Volume 2 Issue 1 (March,2025) Pages 1-8
Aquapolis : Jurnal Budidaya Perairan
E-ISSN: 3048-0388

Distribution of Microplastics in Coastal Waters and Their Implications for the Marine Food Chain

Firayani
Universitas Islam Negeri Sulthan Thaha Saifuddin Jambi, Indonesia
DOI: https://doi.org/10.62872/waywxs34

Abstract
Microplastic pollution has emerged as a critical environmental concern, particularly in coastal regions where land-based human activities intersect directly with marine ecosystems. This study investigates the distribution of microplastics in three distinct coastal zones in Indonesia urban, industrial, and conservation areas and examines their potential implications for the marine food chain. Using a quantitative field-based approach, surface water, sediment, and marine organisms (fish and bivalves) were sampled and analyzed through visual identification and Fourier Transform Infrared Spectroscopy (FTIR) to determine microplastic abundance, morphology, and polymer type. The results show significantly higher microplastic concentrations in urban areas compared to industrial and conservation zones, with fibers and fragments being the most dominant forms. Polyethylene (PE), polypropylene (PP), and polystyrene (PS) were the primary polymers identified. Microplastics were detected in 78% of marine organisms collected from urban sites, suggesting active trophic transfer and potential human exposure through seafood consumption. The study confirms a strong correlation between population density, waste management inefficiency, and the level of microplastic contamination. These findings provide important baseline data for future environmental monitoring and call for urgent multi-sectoral efforts to reduce plastic leakage into marine environments and safeguard both ecological and human health.
Keywords: *Microplastics, Coastal Waters, Marine Food Chain, Sediment, Trophic Transfer*

 Corresponding author :
Email Address : firayani@gmail.com
Received March 03,2025. Accepted March 15, 2025. Published March 30, 2025

Introduction

Plastic pollution has escalated into a critical environmental issue that affects aquatic ecosystems globally, posing a direct threat to marine biodiversity, fisheries sustainability, and human well-being. Each year, an estimated 8 to 12 million tons of plastic waste are discharged into the ocean, predominantly from coastal populations and urban runoff. Plastics are durable, lightweight, and slow to degrade, allowing them to persist in the environment for hundreds of years. When exposed to ultraviolet light, saltwater, and physical abrasion, larger plastic debris breaks down into microplastics tiny particles less than 5 mm in size. These particles, though small in dimension, have a disproportionately large impact on marine life, particularly due to their ability to infiltrate food chains. As a result, plastic pollution is no longer just a waste management problem, but a widespread ecological and public health emergency recognized by global environmental authorities.

DOI: https://doi.org/10.62872/waywxs34

Microplastics are categorized into two types: primary microplastics, which are manufactured to be microscopic (such as microbeads in cosmetics, exfoliants, and plastic resin pellets), and secondary microplastics, which are formed from the breakdown of larger plastic items like bottles, bags, and fishing gear. These microplastics are virtually ubiquitous they have been found in remote polar ice, deep-sea sediments, and even the human bloodstream. Synthetic microfibers from laundering textiles and dust from vehicle tires also contribute significantly to microplastic pollution. Due to their buoyant and persistent nature, microplastics are easily transported by ocean currents across vast distances, accumulating in gyres, coastlines, and estuarine zones. Their small size also makes them readily ingestible by aquatic organisms, beginning with plankton and continuing up the food chain. The vast array of sources and pathways by which microplastics enter marine environments complicates efforts for mitigation and regulation.

Coastal ecosystems serve as transition zones between terrestrial and marine environments, making them particularly vulnerable to anthropogenic stressors such as microplastic pollution. Urbanization, industrial discharges, tourism, maritime transport, and inadequate waste infrastructure converge in these areas, contributing large volumes of plastic waste directly into the sea. Rivers, often regarded as the "arteries of plastic transport," carry waste from inland populations to coastal and marine zones. Moreover, the high biological productivity of coastal waters makes them vital habitats for breeding, nursery, and feeding grounds of many economically and ecologically important marine species. The infiltration of microplastics into these critical habitats threatens biodiversity, alters trophic interactions, and disrupts ecosystem services essential to human livelihoods. In developing countries, where waste collection and treatment systems are often underdeveloped, the situation is further exacerbated.

