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Analysis of Marine Debris Distribution Through Sort Transport Clean in the Coastal Waters of Ternate City

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ABSTRACT

Marine pollution, originating from land-based sources and intentional dumping at sea, is a significant hazard to marine life and health. Plastic pollution, which constitutes about 85% of marine debris, causes severe damage to marine ecosystems and species, causing disruptions in marine activities and deteriorating seawater quality. This research aims to see the distribution of marine debris in the coastal waters of Ternate city. The method used in this research is purposive sampling technique through observation to obtain the composition of marine debris, the rate of increase of marine debris with 3 criteria, namely the presence of river mouths, community activities such as ecotourism activities and piles of garbage produced by fishermen. The data obtained was then analyzed by visually observing and recording. The result of this study is the discovery of organic and inorganic waste. The percentage density of organic waste is 13% while inorganic waste is 87%. This shows that inorganic waste is generated the most. Inorganic waste in the form of plastic, cloth, glass, steroform and aluminum is produced by human activities visiting the coast. The organic waste found is wood and fruit peels.

Keywords: Marine debris, Organic waste, Inorganic waste

ABSTRAK

Pencemaran laut, yang berasal dari sumber-sumber berbasis darat dan pembuangan yang disengaja di laut, merupakan bahaya yang signifikan bagi kehidupan dan kesehatan laut. Polusi plastik, yang merupakan sekitar 85% sampah laut, menyebabkan kerusakan parah pada ekosistem dan spesies laut, menyebabkan gangguan dalam aktivitas laut dan memburuknya kualitas air laut. Penelitian ini bertujuan untuk melihat sebaran marine debris diperairan pantai kota Ternate. Metode yang digunakan dalam penelitian ini yaitu dengan teknik purposive sampling melalui observasi untuk mendapatkan komposisi sampah laut, laju pertambahan sampah laut (marine debris) dengan 3 kriteria yaitu adanya muara sungai, aktifitas masyarakat seperti aktifitas ekowisata dan tumpukan sampah yang dihasilkan oleh nelayan. Data yang diperoleh kemudian dianalisis dengan mengamati secara visual dan dicatat. Hasil dari penelitian ini yaitu ditemukannya sampah organik maupun anorganik. Persentase kepadatan sampah organik yaitu 13% sedangkan sampah anorganik yaitu 87%. Hal ini menunjukkan bahwa sampah anorganik paling banyak dihasilkan. Sampah anorganik berupa plastik, kain, kaca, steroform dan aluminium dihasilkan aktivitas manusia yang berkunjung ke pesisir pantai. Adapun sampah organik yang ditemukan yaitu Kayu dan Kulit buah.

Kata Kunci: Marine debris, Sampah anorganik, Sampah organik

INTRODUCTION

The ocean, covering over 70% of the Earth's surface, has historically been viewed as a vast resource and a limitless dumping ground, but this perception has been tragically proven wrong as marine pollution poses a growing threat. Marine pollution, originating from land-based sources and intentional dumping at sea, poses a significant threat to marine life and health. Plastic pollution, which constitutes about 85% of marine debris, causes severe damage to marine ecosystems and species, disrupting marine activities and deteriorating seawater quality. The economic impact of marine pollution, estimated at billions of dollars annually, underscores the urgent need for solutions to reduce plastic production, increase recycling efforts, and transition to environmentally friendly alternatives to mitigate the growing crisis.

Marine debris, a global environmental problem, poses a threat to ecosystems, economies, and societies around the world. Studies highlight various aspects of this problem, such as the impact of debris on marine life and fishing activities (Khezri & Mamkhezri, 2025; Gabriel & Bacosa, 2024). Colonization of marine debris by invasive species is a significant concern, emphasizing the need for standardized methodologies and advanced analytical approaches for better understanding and management (Gabriel & Bacosa, 2024).

