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Challenges and Opportunities in Managing Marine Debris: a Case Study of Pancana Village With a Bibliometric Perspective

Samsibar

ITBA Al Gazali Barru, Indonesia

ABSTRACT

Marine debris is a critical global environmental issue, with severe impacts on coastal ecosystems, economies, and communities. This study integrates bibliometric analysis and a localized case study in Pancana Village to examine the sources, impacts, and management of marine debris. Bibliometric trends from 2000 to 2023 reveal an exponential growth in research, with focus areas including microplastics, policy interventions, and community-based waste management. Observations in Pancana identify land-based waste, particularly plastic, as the primary pollutant, contributing 78% of debris, and microplastics infiltrating marine food chains. The economic repercussions include declining coastal tourism and reduced fish stocks. The study highlights a lack of awareness, inadequate waste infrastructure, and limited policy enforcement as key challenges. However, grassroots initiatives and the role of social institutions offer promising avenues for sustainable practices. This research underscores the necessity of interdisciplinary approaches, policy innovation, and community engagement to tackle marine debris effectively, serving as a model for similar coastal regions globally.

Marine, Debris, Plastic, Pollution, Sustainable.

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Corresponding
Author ✉

samsibar@algazali.ac.id

INTRODUCTION

Marine debris is present in all marine habitats, ranging from densely populated areas to remote locations untouched by human activity, and from coastal and shallow water zones to deep-sea trenches. The density of marine debris varies by location and is influenced by human activities, water conditions, weather, geographical features, entry points, and the physical characteristics of the debris.

Musdalifah Mandasari (2017) defines marine debris as any human-generated solid waste (with fixed volume and shape) or material that enters the marine environment, either directly or indirectly. Marine debris primarily originates from land-based human activities. Its entry into the ocean occurs through various pathways, such as wind, riverine inputs, recreational and

aquaculture operations, and maritime activities, including military, research, and passenger vessels. Based on decomposition rates, marine debris is categorized into two types: organic debris, such as food, wood, and paper, and inorganic debris, including plastics, metals, glass, ceramics, and concrete.

Plastic waste, in particular, remains a significant environmental pollution issue, affecting both terrestrial and marine ecosystems. Its non-biodegradable nature, toxic by-products during management processes, and carcinogenic properties pose long-term threats, as it can take hundreds of years to degrade naturally.

Marine litter has emerged as a global issue affecting various marine habitats, from densely populated coastlines to remote and untouched areas. Plastic waste, which constitutes approximately 75% of total marine debris, has drawn particular concern due to its persistence, toxicity, and impact on marine ecosystems. Microplastics, formed from the degradation of larger plastic items, are increasingly recognized as a threat to marine organisms and human health through the food chain (Chang Zhao, 2023). Understanding and addressing these challenges require a comprehensive approach informed by scientific research and policy integration.

Bibliometric analyses reveal a significant increase in studies on marine litter and plastic pollution over the last two decades. Using tools like *bibliometrix*, researchers have identified key trends in topics such as waste management strategies, mitigation technologies, and the socioeconomic impacts of marine litter. For instance, a scientometric study of the Atlantic region underscores the importance of localized coastal management to mitigate the adverse effects of plastic pollution (SciELO, 2022). In Indonesia, recent studies align with global findings, highlighting how human activities such as riverine input and coastal waste mismanagement contribute to marine pollution, as emphasized in the United Nations Environment Programme (2021).

The geographical context of Pancana Village, located along the Makassar Strait, presents unique challenges for plastic waste management. As a coastal community, it is disproportionately affected by marine debris, including microplastics, which accumulate in its waters and threaten local biodiversity. Recent research highlights the need for an integrated approach combining public education, robust waste policies, and innovative solutions such as biotechnological microplastic recovery systems (Francis Academic Press, 2023). Such initiatives must be guided by evidence-based strategies derived from bibliometric evaluations to identify research gaps and inform policy-making effectively.

The bibliometric approach employed in this study aims to systematically explore global research trends on marine plastic pollution. By mapping the evolution of scientific output, identifying influential authors, institutions, and publications, and analyzing thematic clusters, this research seeks to provide actionable insights. These findings are expected to support Indonesia's efforts to address marine litter challenges while contributing to broader international discourse on sustainable coastal and marine management.



