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Waste Recycling Processing in Indonesian Tourist Attractions: Problems and Challenges of Implementing Legal Policies Restricting Plastic Use

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ABSTRAK

Pengelolaan limbah yang efisien tetap menjadi tantangan utama di lokasi wisata Indonesia. Studi ini melakukan tinjauan literatur untuk mengurai isu-isu yang ada dan intervensi kebijakan yang diperlukan dalam daur ulang limbah di tempat-tempat tersebut. Hasil menunjukkan bahwa kebijakan saat ini tentang penggunaan plastik belum ditegakkan secara efektif, terutama karena kurangnya kesadaran dan keterlibatan pemangku kepentingan. Hambatan utama termasuk kurangnya infrastruktur, partisipasi komunitas yang minim dalam inisiatif daur ulang, dan pengawasan yang terbatas dari pemerintah. Untuk mengatasi masalah ini, studi menyarankan peningkatan penegakan aturan plastik yang ada, peningkatan infrastruktur pengelolaan limbah, dan peningkatan keterlibatan komunitas. Studi ini menganjurkan pendekatan kolaboratif yang melibatkan otoritas pemerintah, bisnis pariwisata, entitas pengelolaan limbah, dan komunitas lokal untuk meningkatkan akuntabilitas dan tanggung jawab lingkungan. Diharapkan dengan upaya bersama, pengelolaan limbah di tempat wisata Indonesia dapat ditingkatkan secara signifikan, sehingga menghasilkan manfaat lingkungan dan sosial.

Kata Kunci: Manajemen Sampah, Daur Ulang, Indonesia, Pariwisata

ABSTRACT

Efficient waste management remains a pivotal challenge at Indonesian tourist sites. This study conducts a literature review to dissect the prevalent issues and necessary policy interventions in recycling waste within these locales. Results reveal that current policies on plastic usage are inadequately enforced, largely due to insufficient awareness and stakeholder engagement. Key barriers include a lack of infrastructure, minimal community participation in recycling initiatives, and limited regulatory oversight. To address these issues, the study suggests amplified enforcement of existing plastic regulations, enhancement of waste management infrastructure, and a boost in community involvement. The study advocates for a cohesive approach involving government authorities, tourism businesses, waste management entities, and local communities to heighten accountability and environmental stewardship. It is posited that with collective effort, waste management in Indonesian tourist spots can be significantly improved, thus yielding environmental and social dividends.

***Keywords*:** Waste Management, Recycling, Indonesian, Tourism

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1. INTRODUCTION

Tourism is essential to employment and gross national domestic product in many countries and regions, especially Indonesia. Tourism also has the potential to contribute to development in rural, periphery, or less developed areas. Infrastructure created for tourism contributes significantly to local area development, while jobs created or maintained can help overcome industrial or rural declines. However, tourism also causes significant environmental impacts and can pressure local resources, resulting in negative externalities. In addition to land use, tourism requires resources such as water, energy, and food, produces large amounts of

waste (solid waste and liquid waste) (Azarmi et al. 2019), as well as road congestion, noise, and air pollution (Zeng et al. 2021).

Indonesia is an archipelagic country with great tourism potential (Sutrisno et al. 2023). Natural wealth and socio-cultural diversity are the main assets for developing the tourism sector as an economic booster. Tourism drives growth, but the resulting solid waste and other pollutants threaten natural beauty, residents' quality of life, tourist attraction, and economic success (Zainul Ikhwan et al. 2021), which manage tourism demand and improve economic and environmental health. The increase in the number of tourists occurred because Indonesia has various tourist destinations that can be visited. Many tourist sites in Indonesia can attract tourists to come on vacation to Indonesia. One of the environmental problems in tourist areas is tourism waste generated from tourism activities. Management must be sustainable in tourism activities to meet the tourism needs of the current generation and not reduce the ability to meet the needs of future generations for tourism. One indicator of good waste management is the recycling rate (Ferronato et al. 2019).

Indonesia is a country with a large number of tourists every year (Haryana 2020; Hasanah et al. 2020). However, tourism growth is also followed by an increasing amount of waste. One type of waste that is quite significant is plastic waste. According to data from the Ministry of Environment and Forestry, Indonesia produces around 64 million tons of plastic waste annually, and around 14% comes from the tourism sector. To reduce the negative impact of plastic waste on the environment, the Indonesian government has implemented several policies and laws regarding plastic waste recycling (Kamaruddin et al. 2022), including in the tourism sector. Several plastic waste recycling techniques implemented in several tourist attractions in Indonesia include using plastic waste chopping machines (Aziz et al. 2021b) to produce plastic pellets that can be resold, making handicrafts from plastic waste, and using plastic waste as raw material for infrastructure development such as roads and sidewalks. However, efforts to recycle plastic waste in Indonesia's tourism sector are still minimal. Several factors contribute to the low effectiveness of plastic waste management in the tourism sector (Mihai et al. 2022), including lack of awareness and education from tourists and managers of tourist attractions, lack of adequate infrastructure and technology support (Suryawan and Lee 2023a), and weak supervision and law enforcement against violations related to waste management (Suryawan and Lee 2023b).

Tourist destinations, often seen as beacons of a country's cultural and natural heritage, can quickly lose their appeal if marred by poor waste management (Agyeiwaah 2020; Hayati et al. 2020). In Indonesia, a country teeming with enchanting landscapes and cultural epicenters, the sustainable management of plastic waste in the tourism sector is both an environmental necessity and an economic imperative.

An integral part of this endeavor is to embed responsibility within the administrative framework. By enhancing the roles of tourist site managers, we make them the custodians of their sites, not just from an operational perspective but also from an environmental one. To achieve this, it's essential to strike a balance between incentives and sanctions (Ulhasanah and Goto 2018; Suryawan and Lee 2023a). Recognizing and rewarding tourist sites that exemplify best practices in plastic waste management can inspire others (Vanapalli et al. 2021; Cordova et al. 2021). Conversely, a well-defined penalty structure can deter negligent behaviors, ensuring that all tourist sites uphold the highest standards of waste management.

The role of technology in advancing this mission cannot be overstated. Harnessing modern environmentally friendly technologies, such as machines that efficiently process plastic waste or systems that segregate waste at source (Kabir et al. 2020; Evode et al. 2021; Kumar et al. 2021b), can significantly enhance the efficacy of plastic waste management. These technologies, while requiring an initial investment, pay dividends in the long run (Suryawan and Lee 2023a), not just in tangible economic terms, but in environmental preservation and the conservation of the allure of these tourist sites. However, technology and regulations alone won't suffice. Education and awareness form the backbone of any successful waste management initiative (Suryawan and Lee 2023b). Campaigns aimed at both tourists and site managers can cultivate a collective sense of responsibility. When individuals understand the broader implications of their actions, they're more likely to align their behaviors with sustainable practices.