Marine debris, including solid, liquid, or gaseous wastes discharged into the marine environment, poses a severe global environmental threat, as highlighted by various research papers (Sannigrahi et al., 2022). Plastic pollution, a major concern in marine ecosystems, is exacerbated by the staggering annual production of over 300 million tonnes of plastic, half of which is single-use items (Sina et al., 2023). This plastic debris poses a severe threat to marine life, as it can persist in the environment for decades, breaking down into smaller fragments that are ingested by marine organisms, leading to entanglement and ingestion problems for marine mammals (Pramudianto, 2023). The impact of plastic debris on marine ecosystems is enormous, affecting carbon and nitrogen cycles, habitats, and aquatic species, including rare and keystone species (Babu et al., 2023). In areas such as the coastal zone of Makassar, plastic pollution is a pressing issue due to the direct contribution of land-based plastic waste to marine debris, which requires advanced detection methods such as the use of satellite imagery for monitoring and management (Damayanti et al., 2022). Efforts to address this global challenge require a coordinated waste management strategy and international cooperation to reduce the harmful effects of plastic pollution on the marine environment, emphasizing the importance of reducing plastic use and implementing effective regulations.

Marine debris, mostly consisting of plastic waste, does pose a major threat to marine ecosystems worldwide. Studies have revealed that plastic packaging and small non-packaging plastic items (PPSI) play a significant role in marine litter, with an estimated 26.1 million tonnes of mismanaged PPSI waste generated in Europe in 2018. This waste generation trend has been increasing, indicating an urgent need for improved waste management strategies to curb the influx of plastics into the marine environment (Pourebrahimi & Pirooz, 2023; Winterstetter et al., 2023). Efforts to reduce mismanaged PPSI waste have shown some progress, especially at the end-of-life stage of plastics, but the overall increase in plastic waste generation underscores the need for comprehensive waste management and preventive measures to transition towards a circular economy and reduce the detrimental impacts of plastic pollution on marine ecosystems (Winterstetter et al., 2023).

Indonesia, with its extensive coastline and dense population, has emerged as a significant contributor to marine plastic pollution, ranking as the second largest source of marine plastic

waste in the world (Utami et al., 2023; Prabawati et al., 2023). The country's marine plastic debris is estimated to range from 0.48 to 1.29 million metric tons per year, with the coastal areas of Jakarta alone accounting for 59% of marine plastic debris (Prabawati et al., 2023). Efforts to address this issue include Indonesia's National Action Plan on Marine Plastic Debris, which aims to reduce marine plastic debris by 70% by 2025. However, challenges remain, such as the need for increased partnerships for plastic waste management and enforcement of regulations to prevent and manage. plastic pollution in Indonesian waters (Sasradinata et al., 2023; Yuliantiningsih et al., 2023). Addressing these challenges is critical to maintaining Indonesia's marine ecosystems and protecting the environment and human health from the detrimental impacts of plastic pollution.

METHODOLOGY

This research was conducted in April-May 2024 in the Coastal Waters of Ternate City. Data collection was carried out using a purposive sampling technique through observation to obtain the composition of marine debris, the rate of increase in marine debris with three criteria, namely the presence of a river estuary, community activities such as ecotourism activities and piles of garbage produced by fishermen. Visual observation of the three criteria, namely observation of the presence of marine debris at the river estuary was carried out in the coastal waters of Salero Village as the Sentosa river estuary zone, then observation of waste produced by ecotourism activities was carried out on the Kastela Village beach and observation of piles of marine debris produced by fishermen on the Dufa-Dufa Village beach. Following marine debris research flow chart is shown in figure 1.