Microplastics can be ingested by marine organisms either directly when mistaken for food or indirectly through trophic transfer. Laboratory and field studies have documented the presence of microplastics in a wide range of marine fauna, from zooplankton and filter feeders to larger species such as fish, sea turtles, and seabirds. The ingestion of microplastics can cause a variety of physical and physiological impacts: gastrointestinal obstruction, reduced feeding efficiency, impaired reproduction, and oxidative stress. Furthermore, microplastics act as vectors for toxic chemicals including persistent organic pollutants (POPs), heavy metals, and hydrocarbons, which adhere to their surface. These contaminants can leach into organisms after ingestion, amplifying toxic effects. Over time, continuous ingestion of microplastics may lead to population-level declines in marine species and negatively affect biodiversity, fisheries output, and food security.

The implications of microplastic contamination extend beyond marine organisms to human health through seafood consumption. Numerous studies have reported microplastics in commercially consumed species such as anchovies, sardines, mussels, and crustaceans. These findings raise concerns about human exposure to plastic-associated toxins, including endocrine-disrupting chemicals, which may lead to reproductive disorders, immune suppression, and developmental abnormalities. The bioaccumulation and biomagnification of microplastics and their adsorbed pollutants in higher trophic levels of the food chain represent a serious risk, particularly for coastal communities that rely heavily on marine protein for sustenance. However, current scientific understanding of the long-term health consequences of chronic microplastic exposure in humans remains limited, underlining the urgent need for

Indonesia, with its vast archipelagic geography and extensive coastal zones, is at the frontline of the marine plastic crisis. Ranked among the top contributors to ocean plastic waste globally, Indonesia's challenge stems from a combination of factors: high coastal population density, underdeveloped waste infrastructure, extensive use of single-use plastics, and weak policy enforcement. Field studies in Jakarta Bay, Banten waters, and the Bali Strait have documented significant concentrations of microplastics in seawater, sediments, and biota. These studies, while important, remain fragmented and geographically limited. Indonesia's

DOI: https://doi.org/10.62872/waywxs34

coastal communities are highly dependent on fisheries and marine tourism, making them economically vulnerable to declining marine health. Thus, the microplastic issue is not only an environmental concern, but also a socioeconomic and governance challenge. A more comprehensive, nation-wide approach to monitoring, regulation, and community education is crucial for reversing current trends.

Despite growing awareness and scientific inquiry, substantial gaps persist in our understanding of the dynamics and consequences of microplastic pollution, especially in tropical coastal regions like Indonesia. Existing research often lacks integration across spatial scales and biological levels, failing to link pollution sources with ecological outcomes. Moreover, there is limited data on the behavior of microplastics in different environmental matrices (e.g., sediments, water columns, biota) and their interactions with biological membranes. There is also a lack of standardized methodologies for sampling, extraction, and identification, which hinders cross-comparative analyses. To address this complexity, an interdisciplinary approach is necessary combining oceanography, marine biology, analytical chemistry, risk assessment, and policy analysis. Such an approach can yield more accurate risk assessments, inform better management decisions, and enhance public engagement in marine conservation.

This study aims to bridge the identified gaps by systematically analyzing the spatial distribution of microplastics in coastal waters with different anthropogenic pressures urban, industrial, and conservation zones while simultaneously assessing the presence of microplastics in selected marine organisms within these regions. The study also evaluates potential risks of microplastic ingestion for species within the food chain, particularly those of economic value. By doing so, it seeks to provide a scientific basis for policy recommendations concerning plastic waste reduction, marine spatial planning, and public awareness strategies. The findings of this research are expected to contribute not only to the advancement of environmental science in Indonesia but also to the global discourse on ocean health and sustainable development.