With the support and joint efforts of the government, managers of tourist attractions, tourists, and the public, waste management is expected. This research is a novelty in identifying problems and challenges in waste management at Indonesian tourism objects and providing policy recommendations to improve waste management. Although several studies have previously discussed waste management in Indonesia, this research is more focused on the problems and challenges in waste management at Indonesian tourist objects. This research also provides a new perspective on implementing plastic use policies and the challenges faced in processing recycled waste in tourist objects.

The main objective of this research is to provide a clear and in-depth description of the problems and challenges in waste management at Indonesian tourism objects and to provide policy recommendations that can be implemented to improve waste management. With this research, it is hoped that related parties can take more appropriate actions in waste management at Indonesian tourist objects to create a healthier and more sustainable

environment for the community and the surrounding environment. In addition, this research can also be a source of information and reference for other researchers who wish to conduct similar studies related to waste management in Indonesia.

2. RESEARCH METHODS

To begin, our focus is honed on defining the research topic, which pertains to the practices of waste processing in these tourist attractions, emphasizing the plastic consumption patterns and their alignment with the prevailing legal guidelines. To make our research efficient, we've identified several keywords that would aid our search, including terms like 'waste recycling processing,' 'Indonesian tourist attractions,' and 'plastic use restrictions.' Our data collection strategy encompasses two main channels: primary sources, which would involve firsthand data collection through interviews and surveys with stakeholders like tourist site managers and tourists; and secondary sources, which would entail a comprehensive review of scientific journals, official government documents, and relevant books that discuss waste processing in Indonesia and the legal frameworks governing plastic use. As we engage with these materials, our aim is to systematically extract key insights, results, and methodologies that resonate with our research topic, employing structured templates to maintain consistency in our extraction process. The heart of our research lies in the synthesis and analysis phase. Here, we'd employ statistical tools to dissect quantitative data, like recycling rates and plastic consumption patterns, while a thematic approach will be utilized to decode qualitative data, helping us understand perceptions and challenges surrounding plastic waste management in the tourism sector. Visualization tools, like charts and tables, will be instrumental in presenting a clearer picture of our findings. The culmination of our research would be the literature review report. This comprehensive document will introduce readers to the significance of waste management in tourist locales, describe our research methodology, present our findings, and delve deep into the implications of these findings in the Indonesian context.

Beginning in June 2023 and continuing through November 2023, our research primarily focuses on the waste processing practices at Indonesian tourist sites, with a particular emphasis on plastic consumption patterns and their compliance with existing legal regulations. To streamline our research, we have identified key terms such as 'waste recycling processing,' 'Indonesian tourist attractions,' and 'plastic use restrictions.' Our data gathering approach includes primary sources through direct interviews and surveys with stakeholders like managers of tourist sites and visitors, and secondary sources involving an extensive review of scientific publications, official government reports, and relevant literature on waste processing in Indonesia and legal frameworks governing plastic use.

During the research, we aim to methodically extract crucial insights, results, and methodologies that align with our topic, using structured templates to ensure consistency. The core of our study is the synthesis and analysis phase, where statistical tools will be utilized to analyze quantitative data like recycling rates and plastic use patterns. Simultaneously, a thematic approach will be employed for qualitative data to comprehend the perceptions and challenges in managing plastic waste within the tourism sector. Visualization aids such as graphs and tables will play a crucial role in elucidating our findings. The culmination of our six-month research project will be a comprehensive literature review report, which will not only introduce the importance of waste management in tourist areas but also outline our methodology, present our findings, and explore the broader implications of these findings within the Indonesian context.

The research primarily utilizes a literature review methodology, focusing on the analysis of existing studies, reports, and academic papers to understand the current landscape of plastic waste recycling at Indonesian tourist attractions. This approach was selected due to the comprehensive nature of available literature, which provides extensive data and insights into the implementation of plastic use policies and their effectiveness within the tourism sector.

The absence of primary data collection through interviews and surveys in the research results stems from the decision to concentrate on secondary data, which offers a breadth of information and has already been validated through previous research efforts. This allows for a more extensive analysis across different locations and time frames than would be possible through direct interviews within the time constraints of this study. However, this reliance on literature review means that the direct perspectives of stakeholders, which could be captured through interviews and surveys, are not present. As a result, some of the nuances and on-the-ground challenges may not be fully represented. This limitation is acknowledged in the study, and it is suggested that future research could benefit from incorporating primary data to supplement the findings from the literature review.

Regarding the research location, our study will focus on three prominent tourist destinations in Indonesia. These include Bali, known for its beaches and vibrant culture; Yogyakarta, renowned for its historical significance and cultural heritage; and Jakarta, the bustling capital city with various tourist attractions. Each location offers a unique perspective on waste management challenges and practices, allowing for a comprehensive analysis of diverse environments and management strategies. This geographical diversity will enable a more holistic

understanding of waste management practices across different tourist hotspots in Indonesia.

The selection of these two regions is strategic due to their prominence as tourist destinations and the distinct waste management challenges they face, making them ideal for studying the implementation of plastic use reduction policies. Bali and Yogyakarta are exemplary due to their advanced waste management practices and pioneering policies, including the ban on single-use plastics in Bali, which can serve as a benchmark for other regions. These areas can provide insights into best practices and the complexities involved in policy implementation that may be relevant on a broader scale. Their experiences can highlight both successes and areas needing improvement, offering a model that can inform nationwide strategies. However, focusing solely on these regions does come with limitations. It may not fully represent the diverse geographic, cultural, and administrative landscapes of Indonesia. To address this limitation, the study acknowledges the need for expanding the scope to include other regions in future work. This would enable a more comprehensive understanding of the effectiveness of legal policies across different contexts within Indonesia.

3. RESULTS AND DISCUSSION

3.1. Tourism Waste Management Policy in Indonesia

Strengthening the roles and responsibilities of tourist attraction managers in managing plastic waste, including by providing appropriate incentives and sanctions, can be done by referring to several existing policies in Indonesia. Minister of Environment and Forestry Regulation (Permen LHK) No. 75 of 2019 concerning Plastic Waste Management. This regulation regulates the responsibility for managing plastic waste for producers, importers, distributors, traders, consumers, and managers of final disposal sites (TPA). Managers of tourist attractions are included in the TPA managers category, so they are obligated to manage plastic waste properly and correctly. This regulation also regulates administrative sanctions for TPA managers who do not meet the requirements for plastic waste management.