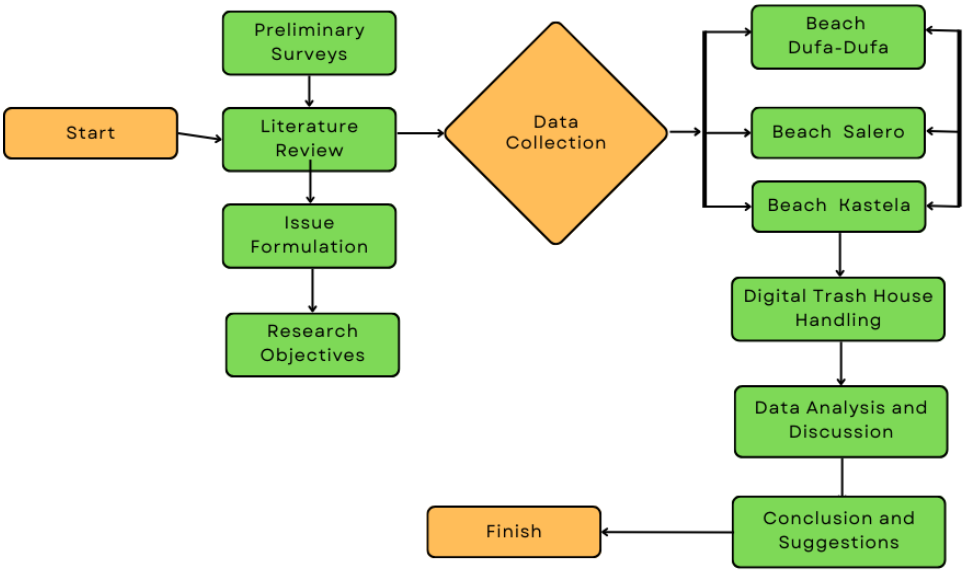

Figure 1. Marine debris research flow

Data on the type of marine debris was carried out through visual observation and recorded based on the type obtained, the waste data taken was waste consisting of organic and inorganic waste. The density of marine debris refers to Marine debris monitoring and assessment (Lippiat et al., 2013).

RESULTS AND DISCUSSION

Based on the results of observations of the types of marine debris obtained are organic and inorganic waste. Organic waste consists of wood and fruit peels while inorganic waste is plastic, pipettes, glass, styrofoam, and aluminum as seen in the figure 2.

(a) (b) (c)

Figure 2. Observation and collection of marine debris: (a) river Estuary, (b) Kastela beach, (c) Dufa-dufa beach

Data from the collection of marine debris types taken at three locations are presented in the Table 1.

Table 1. Types of Marine Debris

Research Sites	Types of Organic and Inorganic Marine Debris						
	Wood	**Fruit skin**	**Plastic**	**Pipette**	**Glass**	**Aluminum**	**Styrofoam**
River Estuary Salero Beach	+	+	+	+	-	+	+
Kastela Beach	+	+	+	-	+	+	+
Dufa Dufa Beach	+	-	+	-	+	-	-

Based on Table 1 obtained at Location 1, the types of organic waste found were wood, fruit peels, plastic, pipettes, aluminum and styrofoam. This shows that the collection of marine debris located at the Estuary of the Salero Village Coastal Waters is an area that is very close to residential areas with very high activity so that the volume of marine waste, especially household waste produced every day by the community, still pollutes the river estuary. At Location 2 is one of the ecotourism areas owned by Ternate city, namely Kastela Beach. At this location, almost all components of organic and inorganic waste were found and the amount was very large. This shows that the activity of the Ternate city community in visiting tourist attractions is very high, as can be ascertained through the large amount of waste found in the

area. In addition, there is also household waste in the form of waste found from the community around the Kastela village coastal waters. While at location 3, namely on the Dufa Dufa village beach, the most marine waste was found in the form of plastic and glass. This shows that the location is a coastal area that is used as a center for trade, tourism, sand mining, ports and markets so that the activities of the community and fishermen groups are very high and of course also produce high plastic waste. In this location there are still many ketapang trees planted and growing along the coastal waters. Marine waste can come from human activities on land that are directly or indirectly dumped into the sea. Waste generated from human activities directly or indirectly will pollute the environment.

Plastic waste, derived from synthetic polymer materials produced in large quantities globally, poses a severe environmental threat due to its non-degradable nature, which causes detrimental effects on marine ecosystems when irresponsibly dumped into the oceans. The exponential increase in global plastic production, reaching 390.7 million metric tons per year in 2021 (Pourebrahimi & Pirooz, 2023), has resulted in extensive dumping of plastic waste, including macro-, micro-, and nanoplastics, which pollute the marine environment and pose risks to marine life and human health (Pourebrahimi & Pirooz, 2023). Plastic pollution, as the largest component of marine debris, contributes significantly to marine pollution, causing harm to marine life, disrupting ecosystems, and impacting human activities such as fishing (Baranova et al., 2022). Urgent action is needed to reduce plastic production, increase recycling efforts, and transition to environmentally friendly alternatives to mitigate the increasing threat of plastic pollution to marine ecosystems (Baranova et al., 2022).