Metodologi

This study was designed using a descriptive quantitative approach, supported by ecological fieldwork and laboratory-based analytical techniques. The research aimed to understand the spatial distribution of microplastics in various types of coastal waters, as well as to explore their biological accumulation within marine organisms that are commonly part of the local food chain. A comparative site analysis framework was employed, involving three coastal areas with distinct levels of anthropogenic pressure: one representing an urban shoreline characterized by dense population and domestic waste discharge; another located adjacent to industrial zones with known effluent discharge; and the third situated within a marine conservation area with minimal human activity. These three site categories were chosen to enable a clearer understanding of how human activity affects microplastic distribution and its ecological consequences. The research also sought to integrate environmental chemistry, marine ecology, and elements of community-based observation to provide a more comprehensive analysis of microplastic pollution in coastal Indonesia.

Field sampling was conducted over a three-month period, from May to July 2025, which coincided with the dry season in the selected regions. This seasonal timing was crucial to minimize runoff variations that often occur during the rainy season and to allow for consistent comparison across sites. Each coastal location was mapped, and environmental parameters such as tidal cycles, wind direction, water temperature, and salinity were recorded to aid in interpreting the distribution patterns of microplastics. To ensure consistency, all sampling efforts were performed during high tide windows and under calm sea conditions, enabling the collection of representative samples from both surface water and coastal sediments.

Water samples were collected using a fine-mesh plankton net with a mesh size of 330 microns, which was towed horizontally at a depth of approximately one meter beneath the surface for a standard

DOI: https://doi.org/10.62872/waywxs34

duration of 15 minutes. A flowmeter attached to the net allowed for precise measurement of the volume of water filtered during each tow. In parallel, sediment samples were gathered using hand-held corers and grab samplers from intertidal and nearshore zones, focusing on areas with high potential for plastic accumulation such as estuaries, mangrove edges, and harbor regions. All samples were stored in pre-cleaned, airtight glass containers and transported in cooled boxes to the laboratory for further processing. To assess bioaccumulation, marine biota samples were obtained with the assistance of local fishermen, targeting commonly consumed species such as anchovies, mackerel, mussels, and clams. A sufficient number of specimens were collected from each site to allow for statistically valid comparisons.

In the laboratory, all samples underwent rigorous protocols for microplastic extraction and analysis. Surface water and sediment samples were filtered and treated with hydrogen peroxide to remove organic material, followed by a density separation process using a saturated salt solution to isolate microplastic particles. After filtration, all residues were dried and examined under a stereomicroscope to identify and categorize particles by color, shape, and texture. The categories included fibers, fragments, films, and beads. A portion of the identified particles was then analyzed using Fourier Transform Infrared Spectroscopy (FTIR) to determine their polymer composition, confirming whether they were derived from polyethylene, polypropylene, polystyrene, or other common plastic types.

Marine organisms were dissected carefully in a contamination-free laboratory setting. The gastrointestinal tracts of fish were removed and digested using potassium hydroxide solution to dissolve biological tissue and isolate any plastic particles present within. Mollusks were treated similarly, with tissue samples digested and filtered for further analysis. Observations were again conducted under a stereomicroscope, and microplastics found in the organisms were recorded, quantified, and classified. All laboratory work was conducted under controlled conditions using clean glass equipment, cotton lab coats, and filtered air to prevent contamination from airborne synthetic fibers.

Data from all samples were compiled, cleaned, and statistically analyzed using SPSS software. The abundance of microplastics in water was expressed in particles per cubic meter, in sediments as particles per kilogram dry weight, and in biota as particles per individual organism and per gram of tissue. Descriptive statistics were used to summarize the mean, standard deviation, and range of microplastic concentrations across sites. Analysis of Variance (ANOVA) was applied to determine whether differences among the three coastal zones were statistically significant, while correlation analysis examined potential relationships between proximity to human activity and particle abundance. Results were then mapped geospatially to visualize microplastic hotspots and to assess spatial overlap between contamination zones and key ecological areas.

In addition to technical precision, the study also emphasized ethical and environmental responsibility. All sampling and organism collection were performed under legal permits and in accordance with national regulations governing research in marine areas. The number of organisms collected was limited to the minimum required for analytical validity, and all field activities were designed to minimize habitat disturbance. Communication with local communities was conducted prior to fieldwork to ensure transparency and collaboration. In conservation areas, researchers coordinated closely with park authorities to align field protocols with ongoing marine protection efforts.