Government Regulation (PP) No. 81 of 2012 concerning the Management of Household and Household-like Waste. This regulation regulates the responsibility for waste management for the community, TPA managers, and local governments. In the case of managers of tourist attractions, they are also included in the category of TPA managers responsible for managing waste properly and contributing to waste reduction efforts. UU No. 18 of 2008 concerning Waste Management. This law stipulates the principles of sustainable waste management and the responsibility of the community, entrepreneurs, and the government in waste management. In the case of managers of tourist attractions, they also have a responsibility as entrepreneurs to manage the waste they produce. In providing appropriate incentives and sanctions, the government can use various policy instruments, including:

1. Fiscal incentives, such as tax exemptions or reduced tax rates for managers of tourist attractions, that implement good plastic waste management (Camilleri 2021; Sedtha et al. 2023; Suryawan and Lee 2023a).
2. Non-fiscal incentives (Pavlova and Singh 2022), such as awards or certifications for tourist attraction managers, have reduced the amount of plastic waste produced.
3. Administrative sanctions, such as reprimands, warnings, or revocation of permits for managers of tourist attractions that do not meet the requirements for managing plastic waste (Hossain et al. 2022).
4. Criminal sanctions, such as fines or imprisonment for managers of tourist attractions who commit serious violations related to plastic waste management (Monsurat et al. 2019).

Applying appropriate incentives and sanctions can encourage managers of tourist attractions to be more responsible in managing plastic waste to help reduce the negative impact of plastic waste on the environment and increase.

3.2. Circular Economy in Tourism Waste Recycling

The idea of a circular economy has received increasing attention in recent years, but the concept is not new (Centobelli et al. 2020). The concept's origins have been widely discussed and cannot be attributed to a single date or author, as many authors have written about it. Several schools of thought have analyzed, developed, and described industrial systems with these features using different terminology and approaches (Rodríguez et al. 2020). Circular economy as a new economic model originates from environmental economics, whose goal is integrating science into sustainability and sustainable development (Andersen 2007). There are many definitions of the circular economy concept. A mode of economic development based on the ecological circulation of natural materials requires adherence to ecological laws and good use of natural resources to achieve economic development (Feng et al. 2007). The focus of circular economies is on resource productivity and increasing eco-efficiency, and they adopt the 4R approach—reduce, reuse, recycle, and recover (Hu et al. 2011). In addition, Geissdoerfer et al. define it as a regenerative system in which resource input and wastage, emissions, and energy leakage are minimized by slowing down, closing, and narrowing material and energy loops (Geissdoerfer et al. 2017).

This is achieved through continuous design, maintenance, repair, reuse, remanufacturing, and recycling. As a result, the tourism sector has not received much attention within the circular economic development framework. Tourism had not received

much attention as a possible context for circular economy initiatives and analysis (Rodríguez et al. 2020; Bosone and Nocca 2022). Tourism implies a model in which every tourism actor (tourists, Destination Management Organizations (DMO), suppliers (hotels, restaurants, etc.), and population) adopts an environmentally friendly approach (Florido et al. 2019).

Circular economy rules in tourism waste recycling are related to the government's efforts to strengthen a sustainable and environmentally friendly waste management system in the tourism sector (Falcone 2019; Rodríguez et al. 2020). The persistent challenges posed by waste, particularly in densely populated countries like Indonesia, have prompted governments to enact regulations and policies to address the issue. The Indonesian government, cognizant of the ramifications of unmanaged waste on the environment and public health, has made legislative strides to ensure sustainable waste management.

The Law Number 18 of 2008 concerning Waste Management is a seminal regulation that emphasizes the responsibility of every individual and entity in the nation towards ensuring proper waste disposal. This mandate is comprehensive in its scope, not only prescribing the duty to manage waste but also urging the reduction at the source. This means citizens and businesses alike are encouraged to adopt lifestyles and processes that generate less waste, to begin with. This law underpins the state's commitment by highlighting the need for supporting infrastructure and the introduction and advancement of technology that would aid in effective waste management.

A more granular approach is evident in the Government Regulation Number 81 of 2012 concerning the Management of Household and Household-like Waste. The specificity of this regulation can be discerned from its explicit coverage of various facets of household waste management, from its initial collection to its eventual disposal. By emphasizing environmentally friendly technologies and infrastructure, it underscores the country's intent to modernize its waste management processes, ensuring minimal harm to its rich biodiversity and ecosystem. However, legislation, while instrumental, needs a tactical framework to guide their implementation. Recognizing this, the Indonesian government introduced the National Action Plan for Waste Management 2018-2028. Acting as a roadmap, this plan elucidates the government's strategies over a decade in crafting a sustainable waste management ecosystem. The inclusion of the tourism sector, a critical segment of Indonesia's economy, in its purview, highlights the emphasis on ensuring that Indonesia's renowned tourist destinations remain pristine and aren't marred by waste issues.

Circular economy policies aim to reduce waste by increasing resource use efficiency and promoting product reuse, recycling, and recovery (Smol et al. 2020; Tangwanichagapong et al. 2020). In the context of tourism waste recycling, these policies and laws can be implemented through several efforts, such as:

1. Encouraging environmentally friendly technology and infrastructure, such as plastic waste chopping machines, separate waste collection points, and modern and efficient waste processing systems.
2. Develop an incentive program to encourage managers of tourist attractions and tourism entrepreneurs to adopt sustainable waste management practices, such as product reuse and recycling.
3. Implement policies to reduce the use of single-use plastic materials in the tourism sector, such as banning the use of plastic straws and plastic bags in tourist attractions.
4. Encouraging collaboration between the government, managers of tourist attractions, and local communities in developing sustainable waste management programs, including recycling tourism waste.