Table 2. Percentage of Marine Debris (marine waste)

Types of Marine Debris	**Percentage (%)**
Organic Waste	13
Inorganic Waste	87

Table 2 illustrates that the weight of organic and inorganic marine debris at all stations obtained a percentage value of organic marine debris of 13% and inorganic marine debris with a percentage value of 87%. Based on the percentage of the number of pieces and the weight of pieces per item of marine debris at the research location, it shows that inorganic marine debris is more than organic marine debris. It is suspected that the organic waste comes from tourists so that it accumulates at the research location. Plastic waste poses a significant hazard to biodiversity and the environment due to its synthetic nature, non-biodegradability, and widespread contamination of terrestrial and marine ecosystems (Anunobi, 2022). It accounts for at least 85% of total marine debris, causing lethal and sublethal effects on various marine organisms, disrupting the global carbon cycle, and causing economic losses in the maritime industry (Baranova et al., 2022).

Plastic waste not only threatens wildlife through entanglement and consumption but also serves as a vector for invasive species in the marine environment (Anunobi, 2022). In addition, microorganisms on plastic surfaces can include pathogenic bacteria and viruses, which can potentially act as carriers of disease and antibiotic resistance genes, although further research is needed to fully understand these health risks (Meng et al., 2021). The accumulation of plastic pollution in areas that cannot be reversed can cause irreversible negative impacts on carbon and nutrient cycles, habitats, and biodiversity, requiring urgent global action to reduce plastic emissions and improve waste management strategies (Cirino et al., 2023).

Plastic waste, particularly in the form of microplastics (MPs), has been increasingly recognized as a significant environmental problem due to its ability to act as a vector for a variety of contaminants, including persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and dichlorodiphenyl trichloroethane (DDT). Studies have shown that MPs can adsorb these contaminants to their surfaces through various intermolecular forces, including electrostatic, hydrophobic, and van der Waals forces, which then delays the degradation process of existing contaminants and affects soil health and fertility by altering soil pH, porosity, and microbial enzymatic activity (Rai et al., 2023). Studies comparing biodegradable and conventional MPs have shown that biodegradable MPs, such as polyhydroxyalkanoates (PHAs) and polybutylene succinate (PBS), tend to accumulate higher amounts of PAHs and organophosphorus flame retardants (PFRs) compared to conventional polyethylene (PE) MPs, although they release lower amounts of additives (Catarci et al., 2023).

The formation of plastic-rock complexes, where plastic debris irreversibly adsorbs to the mineral matrix, has been identified as an emerging environmental phenomenon, serving as hotspots for MP generation and potentially exacerbating ecological risks, especially under climate change conditions such as flooding events (Wang et al., 2023). Furthermore, a review of field studies on organic contaminants adsorbed to MPs highlighted the frequent detection of PCBs, PAHs, and organochlorine pesticides (OCPs), emphasizing the need for standardized protocols to improve the reliability of MPs monitoring studies (Azfaralariff et al., 2023). The relationship between terrestrial and freshwater MPs and wastewater treatment plants as major contributors to environmental MPs underscores the importance of developing comprehensive waste control and management strategies, including the use of bioplastics and advances in wastewater treatment technologies (Saud et al., 2023). Collectively, these findings underscore the complex interactions between MPs and multiple contaminants, which require further research and policy development to mitigate their environmental impacts.

Addressing marine litter requires a multifaceted approach that integrates policy, industry, infrastructure, and education. Effective solutions should prioritize minimizing plastic production and consumption, improving waste management, and reducing waste leakage rather than focusing solely on cleanup activities (García-Hermosa & Woodall, 2023). Collaborative data-driven solutions, such as mobile applications for image collection and classification models, can improve monitoring and mapping of marine litter hotspots, as demonstrated in Ålesund, Norway (Liu et al., 2023). Public willingness to pay for marine litter removal and prevention indicates community support for a mix of short-term measures such as beach cleanups and long-term policies such as single-use plastic bans (Grilli et al., 2022).

In Thailand, initiatives such as the "Trash Back to Shores" scheme engage fishers in marine litter collection, although participation can be improved by addressing factors such as readiness for supported practices, information dissemination, and practical experience (Thongphaijit, 2020). A user-friendly framework that includes defining metrics, listing interventions, identifying influencing factors, and ranking solutions can democratize decision-making and tailor interventions to specific regional contexts (García-Hermosa & Woodall, 2023). Additionally, improving waste reception facilities and providing on-site storage containers can facilitate marine litter collection schemes (Thongphaijit, 2020). Overall, a combination of technological tools, policy measures, community engagement and infrastructure improvements are critical to effectively address marine debris and contribute to sustainable development goals.

