initiated in 2021 marks a positive step towards improving waste management on the Island.

However, more comprehensive efforts are required, particularly establishing auxiliary facilities like garbage collection boats to address waste disposal challenges unique to an island location. With the increasing popularity of the Island among both local visitors and tourists from outside Batam, a systematic waste management study becomes imperative. This study will help identify waste generation patterns, assess the Island's waste management capacity, and determine appropriate waste treatment methods. By implementing responsible waste management practices and embracing sustainable tourism principles, Penawar Rindu Island can safeguard its natural beauty and cultural authenticity for future generations. Collaborative efforts among local authorities, stakeholders, and the community are crucial in preserving the Island's charm while ensuring residents' and visitors' health and wellbeing. Additionally, these efforts can contribute to reducing Indonesia's contribution to marine debris and plastic pollution, reinforcing the nation's commitment to environmental conservation.

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