It is hoped that the waste management system in the tourism sector can become more efficient, sustainable, and environmentally friendly. This can also help reduce the negative impact of waste on the environment by implementing circular economic policies and laws in recycling tourism waste,

Waste-to-Energy Approach

Waste recycling is driven by the need to close the material loop to preserve our natural resources as we strive towards the circular economy and by the alarming observations of plastic waste being dispersed in oceans and lakes due to land- and sea-based activities. Zero waste activities include littering with recreational or tourism activities, wastewater flow, and waste management processes, whereas sea-based activities include fisheries, aquaculture, shipping, and maritime-based tourism (Dahlbo et al. 2018). Renewable energy is crucial in transitioning to a circular economy model (Raksasat et al. 2021) in tourism. Many authors have investigated it (Septiariva et al. 2021; Suryawan et al. 2021). Using renewable resources as a substitute for conventional energy is essential for implementing a circular economy in tourism. This renewable energy can be widely used in tourist areas, travel, accommodation, catering, transportation, shopping, entertainment, and other tourism companies. The tourism sector must adopt a clean energy approach to lower its carbon footprint and use its inputs more efficiently to transition to a circular economy. Tourism, one of the major driving forces of the Indonesian economy, has faced multifaceted challenges, including waste management. However, the approach to view waste not just as a problem, but also as a potential resource, especially for energy, heralds a transformative era in waste management.

Waste-to-energy technologies can metamorphose the landscape of waste management in Indonesian tourist hotspots. First and foremost, the

environmental advantages are pivotal. Transforming waste into energy directly correlates with a reduction in the volume of waste that is otherwise left untreated, leading to detrimental environmental consequences. Tourist destinations, which are often the pride of the nation, suffer from the eyesore of accumulating waste, not to mention the more severe implications like water contamination and air pollution. The advent of waste-to-energy systems can potentially ameliorate these issues, safeguarding the pristine nature of these destinations. From an economic standpoint, the proposition becomes even more compelling. Despite the initial financial outlay required to set up waste-to-energy infrastructure, the long-term financial benefits are pronounced. Traditional waste management techniques, over the years, can accrue massive expenses. However, harnessing energy from waste can offset these costs. Not only can the location save on the direct costs associated with waste management, but also the energy generated can potentially be monetized, offering dual financial incentives.

Moreover, the strategic relevance of such an initiative can't be overlooked. Indonesia, like many countries, grapples with the challenge of energy security. A substantial portion of its energy is derived from fossil fuels, the reserves of which are finite. As tourist destinations start tapping into waste as an energy source, it could lead to a broader shift in the national energy paradigm, reducing the overarching reliance on non-renewable resources. Lastly, the end beneficiary of such initiatives would be the tourists themselves. The allure of any destination is not just its natural beauty or historical significance but also the overall experience it offers. A locale that is clean, sustainable, and eco-friendly enhances the overall visitor experience. Tourists today are more environmentally conscious than ever, and a commitment to sustainable practices, like waste-to-energy, can be a major draw, enhancing the reputation of the destination.

3.3. Plastic Waste Recycling for a Circular Economy in Tourist Attractions

Plastics have become an essential pillar for the modern lifestyle of tourists in developing countries (Kumar et al. 2021a). Conventionally, plastic can be recycled into plastic granules (Olofinnade et al. 2021). These plastic granules can be made into various products, such as jerseys, bib shorts, jackets and base layers (Kumartasli and Avinc 2021). Plastics have low production costs and a suitable range of properties, such as low density, durability, and corrosion resistance (Begum et al. 2020), and have led to the displacement of traditional materials, such as wood, metals, and ceramics (Fernandes 2021). The increase in plastic consumption corresponds to traditional plastics and new plastic composites, with the main application sectors being packaging, building, automotive, electrical and electronics, and agriculture, the distribution of various types of plastics. As observed (Nurhati & Cordova, 2020; M. Sari et al., 2022; M. M. Sari, Inoue, Harryes, et al., 2022), polyolefins account for half of the plastics produced, but polyvinyl chloride (PVC), polyurethane (PUR), polyethylene terephthalate (PET) and polystyrene (PS) are also produced in appreciable quantities.

Plastic waste management is a big challenge that must be overcome immediately in Indonesia (Budihardjo et al. 2022; Sianipar et al. 2022). Thus, low plastic degradation causes serious environmental problems, especially marine ones. In addition, inadequate management of plastic waste causes sustainability problems due to the loss of valuable and rare resources derived from petroleum.Plastic waste management in tourist attractions in Indonesia is still experiencing many obstacles (Kamaruddin et al. 2022). Some of the obstacles that often occur include the lack of training (Filimonau and De Coteau 2019) of the public and tourist visitors about the importance of good waste management, lack of waste management infrastructure and facilities, and lack of coordination and cooperation between related parties in waste management.

Even though the government has issued a policy to limit the use of plastic, its implementation is still not fully legally effective in all regions of Indonesia (Hermawan and Astuti 2021; Kamaruddin et al. 2022). Several factors have caused this policy to not work correctly, such as the lack of public awareness and understanding of the negative impacts of plastic waste on the environment and health, the lack of incentives and strict sanctions for violators, and the lack of access to alternative infrastructure and facilities to replace the use of plastic. To address this situation, the government and related parties are making more comprehensive efforts, such as raising public and tourist visitor awareness of the importance of good waste management, strengthening infrastructure and facilities for better waste management, increasing cooperation among related parties, and providing appropriate incentives and sanctions. Tough on offenders. In the long term, efforts are needed to develop alternative solutions to reduce plastic waste that is more environmentally friendly.

Different approaches are being considered to reduce waste sent to landfills, namely waste minimization, reuse, recycling, and energy recovery. However, in the case of plastic waste, minimization, and reuse are hardly implemented in Indonesia (Sari et al. 2022b). Given its high calorific value, combustion is a viable valorization route, but this alternative is constrained by the resulting emissions (Sarwono et al. 2021; Zahra et al. 2022). Plastic waste has burgeoned into a global environmental concern, prompting widespread research into effective recycling strategies. Among the various methods that have been explored, chemical recycling has emerged as a particularly promising avenue, especially for large-scale operations. This method not only addresses the burgeoning waste issue but also brings forth the

potential for deriving valuable resources from these discarded materials.

Chemical recycling essentially refers to the process of breaking down plastics into their constituent monomers or simpler compounds through chemical reactions, often facilitated by heat, catalysts, or other agents. The value proposition of this recycling route is twofold. Firstly, it allows for the extraction of valuable products like fuels, chemicals, and syngas or hydrogen from the waste plastic. These outputs can potentially feed into various industries, from energy to manufacturing, making the entire process economically viable. Secondly, the outputs, especially when viewed from the lens of sustainability, can reduce the dependence on virgin fossil resources, thus mitigating some of the environmental concerns associated with their extraction and use.

Moreover, derivative products from plastic waste, such as those resulting from pyrolysis, add another dimension to the recycling spectrum. Pyrolysis, a thermal decomposition process, yields products like pyrolytic oil, gas, and even a solid residue often referred to as 'char' or 'biochar'. This char, in many ways resembling charcoal, has a range of applications. It can be utilized as a soil additive, enhancing its fertility, or can be further processed to generate activated carbon, which finds use in purification processes. When we think about looping this into the recycling unit, it offers the potential to transform waste into a product with substantial utility.