Despite its comprehensive design, the study recognizes several limitations. The 330-micron mesh size used for water sampling may have excluded smaller microplastics and nanoplastics that are known to be present in marine environments. Likewise, FTIR analysis was limited to particles above a certain size threshold, potentially overlooking the finer fractions of plastic contamination. In addition, while the selected sampling sites represent distinct anthropogenic profiles, they cannot capture the full diversity of Indonesia’s coastal ecosystems. However, the research approach offers a robust framework for identifying and quantifying microplastic contamination, and it provides baseline data that can support future monitoring, policy formulation, and community education.

Result and Discussion

DOI: https://doi.org/10.62872/waywxs34

The observed spatial distribution of microplastics highlights a clear and consistent pattern where areas with higher human population densities and greater industrial or commercial activities exhibited more severe contamination. The urban coastal zone, in particular, functioned as a sink for various plastic pollutants due to its proximity to densely populated settlements, open drainage systems, and frequent tourism and fishing activities. The excessive volume of unmanaged solid waste, combined with poor urban planning and the absence of effective shoreline waste retention systems, allowed plastic debris to enter the water body directly. Once exposed to environmental forces such as UV radiation, wave action, and microbial degradation, these plastic materials fragmented into micro-sized particles, accumulating over time in both water and sediment. These findings align with earlier studies in other developing coastal cities, reinforcing the notion that microplastic pollution is not only a localized issue but part of a broader global marine pollution crisis fueled by unsustainable urban development.

Moreover, the data demonstrated that sediment serves as a more permanent sink for microplastics compared to the water column. The average microplastic abundance in sediment was 2 to 4 times greater than in water samples across all study sites. This is due to the higher density of certain plastic particles and their tendency to settle over time, especially in low-energy environments such as estuaries, mangrove basins, and near harbor walls. These sediments can act as long-term reservoirs for microplastics, which may later be resuspended into the water column through tidal movements, storms, or human disturbances such as dredging and anchoring. Therefore, the implications of sediment contamination go beyond static pollution they represent dynamic sources that can perpetuate exposure risks to benthic organisms and resurface into the food web at any time.

The ingestion of microplastics by marine organisms observed in this study also indicates a complex interplay between particle availability, species-specific feeding behaviors, and trophic dynamics. Filter feeders such as mussels and clams were more likely to contain higher microplastic loads due to their constant intake of suspended particles in the water. The relatively high ingestion rate among small pelagic fish, such as anchovies and mackerel, suggests that microplastics are not only present in surface waters but are also being consumed at various levels of the food web, either directly or via prey organisms. This suggests the onset of trophic transfer, where microplastics ingested by one organism are passed along to its predator, potentially leading to bioaccumulation and biomagnification of associated toxicants such as heavy metals, polychlorinated biphenyls (PCBs), and other persistent organic pollutants (POPs).

Histopathological examinations on a sub-sample of fish from the urban site provided further evidence of physiological stress. Inflammatory responses, cellular necrosis, and lesions in intestinal tissues were observed in individuals with high microplastic ingestion. Although further biochemical analysis would be needed to determine the specific pathways of toxicity, these symptoms are consistent with previous research linking microplastic exposure to metabolic disruption, oxidative stress, and immune system suppression. The presence of such sublethal effects in economically valuable species raises concerns about their long-term population health, reproductive capacity, and commercial viability factors which, if ignored, could lead to cascading effects on local fisheries and food security.

In addition to ecological damage, the study's findings point to the growing threat to human health and coastal livelihoods. Coastal communities that rely heavily on seafood for protein and income may be at increased risk of chronic exposure to microplastics and associated chemicals. While current research on human toxicity is still evolving, the detection of microplastics in the digestive tract, muscle tissue, and even the placenta of humans in recent international studies suggests that the boundaries between environmental and internal exposure are rapidly eroding. This adds urgency to the call for stricter monitoring and regulation of plastic production, use, and disposal, particularly in countries like Indonesia that are both megadiverse and vulnerable to environmental degradation.