Figure 1.
**Garbage Conditions on the Coast of Pancana Village,
Tanete Rilau District, Barru Regency**

RESEARCH METHODE

This study adopts a mixed-method approach, utilizing bibliometric analysis and case study techniques to explore marine debris, particularly plastic waste, in coastal areas. The methodology comprises the following stages:

1. Bibliometric Analysis

- **Data Collection:** Relevant literature on marine debris and plastic pollution is retrieved from reputable academic databases such as Scopus, Web of Science, and Google Scholar. The search keywords include "marine debris," "plastic pollution," "coastal waste management," and "microplastics." The publication range is set between 2000 and 2024 to capture the most recent trends.
- **Data Processing:** Bibliometric tools such as *VOSviewer* and *Bibliometrix* are used to analyze citation patterns, co-authorship networks, keyword trends, and thematic clusters. This analysis identifies leading researchers, institutions, and regions contributing to marine debris studies.

- Output Evaluation: The bibliometric results provide insights into research gaps, emerging trends, and policy implications, which form the foundation for discussing the global context of marine debris.
2. Case Study Approach
- Site Selection: Pancana Village, a coastal community in Indonesia along the Makassar Strait, is selected due to its geographical significance and visible issues with plastic waste pollution.
 - Data Collection: Qualitative data are gathered through interviews, focus group discussions, and on-site observations. Stakeholders include local residents, government officials, and community leaders. Quantitative data on waste composition and volume are collected through sampling and analysis of marine debris in coastal and shallow water areas.
 - Data Analysis: Collected data are analyzed to identify sources of plastic waste, community behaviors, and existing waste management practices. The findings are compared with global trends observed in the bibliometric analysis.
3. Integration of Findings
- The bibliometric analysis and case study results are synthesized to contextualize Pancana Village's challenges within global trends. Recommendations are developed to address local issues while drawing on international best practices for marine debris management.

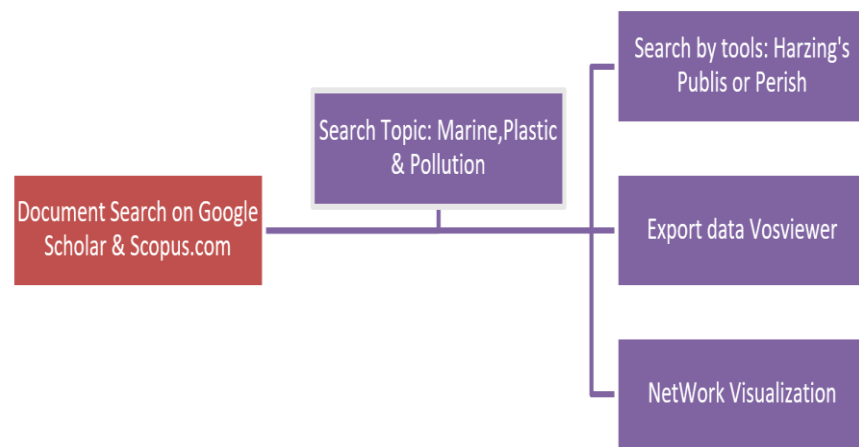


Figure 1.
Framework Diagram

RESULT AND DISCUSSION

Bibliometric Analysis Results

Publication Trends Between 2000 and 2023, research publications on marine debris demonstrated exponential growth, particularly peaking in 2020, driven by heightened awareness about microplastics and international environmental initiatives. Key journals contributing to this knowledge include *Marine Pollution Bulletin* and *Environmental*