The overarching process of plastic waste processing, from collection to its final transformation into valuable products, can be visualized in a systematic flowchart, depicted in Figure 1. Such a diagrammatic representation offers clarity, tracing the journey of waste from its origin to its eventual reincarnation as a valuable product. This not only offers a roadmap for industries looking to adopt these practices but also underscores the immense potential that lies in what we often dismiss as 'waste'.

3.4. Related Research

Plastic waste management has become a focal point for environmentalists, policymakers, and researchers alike. With the rise in plastic production and consumption, especially in tourist areas, finding viable solutions for its disposal has become paramount. Among the solutions being explored, gasification and pyrolysis have emerged as promising options.

Gasification, a thermochemical process, can convert plastic waste into a gaseous mixture, predominantly made up of hydrogen (H2), carbon monoxide (CO), carbon dioxide (CO2), methane (CH4), and nitrogen (N2). This gas mixture, often termed syngas, has a broad range of applications, offering the potential to harness energy, develop energy carriers like hydrogen, and derive essential chemicals. The exact composition of the syngas is contingent upon the type of plastic being gasified and the conditions under which the process is executed. As (Aziz et al. 2021a) point out, the merits of gasification extend beyond just waste management. The ability to produce syngas provides a dual advantage: managing waste while generating vital resources.

On the other hand, pyrolysis operates on a slightly different premise. It entails the thermal decomposition of plastic waste in an oxygen-free environment. The process yields various products, including energy-rich gases, fuel oils, waxes, naphtha, and even pure monomers. As noted by (Dahlbo et al. 2018), the real potential of pyrolysis lies in its contribution to chemical recycling. This technique facilitates the homolysis of plastic polymers, allowing their conversion into valuable products. It offers a way to transform what were once considered waste products of little to negative value into high-value outputs. In essence, pyrolysis provides a tangible route to achieving the goals of a circular economy, where resources are recycled and reused, minimizing the dependence on virgin raw materials.

The tourism sector, with its considerable footprint, has also begun to recognize the value of these waste management techniques. Several studies have delved into the potential of both gasification and pyrolysis, specifically in the context of tourism locales. The cumulative findings and insights from these investigations are systematically collated in Table 1, offering a comprehensive overview of how waste management paradigms are shifting in one of the world's largest industries.

The flowchart in Figure 1 illustrates various pathways for recycling plastic waste, splitting into two main branches for fuel derivation and recycling into new products. The processes depicted, gasification and pyrolysis, lead to the creation of syngas and electricity, and carbon and electricity respectively. Additionally, there is a pathway for converting plastic waste into new, recycled products.

Table 1 complements Figure 1 by providing specific examples of how these processes are applied in real-world settings across various tourist sites in Indonesia. For instance, Klungkung and Nusa Penida are turning PET waste into plastic-derived fuel (PRF/RDF), which corresponds with the 'Plastic Derived Fuel' branch in the flowchart. In Parangtritis, Yogyakarta, general plastic waste and masks are subjected to both PRF/RDF and gasification processes, which align with the branches leading to 'Syngas + Electricity' and potentially 'Recycle Product' in Figure 1. Kuta, Bali, is highlighted for its use of pyrolysis, fitting into the 'Pyrolysis' branch, which results in carbon and electricity.

These connections indicate that the flowchart provides a conceptual framework for the plastic waste processing methods that are being utilized in practice, as detailed in the table. The recycling processes lead to valuable end products and are instrumental in achieving the waste-to-energy goals, as observed in Klungkung and potentially reducing environmental

pollution, as indicated by the results from Daerah Selatan Bali. The practical applications of these methods, as seen in the Indonesian tourist sites, demonstrate the potential and versatility of plastic waste as a resource for generating energy and creating new materials.

Indonesia, with its vast array of tourist attractions, faces a mounting challenge in the form of plastic waste. As discussions surrounding plastic waste management intensify worldwide, it's noteworthy that research focusing on its potential utility within Indonesian tourist locales remains starkly limited. Addressing this issue hinges on viewing plastic waste not as mere refuse but as a valuable resource. Systems that tap into plastic waste, be it through standalone applications or as part of an encompassing circular economy model, have demonstrated success elsewhere. Dual stand-alone systems emerge as powerful alternatives to traditional landfill-based waste management, signaling a path towards sustainable resource use.

Given the limited research concerning the utilization of plastic waste in tourist spots, an integrated strategy is essential. This involves nurturing academic and industry alliances, securing funding for preliminary projects, and setting up dedicated research institutes committed to waste innovation. The overarching goal is dual-pronged: deepening our comprehension of plastic waste dynamics in tourist regions and propelling forward innovations that resonate with both the environment and societal needs.

Table 1. Research related to plastic waste recycling at tourist attractions in Indonesia.

No	Tourism Site	Waste Feed	Recycling Process	Result	Source
1	Klungkung	PET	PRF/RDF	Using PET waste at this tourist spot can also help Klungkung Regency's goal of putting the Waste to Energy idea into practice at the Local Waste Processing Facility (TOSS).	(Yenis et al. 2022)
2	Daerah Selatan Bali	Mask	PRF/RDF	The Piro GC-MS analysis shows that the waste from the lit mask will break down into pieces of compounds that can be used again as fuel. The process is simple and easy, and it leaves behind waste that can be used again to cut down on environmental pollution caused by COVID-19 waste.	(Sari et al. 2022c)
3	Nusa Penida	PET	PRF/RDF	Masks, plastics, metals, and biodegradable organics make up the waste materials, which are worth 4.12%, 32.7%, 19.54, and 43.57%, respectively. So, the amount of energy that could be gained from using organic materials as solid fuel is up to 51,933.8 MJ/day, or 14,426 kWh/day.	(Mutiara et al. 2021)
4	Parangkritis, Yogyakarta	Plastic in general and masks	PRF/RDF	Because of the COVID-19 pandemic, masks have been added to a new type of trash: infectious waste. Marine debris that isn't organic and can't be broken down by living things tends to have a high calorific value.	(Sari et al. 2022a)
5	Parangkritis, Yogyakarta	Plastic in general	Gasification	The efficiency of making electricity from a generator set that uses 100% syngas from gasification is 11%, so the amount of electricity that can be made is 6.38 kW.	(Ma 2019)
6	Kuta, Bali	Plastic in general	Pyrolysis	Cracking plastic waste into fuel depends on the type of plastic, the process used to crack it, the type of catalyst, the temperature of the pyrolysis, and the temperature of the condenser. Diesel fuel will likely be replaced by fuel made from used plastic. Plastics can be turned into fuel, but they can also be used to make things that go into activated carbon.	(Wedayani 2018)