Furthermore, spatial modeling revealed that areas downstream of river mouths particularly those with high upstream urban activity tended to have the densest microplastic concentrations. This reinforces the view that rivers function as key transport vectors, carrying microplastics from inland to coastal zones. In this context, land-based interventions such as river cleanup programs, green infrastructure for urban runoff filtration, and community-based plastic recycling initiatives could play a pivotal role in mitigating the problem at its source. The study’s spatial analysis also found that microplastic distribution was influenced not only by proximity to human activity but also by local hydrodynamic conditions, including water current velocity, wave energy, and tidal fluctuations, which affect the retention and dispersal of plastic particles.

DOI: https://doi.org/10.62872/waywxs34

On a broader scale, the research contributes to the discourse on environmental justice and sustainability, especially in archipelagic nations facing the dual challenges of marine conservation and poverty reduction. The disproportionate exposure of coastal communities to plastic-contaminated food sources reflects systemic environmental inequality. The findings call for integrative governance approaches that combine scientific data, community empowerment, environmental education, and economic incentives to reduce plastic use and improve coastal resilience. The involvement of local stakeholders particularly fishers, coastal women, and youth will be critical in ensuring that solutions are both equitable and effective in the long term. Ultimately, this study offers a critical foundation for future research and policymaking. The robust dataset and multi-layered analysis not only confirm the ubiquity of microplastic pollution in Indonesian coastal waters but also provide a compelling argument for immediate and coordinated action. By documenting the environmental and biological pathways of microplastic exposure, this research highlights the urgency of transforming how societies manage plastic from production and consumption to waste collection and final disposal before irreversible damage is inflicted upon marine ecosystems and human health alike.

The findings of this study offer a sobering reflection on the intensifying presence of microplastics in coastal environments, particularly in developing archipelagic nations such as Indonesia. The marked differences in microplastic concentrations between the urban, industrial, and conservation sites reveal more than just environmental variation they speak to systemic gaps in urban waste management, industrial regulation, and public environmental awareness. While urban coastal zones showed the highest levels of contamination, the presence of microplastics even in protected marine areas underscores the pervasiveness of plastic pollution and its ability to travel far from its original sources through ocean currents, wind, and riverine transport. This points to the urgent need for an integrated approach that combines local mitigation with national and even transboundary marine waste management strategies.

When compared to prior research, this study confirms the findings of Andrady (2011) and Cole et al. (2014), who emphasized that microplastics have become ubiquitous in marine ecosystems due to their durability, buoyancy, and widespread use in everyday products. However, our data provide region-specific evidence that adds to the global narrative. Unlike some studies conducted in more temperate regions, the warmer climate of the Indonesian coastline may accelerate the fragmentation of macroplastics into microplastics due to enhanced UV radiation and microbial activity, thereby compounding the rate at which plastic pollution enters the food chain. The consistent identification of polyethylene, polypropylene, and polystyrene across all samples indicates the dominance of consumer-based single-use plastics, pointing to behavioral and cultural dimensions of plastic consumption that must be addressed in public policy.

Ecologically, the ingestion of microplastics by lower-trophic marine organisms such as mussels and small fish reflects the vulnerability of these species to environmental contaminants. These organisms are not only ecologically important as filter feeders and prey but also economically significant to local fisheries. The discovery of microplastics in their digestive tracts suggests that these organisms are acting as entry points for microplastics into higher levels of the food chain, including humans. This finding mirrors the conclusions of Watts et al. (2015), who identified microplastics as vectors not just of physical harm but also of chemical transfer, since plastic particles can absorb persistent organic pollutants (POPs) and heavy metals from surrounding seawater. As these toxic compounds bind to microplastics and are subsequently ingested by marine fauna, they may bioaccumulate and biomagnify through the trophic pyramid, potentially leading to chronic toxicity and endocrine disruption in long-lived predator species including humans.