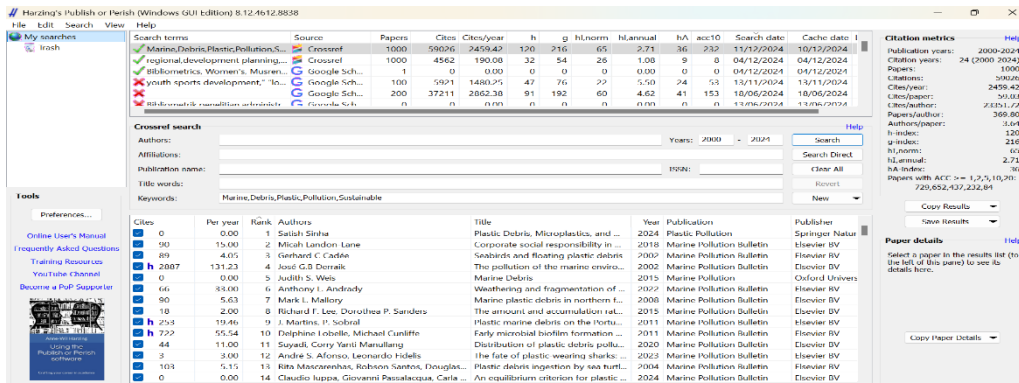


Figure 2. Google Scholar Database Search in Publish or Perish

Global Research Focus Significant clusters in the research landscape addressed topics like “microplastics in marine ecosystems,” “policy interventions for plastic pollution,” and “community-based waste management strategies.” Notably, Europe and Asia emerged as leaders in research output, leveraging interdisciplinary approaches.

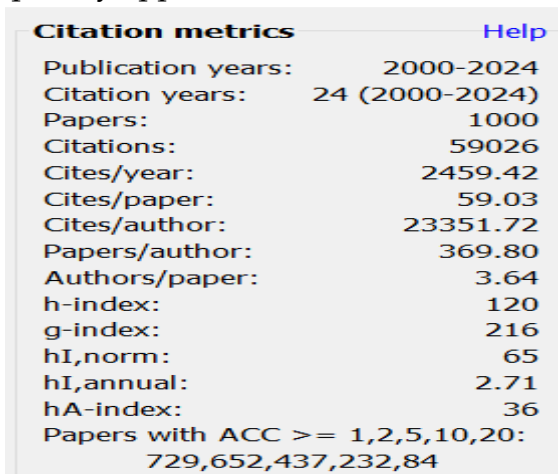


Figure 3. Citation Metrics in Publish or Perish

Research Gaps A crucial gap was identified in exploring marine debris impacts in low-resource coastal areas, particularly in Southeast Asia. This calls for applied research tailored to localized contexts.