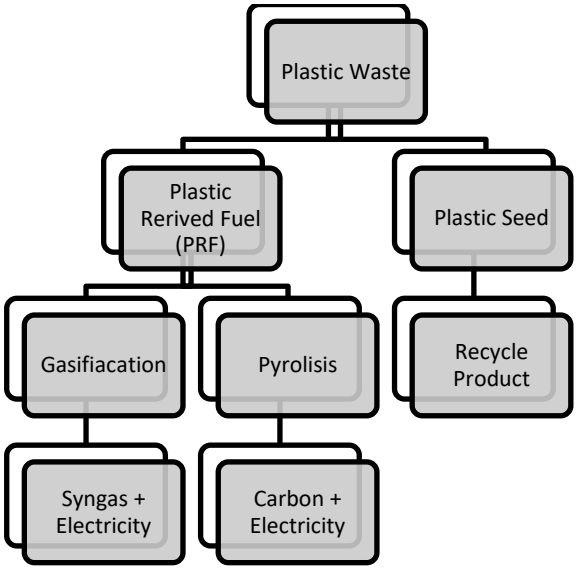

Figure 1. The processing of plastic waste

The government's proactive involvement remains indispensable in this endeavor. To make a tangible difference, there's an urgent need to strictly enforce existing regulations, particularly those addressing single-use plastics. This could involve implementing penalties for non-compliant businesses or offering incentives to those adopting sustainable practices. Concurrently, it's essential to bolster oversight mechanisms to ensure that all entities involved in waste management, from the collection phase to landfill operations, adhere to the highest environmental standards. Developing robust waste management infrastructure, inclusive of recycling plants, waste-to-energy units, and eco-friendly disposal mechanisms, is another pivotal step forward. Alongside this, there's a compelling need to weave in community-centric waste management approaches. By championing grassroots initiatives, from community-driven waste collection drives to educational campaigns on responsible waste disposal, a sense of shared responsibility towards our environment can be fostered. In navigating these challenges, Indonesia possesses an opportunity not just to address its plastic waste dilemma, but to fortify its reputation as a sustainable tourist haven.

4. CONCLUSION

Tourism, one of the foremost contributors to Indonesia's economy, showcases the country's rich cultural, historical, and natural heritage. However, the booming tourism industry also brings with it certain challenges, especially in terms of environmental sustainability. Our findings, provide concrete instances of these recycling methods being implemented across tourist sites in Indonesia, showcasing sufindings, pplications of the theoretical model presented in the flowchart. The practices in locations such as Klungkung and Nusa Penida align with the 'Plastic Derived Fuel' branch, indicating an effective waste-to-energy conversion that can serve as a blueprint for other regions. In Parangtritis, Yogyakarta, the integration of PRF/RDF and gasification techniques exemplifies a holistic approach to waste management that yields both energy and material recovery. Similarly, the pyrolysis process employed in Kuta, Bali, aligns with sustainable practices by producing carbon and electricity.

The research underscores the versatility of plastic waste as a resource and the importance of adopting varied recycling methods to suit different local contexts. The case studies from Indonesia demonstrate the potential benefits of these methods, which can be instrumental in achieving sustainability goals in tourist hotspots. However, this study also reveals gaps in the implementation of waste management strategies and suggests a need for enhanced stakeholder involvement, infrastructure development, and policy enforcement.

For future endeavors, it is recommended that similar waste management frameworks be adapted and tested in other regions to assess their effectiveness on a broader scale. There's a vital need for research that not only examines the environmental aspects but also considers the economic impacts of such recycling initiatives. By combining this knowledge, stakeholders can develop more informed and comprehensive strategies to tackle the pressing issue of plastic waste in tourist destinations.

REFERENCES

Arnia dan Warganegara. 2012. Identifikasi Kontaminasi Bakteri coliform pada Daging sapi Segar yang Dijual di Pasar Sekitar Kota Bandar Lampung. Majority 26 (4) 101-108. ISSN 2337-3776.

Bazrafshan, E., F. Kord Mustafapour, M. Farzadkia, K.A. Ownagh, A.H. Mahvi. 2012. Slaughter house Wastewater Treatment by Combined Chemical Coagulation and Electrocoagulation Process. Plos ONE 7 (6): e40108. Doi:10.1371/journal.pone.0040108.

Darmayasa, I.G.B. 2008. Isolasi dan Identifikasi Bakteri Pendegradasi Lipid (lemak) pada Beberapa Tempat Pembuangan Sampah dan Estuari DAM Denpasar. Jurnal Bumi Lestari, Vol. 8 No. 2, Agustus 2008. Hal 122-127.

Effendi, H. 2003. Telaah kualitas air bagi pengelola sumber daya dan lingkungan perairan. Yogyakarta. Kanisius.

Kementerian Pertanian. 2010. Peraturan Menteri Pertanian Republik Indonesia No. 13/permentan/OT.140/I/2010 Tentang Persyaratan Rumah Potong Hewan Ruminansia dan Unit Penanganan daging (meat cutting plant).

Kementerian Lingkungan Hidup. 2014. Peraturan Menteri Lingkungan Hidup No. 5 Tahun 2014 Tentang Baku Mutu Air Sampah.

Kobya, M., E. Sentruk, C. Aydiner and E. Demirbas. 2006. Treatment of potato chips manufacturing waste water by electroagulation. Desalination, 190: 201-211.

Kundu, P., A. Dabsarkar, S. Mukherjee. 2013. Treatment of Slaughter House Wastewater in a sequencing Batch Reactor, Performance evaluation and Biodegradation Kinetics. Hindawi Publishing Corporation, BioMed Research International Article ID134872, II pages.