CONCLUSION

The waste found on the coast of Ternate City is organic waste and inorganic waste. The organic waste found is wood and fruit skin, while the inorganic waste found is Plastic, Cloth, Glass, Aluminum and Styrofoam. The percentage of marine waste density found is 13% organic and 87% inorganic. The results of this study have implications for the importance of waste management, the need for routine monitoring of marine waste distribution to understand the dynamics and prevent pollution that damages the ecosystem, and the need to increase public awareness of the negative impacts of waste on their livelihoods. In addition, there is a need for stricter local policies in waste management in the surrounding environment.

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REFERENCES

Anunobi, T. J. (2022). Hazardous effects of plastic wastes on land biodiversity: A review. *Zoologist (The)*, *20*(1), 80–86. https://doi.org/10.4314/tzool.v20i1.10.

Azfaralariff, A., Mat Lazim, A., Amran, N. H., Mukhtar, N. H., Bakri, N. D., Azrihan, N. N., & Mohamad, M. (2023). Mini review of microplastic pollutions and its impact on the environment and human health. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, *41*(7), 1219–1226. https://doi.org/10.1177/0734242X231155395.

Babu T, N. S., Sindhu, P., Anand, D. R. G., & Mary T, M. S. (2023). A study on the effects of plastic on marine life & its possible solutions. *Interantional Journal of Scientific Research in Engineering and Management*, *07*(04), 1-9. https://doi.org/10.55041/IJSREM18790.

Baranova, A., Novozhilova, T., Litovka, A., & Bilousov, M. (2022). The problem of plastic waste pollution in the world ocean. *Bulletin of the National Technical University «KhPI» Series: New Solutions in Modern Technologies*, *2(12)*, 69–73. https://doi.org/10.20998/2413-4295.2022.02.10.

Catarci, C. C., Amato, E. D., Pfeiffer, F., Christia, C., Estoppey, N., Poma, G., Covaci, A., & Blust, R. (2023). Accumulation and release of organic pollutants by conventional and biodegradable microplastics in the marine environment. *Environmental Science and Pollution Research*, *30*(31), 77819–77829. https://doi.org/10.1007/s11356-023-27887-1.

Cirino, E., Curtis, S., Wallis, J., Thys, T., Brown, J., Rolsky, C., & Erdle, L. M. (2023). Assessing benefits and risks of incorporating plastic waste in construction materials. *Frontiers in Built Environment*, *9*. https://doi.org/10.3389/fbuil.2023.1206474.

Damayanti, A. D., Hanami, Z. A., Hirose, K., Ainun, S., & Putra, R. D. (2022). Potential marine plastic debris detection using sentinel-2 multi-spectral instrument (MSI). *IOP Conference Series: Earth and Environmental Science*, *1117*(1), 012054. https://doi.org/10.1088/1755-1315/1117/1/012054.

Gabriel, A. D., & Bacosa, H. P. (2024). Microplastic abundance and distribution in the sediment of Cagayan de Oro River, Philippines. *Soil and Sediment Contamination: An International Journal*, *33*(8), 1252-1268. https://doi.org/10.1080/15320383.2023.2301495.

García-Hermosa, M. I., & Woodall, L. C. (2023). Marine plastic: The solution is bigger than removal. *Frontiers in Sustainability*, *4*, 1023480. https://doi.org/10.3389/frsus.2023.1023480.

Grilli, G., Andrews, B., Ferrini, S., & Luisetti, T. (2022). Could a mix of short- and long-term policies be the solution to tackle marine litter? Insights from a choice experiment in England and Ireland. *Ecological Economics*, *201*, 107563. https://doi.org/10.1016/j.ecolecon.2022.107563.

Khezri, M., & Mamkhezri, J. (2025). Evaluating the ecological footprints of entrepreneurial activities: Insights from a cross-country assessment. *Technology in Society*, *81*, 102815. https://doi.org/10.1016/j.techsoc.2025.102815.

Lippiatt, S., Opfer, S., & Arthur, C. (2013). Marine debris monitoring and assessment: recommendations for monitoring debris trends in the marine environment. NOAA Technical Memorandum NOS-OR&R-46, 88 pp. http://dx.doi.org/10.25607/OBP-727.