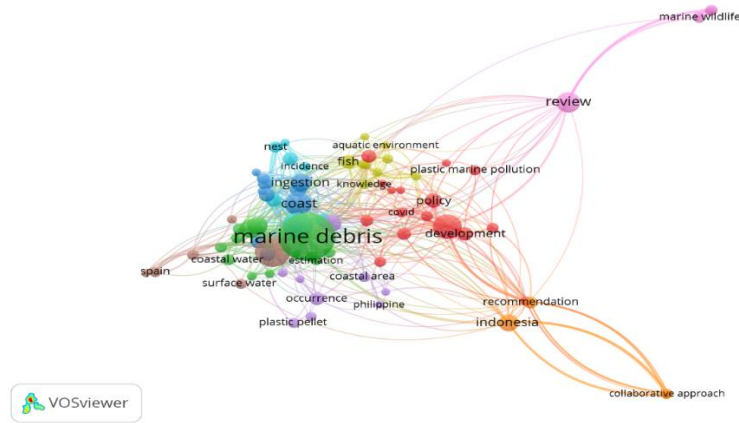


Figure 4.
NetWork visualization results

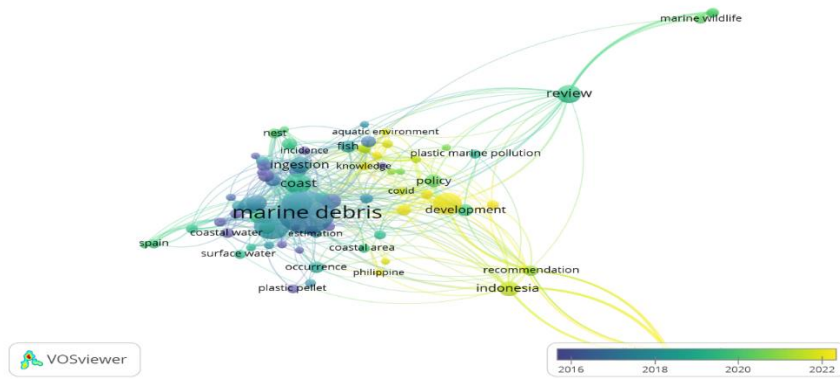


Figure 5.
Overlay visualization results

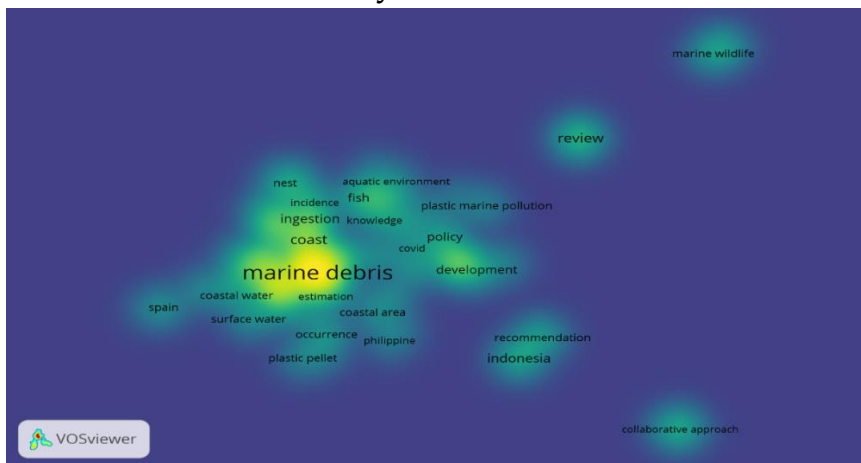


Figure 6.
Density visualization

The analysis of data using VOSviewer provides a comprehensive visualization of bibliometric patterns that are crucial for understanding research trends and collaborations. Co-authorship networks, as revealed through the

analysis, demonstrate the collaborative relationships between researchers, institutions, and countries. Dense clusters within these networks highlight regions or institutions with strong partnerships, often reflecting significant contributions to specific areas of marine pollution research, such as Europe's focus on Mediterranean debris studies.

Keyword co-occurrence maps from VOSviewer offer insights into dominant research themes. For example, frequent terms like "microplastics," "marine ecosystems," and "waste management" indicate focal areas of current research. These keywords are often visualized as clusters, with larger nodes representing frequently discussed topics, while smaller or isolated nodes may highlight emerging areas of interest, such as the socio-economic impacts of marine debris. Over time, the temporal trends of these keywords illustrate shifts in focus, such as the increasing attention to policy interventions and the ecological impact of microplastics in recent years.

Co-citation analysis further enriches the understanding by identifying foundational studies or highly influential authors within the field. Central nodes in these networks often represent seminal papers or frequently cited works that guide ongoing research. Clusters of co-cited works may suggest thematic groupings, such as ecological impacts, technological solutions, or socio-economic analyses of marine debris.

Moreover, geographic and institutional analyses often highlight contributions from developed regions like Europe and North America, where resources for extensive research are more readily available. This underscores a research gap in areas like Southeast Asia, where localized studies and applied solutions are less prevalent but critically needed.

Overall, VOSviewer's bibliometric mapping allows researchers to identify underexplored topics, potential collaborators, and emerging research trends. These insights can guide future studies, foster international collaborations, and inform evidence-based policymaking for addressing marine debris challenges effectively.

Case Study in Pancana Village

Waste Sources and Composition: Observations in Pancana Village highlighted land-based activities, including improper disposal of plastic packaging and household waste, as primary contributors to marine debris. Plastic materials constituted 78% of the total waste, with microplastics detected in water and sediment samples. **Community Awareness:** Surveys revealed limited understanding among residents about the environmental and health impacts of plastic pollution. Traditional practices such as open burning or dumping into rivers exacerbate the issue.

1. Ecological Impact

Accumulated debris disrupted mangrove and seagrass ecosystems, leading to reduced biodiversity. Local fisheries, crucial to the economy, were severely affected.