Agyeiwaah E (2020) The contribution of small accommodation enterprises to sustainable solid waste management. J Hosp Tour Manag 44:1–9. https://doi.org/https://doi.org/10.1016/j.jhtm.2020.04.013

Andersen MS (2007) An introductory note on the environmental economics of the circular economy. Sustain Sci 2:133–140. https://doi.org/10.1007/s11625-006-0013-6

Azarmi S, Vaziri R, Oladipo A (2019) Environmental impact of the ugly face of tourism Pollution and management perspectives. p chapter 23

Aziz M, Darmawan A, Juangsa FB (2021a) Hydrogen production from biomasses and wastes: A technological review. Int J Hydrogen Energy 46:33756–33781. https://doi.org/https://doi.org/10.1016/j.ijhydene.2021.07.189

Aziz R, Ruslinda Y, Yeni YS, Dewilda Y (2021b) Solid waste management system model of village tourism area of Nagari Tuo Pariangan, Indonesia. In: IOP Conference Series: Materials Science and Engineering. IOP Publishing, p 12030

Begum SA, Rane AV, Kanny K (2020) Chapter 20 - Applications of compatibilized polymer blends in automobile industry. In: A.R. A, Thomas SBT-C of PB (eds). Elsevier, pp 563–593

Bosone M, Nocca F (2022) Human Circular Tourism as the Tourism of Tomorrow: The Role of Travellers in Achieving a More Sustainable and Circular Tourism. Sustainability 14

Budihardjo MA, Humaira NG, Putri SA, et al (2022) Indonesian efforts to overcome covid-19's effects on its municipal solid waste management: a review. Cogent Eng 9:2143055. https://doi.org/10.1080/23311916.2022.2143055

Camilleri MA (2021) Sustainable Production and Consumption of Food. Mise-en-Place Circular Economy Policies and Waste Management Practices in Tourism Cities. Sustainability 13

Centobelli P, Cerchione R, Chiaroni D, et al (2020) Designing business models in circular economy: A systematic literature review and research agenda. Bus Strateg Environ 29:1734–1749. https://doi.org/https://doi.org/10.1002/bse.2466

Cordova MR, Nurhati IS, Riani E, et al (2021) Unprecedented plastic-made personal protective equipment (PPE) debris in river outlets into Jakarta Bay during COVID-19 pandemic. Chemosphere 268:129360. https://doi.org/10.1016/J.CHEMOSPHERE.2020.129360

Dahlbo H, Poliakova V, Mylläri V, et al (2018) Recycling potential of post-consumer plastic packaging waste in Finland. Waste Manag 71:52–61. https://doi.org/https://doi.org/10.1016/j.wasman.2017.10.033

Evode N, Qamar SA, Bilal M, et al (2021) Plastic waste and its management strategies for environmental sustainability. Case Stud Chem Environ Eng 4:100142. https://doi.org/https://doi.org/10.1016/j.cscee.2021.100142

Falcone PM (2019) Tourism-Based Circular Economy in Salento (South Italy): A SWOT-ANP Analysis. Soc. Sci. 8

Feng W-J, Mao Y-R, Chen H, Chen C (2007) Study on development pattern of circular economy in chemical industry parks in China. 27:7–10

Fernandes AC (2021) Reductive Depolymerization of Plastic Waste Catalyzed by Zn(OAc)2 · 2H2O. ChemSusChem 14:4228–4233. https://doi.org/https://doi.org/10.1002/cssc.202100130

Ferronato N, Ragazzi M, Gorritty Portillo MA, et al (2019) How to improve recycling rate in developing big cities: An integrated approach for assessing municipal solid waste collection and treatment scenarios. Environ Dev 29:94–110. https://doi.org/https://doi.org/10.1016/j.envdev.2019.01.002

Filimonau V, De Coteau DA (2019) Food waste management in hospitality operations: A critical review. Tour Manag 71:234–245. https://doi.org/https://doi.org/10.1016/j.tourman.2018.10.009

Florido C, Jacob M, Payeras M (2019) How to Carry out the Transition towards a More Circular Tourist Activity in the Hotel Sector. The Role of Innovation. Adm. Sci. 9

Geissdoerfer M, Savaget P, Bocken NMP, Hultink EJ (2017) The Circular Economy – A new sustainability paradigm? J Clean Prod 143:757–768. https://doi.org/https://doi.org/10.1016/j.jclepro.2016.12.048

Haryana A (2020) Economic and Welfare Impacts of Indonesia's Tourism Sector. J Perenc Pembang Indones J Dev Plan 4:300–311. https://doi.org/10.36574/jpp.v4i3.127

Hasanah NAI, Maryetnowati D, Edelweis FN, et al (2020) The climate comfort assessment for tourism purposes in Borobudur Temple Indonesia. Heliyon 6:e05828. https://doi.org/https://doi.org/10.1016/j.heliyon.2020.e05828

Hayati Y, Adrianto L, Krisanti M, et al (2020) Magnitudes and tourist perception of marine debris on small tourism island: Assessment of Tidung Island, Jakarta, Indonesia. Mar Pollut Bull 158:111393. https://doi.org/https://doi.org/10.1016/j.marpolbul.2020.111393

Hermawan S, Astuti W (2021) Analysing several ASEAN countries' policy for combating marine plastic litter. Environ Law Rev 23:9–22. https://doi.org/10.1177/1461452921991731

Hossain R, Islam MT, Ghose A, Sahajwalla V (2022) Full circle: Challenges and prospects for plastic waste management in Australia to achieve circular economy. J Clean Prod 368:133127. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.133127

Hu J, Xiao Z, Zhou R, et al (2011) Ecological utilization of leather tannery waste with circular economy model. J Clean Prod 19:221–228. https://doi.org/https://doi.org/10.1016/j.jclepro.2010.09.018

Kabir E, Kaur R, Lee J, et al (2020) Prospects of biopolymer technology as an alternative option for non-degradable plastics and sustainable management of plastic wastes. J Clean Prod 258:120536. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.120536

Kamaruddin H, Maskun, Patittingi F, et al (2022) Legal Aspect of Plastic Waste Management in Indonesia and Malaysia: Addressing Marine Plastic Debris. Sustainability 14

Kumar R, Verma A, Shome A, et al (2021a) Impacts of Plastic Pollution on Ecosystem Services, Sustainable Development Goals, and Need to Focus on Circular Economy and Policy Interventions. Sustainability 13

Kumar S, Singh E, Mishra R, et al (2021b) Utilization of Plastic Wastes for Sustainable Environmental Management: A Review. ChemSusChem 14:3985–4006. https://doi.org/https://doi.org/10.1002/cssc.202101631

Kumartasli S, Avinc O (2021) Recycled Thermoplastics: Textile Fiber Production, Scientific and Recent Commercial Developments BT - Recent Developments in Plastic Recycling. In: Parameswaranpillai J, Mavinkere Rangappa S, Gulihonnehalli Rajkumar A, Siengchin S (eds). Springer Singapore, Singapore, pp 169–192