Liu, J., Wu, D., Hellevik, C. C., & Wang, H. (2023). PlastOPol: A collaborative data-driven solution for marine litter detection and monitoring. *2023 IEEE International Conference on Industrial Technology (ICIT)*, 1–6. https://doi.org/10.1109/ICIT58465.2023.10143112.

Meng, J., Zhang, Q., Zheng, Y., He, G., & Shi, H. (2021). Plastic waste as the potential carriers of pathogens. *Current Opinion in Food Science*, *41*, 224–230. https://doi.org/10.1016/j.cofs.2021.04.016.

Pourebrahimi, S., & Pirooz, M. (2023). Microplastic pollution in the marine environment: A review. *Journal of Hazardous Materials Advances*, *10*, 100327. https://doi.org/10.1016/j.hazadv.2023.100327.

Prabawati, A., Frimawaty, E., & Haryanto, J. T. (2023). Strengthening stakeholder partnership in plastics waste management based on circular economy paradigm. *Sustainability*, *15*(5), 4278. https://doi.org/10.3390/su15054278.

Pramudianto, A. (2023). The need for asian regional cooperation in establishing international agreements on marine plastic debris. *Russian Law Journal*, *11*(3), 95-99. https://doi.org/10.52783/rlj.v11i3.959.

Rai, M., Pant, G., Pant, K., Aloo, B. N., Kumar, G., Singh, H. B., & Tripathi, V. (2023). Microplastic pollution in terrestrial ecosystems and its interaction with other soil pollutants: A potential threat to soil ecosystem sustainability. *Resources*, *12*(6), 67. https://doi.org/10.3390/resources12060067.

Sannigrahi, S., Pilla, F., Maiti, A., Bar, S., Bhatt, S., Zhang, Q., ... & Cerda, A. (2022). Examining the status of forest fire emission in 2020 and its connection to COVID-19 incidents in West Coast regions of the United States. *Environmental Research*, *210*, 112818. https://doi.org/10.1016/j.envres.2022.112818.

Sasradinata, I., Pramono, A., & Lufsiana, L. (2023). Pengaturan hukum laut internasional dan nasional dalam pencemaran lingkungan hidup di perairan indonesia akibat sampah plastik. *ARBITER: Jurnal Ilmiah Magister Hukum*, *5*(1), 23–29. https://doi.org/10.31289/arbiter.v5i1.1645.

Saud, S., Yang, A., Jiang, Z., Ning, D., & Fahad, S. (2023). New insights in to the environmental behavior and ecological toxicity of microplastics. *Journal of Hazardous Materials Advances*, *10*, 100298. https://doi.org/10.1016/j.hazadv.2023.100298.

Sina, Pourebrahimi., Majid, P. (2023). Microplastic pollution in the marine environment: A review. *Journal of Hazardous Materials Advances*, *10*, 100327. https://doi.org/10.1016/j.hazadv.2023.100327.

Thongphaijit, P. (2020). Fishermen's participation in marine litter collection schemes in Thailand. *Chulalongkorn University Theses and Dissertations (Chula ETD)*. 458. https://doi.org/10.58837/CHULA.THE.2020.192.

Utami, D. A., Reuning, L., Schwark, L., Friedrichs, G., Dittmer, L., Nurhidayati, A. U., Al Fauzan, A., & Cahyarini, S. Y. (2023). Plastiglomerates from uncontrolled burning of plastic waste on Indonesian beaches contain high contents of organic pollutants. *Scientific Reports*, *13*(1), 10383. https://doi.org/10.1038/s41598-023-37594-z.

Wang, L., Bank, M. S., Rinklebe, J., & Hou, D. (2023). Plastic–rock complexes as hotspots for microplastic generation. *Environmental Science & Technology*, *57*(17), 7009–7017. https://doi.org/10.1021/acs.est.3c00662.

Winterstetter, A., Veiga, J. M., Sholokhova, A., & Šubelj, G. (2023). Country-specific assessment of mismanaged plastic packaging waste as a main contributor to marine litter in Europe. *Frontiers in Sustainability*, *3*. https://doi.org/10.3389/frsus.2022.1039149.

Yuliantiningsih, A., Suherman, A. M., & Jati, B. K. H. (2023). Marine plastic pollution handling based on international and indonesian law to support sustainable development goals. *UNIFIKASI: Jurnal Ilmu Hukum*, *10*(01), 58-73. https://doi.org/10.25134/unifikasi.v10i1.7498.