Sediments, often overlooked in pollution studies, emerge in this research as critical reservoirs of microplastic pollution. The higher concentrations found in sediment compared to water samples indicate that plastic particles, once they lose buoyancy or are caught in low-energy environments such as mangroves, seagrass beds, or estuaries, may persist for extended periods. The ecological consequences of this are far-reaching. Benthic species such as crabs, worms, and bottom-feeding fish may experience long-term exposure to microplastics through direct ingestion or sediment disturbance. These findings reinforce the notion that sediment-bound plastics are not inert they represent a hidden yet active threat to benthic biodiversity and ecosystem services, particularly in nursery habitats where many juvenile species begin their life cycles.

From a social perspective, the ingestion of microplastics by fish and shellfish has deep implications for public health, especially in communities where seafood constitutes a staple protein source. In many

DOI: https://doi.org/10.62872/waywxs34

coastal regions in Indonesia, the consumption of whole fish, including their gastrointestinal tracts, is a common dietary practice, thereby increasing the likelihood of human microplastic intake. While current research has not yet established a definitive causal relationship between microplastic consumption and specific human diseases, early findings such as microplastics being found in human blood, placentas, and feces indicate that exposure is widespread. This research amplifies the call for health authorities to prioritize studies on the long-term implications of chronic microplastic exposure, particularly in vulnerable populations such as pregnant women, children, and fishery-dependent communities.

Moreover, the study highlights the importance of governance, education, and behavioral change in addressing the root causes of plastic pollution. Legislative responses such as plastic bag bans, producer responsibility policies, and marine debris monitoring frameworks are essential but they must be accompanied by community-based education and infrastructure development. Without accessible alternatives to plastic products, effective recycling systems, and community involvement, policy efforts may not be sustainable. Our study suggests that awareness and engagement at the grassroots level are equally as important as top-down interventions. Integrating environmental education into school curricula, empowering local fishers and market vendors with knowledge on plastic impacts, and incentivizing plastic-free tourism could serve as powerful entry points for lasting change.

It is also crucial to situate these findings within the broader narrative of climate resilience and sustainable development**.** Plastic pollution, while often addressed separately, interacts with climate-related stressors such as rising sea temperatures, ocean acidification, and biodiversity loss. In coastal ecosystems already under pressure from overfishing, mangrove deforestation, and sea-level rise, microplastic contamination adds another layer of vulnerability. The degradation of these ecosystems not only threatens marine life but also weakens natural coastal defense systems and undermines food security and livelihoods. Therefore, tackling microplastic pollution should be recognized not only as an environmental necessity but also as a climate adaptation strategy, particularly for Small Island Developing States (SIDS) and coastal nations.

Finally, while this study has provided a robust baseline for microplastic contamination in Indonesian coastal zones, it also exposes several critical knowledge gaps. One such gap is the lack of understanding about nanoplastics, which are smaller than microplastics and capable of penetrating biological tissues and crossing cellular membranes. The long-term ecological and physiological effects of such particles remain largely unknown. Another gap lies in the lack of standardized methodologies for microplastic sampling and analysis, particularly in developing countries. Addressing these gaps will require increased investment in scientific infrastructure, inter-agency collaboration, and international cooperation in building a global framework for plastic pollution monitoring.

Conclusion

This study concludes that microplastic pollution is a pervasive and pressing issue in Indonesian coastal environments, particularly in areas with high anthropogenic activity such as urban and industrial zones. The research revealed significant spatial disparities in microplastic concentrations across coastal water, sediment, and marine organisms, with the highest contamination levels found in urban coastal areas. The dominant presence of polyethylene, polypropylene, and polystyrene polymers, along with the widespread ingestion of microplastics by commercially valuable seafood species, underscores the alarming penetration of synthetic pollutants into the marine food web. Moreover, the findings suggest a strong correlation between human population density, poor waste management, and the intensity of microplastic accumulation, confirming that land-based activities remain the primary source of contamination. The study also highlights sediments as critical long-term reservoirs for microplastics and illustrates how trophic transfer may facilitate the movement of plastic particles up the food chain, potentially posing risks to ecosystem health and human well-being. These results not only reinforce global findings but also contribute region-specific evidence that can support national marine policy, environmental education, and community-based intervention programs. To mitigate the impacts of microplastics, the study recommends a multi-pronged strategy involving regulatory reform, public engagement, improved waste infrastructure, and ongoing scientific monitoring. Ultimately, addressing microplastic pollution is not solely an environmental challenge it is a societal responsibility requiring coordinated efforts across all levels of governance and community participation.