Ma S (2019) Potensi Energi Listrik Hasil Gasifikasi Sampah Organik dari Wisatawan di Pantai Parangtritis. 2019:405–409

Mihai F-C, Gündoğdu S, Markley LA, et al (2022) Plastic Pollution, Waste Management Issues, and Circular Economy Opportunities in Rural Communities. Sustainability 14

Monsurat S, Raimi M, Sawyerr H (2019) A Deep Dive into the

Review of National Environmental Standards and Regulations Enforcement Agency (NESREA) Act. Res J Appl Sci 1:

Mutiara M, Inoue T, Harryes RK, et al (2021) Potential of Waste to Energy Processing for Sustainable Tourism in Nusa Penida Island, Bali. J Bahan Alam Terbarukan 10:96–103

Olofinnade O, Chandra S, Chakraborty P (2021) Recycling of high impact polystyrene and low-density polyethylene plastic wastes in lightweight based concrete for sustainable construction. Mater Today Proc 38:2151–2156. https://doi.org/https://doi.org/10.1016/j.matpr.2020.05.176

Pavlova M, Singh M (2022) Recognizing Green Skills Through Non-formal Learning A Comparative Study in Asia

Raksasat R, Kiatkittipong K, Kiatkittipong W, et al (2021) Blended sewage sludge–palm kkernel expeller to enhance the palatability of black soldier fly larvae for biodiesel production. Processes 9:. https://doi.org/10.3390/pr9020297

Rodríguez C, Florido C, Jacob M (2020) Circular Economy Contributions to the Tourism Sector: A Critical Literature Review. Sustainability 12

Sari M, Suryawan IWK, Ramadan BS, et al (2022a) Marine Debris Management in the Parangtritis Beach Tourism Area , Yogyakarta During Covid-19 Pandemic. Nat Environ Pollut Technol 21:1183–1190

Sari MM, Inoue T, Harryes RK, et al (2022b) Potential ofrecycle marine debris in pluit emplacement, Jakarta to achieve sustainable reduction of marine waste generation. Int J Sustain Dev Plan 17:119–125. https://doi.org/10.18280/ijsdp.170111

Sari MM, Inoue T, Septiariva IY, et al (2022c) Identification of Face Mask Waste Generation and Processing in Tourist Areas with Thermo-Chemical Process. Arch Environ Prot 48:

Sarwono A, Septiariva IY, Qonitan FD, et al (2021) Refuse Derived Fuel for Energy Recovery by Thermal Processes. A Case Study in Depok City, Indonesia. J Adv Res Fluid Mech Therm Sci 88:12–23

Sedtha S, Nitivattananon V, Ahmad MM, Cruz SG (2023) The First Step of Single-Use Plastics Reduction in Thailand. Sustainability 15

Septiariva IY, Suryawan IWK, Suhardono S, et al (2021) Strategy and Master Plan for Water Supply and Domestic Wastewater in Klungkung Regency, Bali. IOP Conf Ser Mater Sci Eng 1096:012058. https://doi.org/10.1088/1757-899x/1096/1/012058

Sianipar IMJ, Suryawan IWK, Tarigan SR (2022) The Challenges and Future of Marine Debris Policy in Indonesia and Taiwan Case Studies. J Sustain Infrastruct 1:56–62

Smol M, Marcinek P, Duda J, Szołdrowska D (2020) Importance of Sustainable Mineral Resource Management in Implementing the Circular Economy (CE) Model and the European Green Deal Strategy. Resources 9

Suryawan IWK, Lee C-H (2023a) Citizens' willingness to pay for adaptive municipal solid waste management services in Jakarta, Indonesia. Sustain Cities Soc 97:. https://doi.org/https://doi.org/10.1016/j.scs.2023.104765

Suryawan IWK, Lee C-H (2023b) Community preferences in carbon reduction: Unveiling the importance of adaptive capacity for solid waste management. Ecol Indic 157:111226. https://doi.org/https://doi.org/10.1016/j.ecolind.2023.111226

Suryawan IWK, Sarwono A, Septiariva IY, Lee C-H (2021) Evaluating Marine Debris Trends and the Potential of Incineration in the Context of the COVID-19 Pandemic in Southern Bali, Indonesia. J Ilm Perikan dan Kelaut 13:

Sutrisno AD, Chen Y-J, Suryawan IW, Lee C-H (2023) Establishing Integrative Framework for Sustainable Reef Conservation in Karimunjawa National Park, Indonesia. Water 15

Tangwanichagapong S, Logan M, Visvanathan C (2020) Circular Economy for Sustainable Resource Management: The Case of Packaging Waste Sector in Thailand BT - Circular Economy: Global Perspective. In: Ghosh SK (ed). Springer Singapore, Singapore, pp 353–387

Ulhasanah N, Goto N (2018) Assessment of citizens' environmental behavior toward municipal solid waste management for a better and appropriate system in Indonesia: a case study of Padang City. J Mater Cycles Waste Manag 20:1257–1272. https://doi.org/10.1007/s10163-017-0691-4

Vanapalli KR, Sharma HB, Ranjan VP, et al (2021) Challenges and strategies for effective plastic waste management during and post COVID-19 pandemic. Sci Total Environ 750:141514. https://doi.org/https://doi.org/10.1016/j.scitotenv.2020.141514

Wedayani NM (2018) Studi pengelolaan sampah plastik di pantai kuta sebagai bahan bakar minyak. J Presipitasi Media Komun dan Pengemb Tek Lingkung 15:122–126

Yenis I, Suhardono S, Mutiara M, Koko IW (2022) Preliminary Analysis of the Utilization of PET Plastic Waste in Tourism Areas for Energy Recovery. 05:78–85

Zahra NL, Septiariva IY, Sarwono A, et al (2022) Substitution garden and polyethylene terephthalate (PET) plastic waste as refused derived fuel (RDF). Int J Renew Energy Dev 11:523–532. https://doi.org/10.14710/ijred.2022.44328

Zainul Ikhwan, R. Hamdani Harahap, Lita Sri Andayani, Miswar Budi Mulya (2021) THE ECONOMIC POTENTIAL OF WASTE MANAGEMENT IN PENYENGAT ISLAND TOURISM, TANJUNGPINANG CITY, RIAU ISLAND PROVINCE, INDONESIA. PalArch's J Archaeol Egypt / Egyptol 18:3043–3065

Zeng J, Wen Y, Bi C, Feiock R (2021) Effect of tourism development on urban air pollution in China: The moderating role of tourism infrastructure. J Clean Prod 280:124397. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.124397