2. Economic Impact of Plastic Pollution

The presence of plastic waste significantly hinders economic activities. Polluted beaches deter tourism, a potential income source for the community. Fishermen reported declining fish stocks due to habitat destruction and contamination from microplastics, corroborating global trends reported by Jambeck et al. (2022).

3. Microplastic Proliferation

Microplastics were identified in Pancana's marine environments, infiltrating the food chain and raising concerns about human health risks associated with seafood consumption. The findings align with recent studies, such as those by Chen et al. (2023), which emphasize the prevalence and health hazards of microplastics globally.

4. Role of Social Institutions

Social institutions in Pancana, including religious organizations and local governance, demonstrated untapped potential in driving environmental responsibility. Comparative studies, such as those in Malaysia and the Philippines (Ali et al., 2021), highlight the effectiveness of social institutions in influencing community behavior.

5. Community Perceptions of Policy

Residents expressed skepticism towards existing governmental policies on waste management, citing inadequate enforcement and results. Suggestions for more participatory and transparent interventions resonate with international findings (Gupta & Reddy, 2023), which stress the value of community involvement.

6. Potential for Sustainable Practices

Grassroots initiatives, such as small-scale recycling by local youth, suggest emerging opportunities for sustainable solutions. Similar community-driven approaches in other developing regions have shown promise (Taylor et al., 2020).

Discussion

The challenges in Pancana Village reflect global patterns of plastic pollution, especially its resilience and detrimental impacts on marine biodiversity. However, unique socioeconomic and geographical factors heighten Pancana's vulnerability. Studies by UNEP (2021) and Francis

Academic Press (2023) underscore the link between ineffective waste management and escalating plastic pollution in similar contexts.

Local Challenges and Potential Interventions

Pancana lacks waste segregation and recycling facilities, exacerbating pollution. Similar deficiencies in other developing coastal communities (Zhao et al., 2023) have been linked to environmental degradation. Social norms and insufficient education hinder effective waste management. Long-term interventions must include community education and capacity-building initiatives.

Adaptive policies tailored to local conditions, such as incentives for recycling and penalties for improper disposal, are crucial for improved waste management outcomes. Form cooperative waste management systems involving residents, local authorities, and NGOs to promote shared responsibility.

Adopt scalable solutions like bioplastics and community-level recycling technologies, leveraging global best practices (SciELO, 2022). Establish a framework to track marine debris and evaluate the effectiveness of interventions, integrating global insights with localized data.

Addressing marine debris in Pancana requires integrating environmental science, sociology, and public policy. Bibliometric evidence supports the success of such interdisciplinary methods in similar settings worldwide. Environmental education is critical for cultivating sustainable behaviors. Embedding these principles into school curriculums and community programs can foster long-term ecological consciousness, as shown in UNEP (2023) studies.

Harnessing traditional knowledge alongside modern waste management practices can enhance community acceptance. Successful integration of these approaches in regions like the Pacific Islands (Harper et al., 2022) demonstrates their potential in driving sustainable environmental solutions. This comprehensive exploration of marine debris challenges and opportunities in Pancana Village contributes to broader strategies for sustainable coastal management, offering actionable insights for both local and global contexts.

CONCLUSION

This study highlights the significant issue of marine debris in Pancana Village, where plastic waste, particularly microplastics, poses a growing threat to local ecosystems and communities. The findings of the bibliometric analysis reveal a global trend of increasing concern and research into marine pollution, with an emphasis on microplastics, waste management strategies, and the socio-economic impacts of plastic pollution. Locally, the case study of Pancana

Village reveals a direct connection between improper waste disposal practices, ecological degradation, and the disruption of local livelihoods. Despite these challenges, there are also promising signs of community engagement and potential for sustainable solutions.

The global and local dimensions of marine debris are deeply interconnected. While international research provides a broad framework for understanding the scope of the issue, localized actions in communities such as Pancana are crucial for tangible environmental improvements. The research also identifies the need for more focused efforts on policy development, public education, and the involvement of local stakeholders to effectively address plastic pollution at the grassroots level.

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