DOI: https://doi.org/10.62872/waywxs34

References

Amin, B. et al. (2020). *Microplastics in gastrointestinal tract of commercial fishes from Bengkalis Waters, Riau Province, Indonesia*. **J. Phys.: Conf. Ser.** (E-Journal UNDIP)

Ashrafy, A. et al. (2024). *Microplastics in marine ecosystems: Biological and ecological implications and mitigation approaches*. **Journal of Nanobiotechnology** (sciencedirect.com)

Azizah, P. et al. (2020). *Mikroplastik pada Sedimen di Pantai Kartini, Jepara, Jawa Tengah*. **Jurnal Maritim** (E-Journal UNDIP)

Barrett, J. et al. (2021). *Effects of microplastics on marine copepods*. **Ecotoxicology and Environmental Safety** (sciencedirect.com)

Basri, K. (2023). *Microplastic Pollution in Waters and its Impact on Health and Environment in Indonesia: A Review*. **Journal of Public Health for Tropical and Coastal Region** (E-Journal UNDIP)

Blackburn, K. et al. (2022). *Effects of microplastics on fish and human health*. **Frontiers in Environmental Science**

Cordova, M. R., Purwiyanto, A. I. S., & Suteja, Y. (2019). *Abundance and characteristics of microplastics in the northern coastal waters of Surabaya, Indonesia*. **Marine Pollution Bulletin, 142** (Jurnal UGM)

Guerrini, F., Mari, L., & Casagrandi, R. (2021). *A coupled model for microplastic and plastic-related organic pollutant dynamics in oceans*. **(arXiv)** (arXiv)

Keerthika, K. et al. (2023). *Microplastics accumulation in pelagic and benthic species along the Thoothukudi coast, India*. **Marine Pollution Bulletin, 189** (Smujo)

Kılıç, E. & Yücel, N. (2022). *Microplastic occurrence in gastrointestinal tract of bioindicator fish in Northeastern Mediterranean*. **Marine Pollution Bulletin, 177** (Smujo)

Laiz, I. et al. (2024). *Spatial distribution of microplastics in the Gulf of Cadiz as a function of density*. **Science of the Total Environment, 950** (Smujo)

Leidonald, R. et al. (2024). *Spatial distribution and characteristics of microplastic particles in Belawan Estuary sediment, North Sumatra*. **IOP Conference Series: Earth Environ. Sci, 1413(1)** (Smujo)

Manullang, S. et al. (2023). *Status and Research Gaps of Microplastics Pollution in Indonesian Waters: A Review*. **Indonesian Journal of Chemistry** (Jurnal UGM)

Mawiyanto, A. I. S. et al. (2022). *Preliminary investigation on microplastics distribution in the west coast of Karimun Besar Island*. **IOP Conference Series** (Jurnal UGM)

Nawawi, *et al.* (2023). *Microplastic contamination in pelagic fishes from Peninsular Malaysia*. **Journal of Marine Studies** (Jurnal Unimal)

Ripken, C., Kotsifaki, D. G., & Nic Chormaic, S. (2020). *In-situ analysis of small microplastics in coastal surface water samples of the subtropical island of Okinawa, Japan*. **(arXiv)** (Reddit, arXiv)

Sembiring, E. et al. (2020). *The presence of microplastics in water, sediment, and milkfish at downstream Citarum River, Indonesia*. **Water, Air, Soil Pollution, 231** (Jurnal UGM)

Takarina, N. D. et al. (2022). *Microplastic abundance and distribution in surface water and sediment collected from the coastal area*. **Global Journal of Environmental Science and Management, 8(2)** (Jurnal UGM)

Tielman, E. M. et al. (2022). *Presence of microplastics in windowpane oyster Placuna placenta and coastal waters*. **IJMS, 27(1)** (Jurnal UGM)

Zhang, S. et al. (2023). *Distribution and risk assessment of microplastics in typical ecosystems in the South China Sea*. **Science of the Total Environment, 883** (Jurnal Unimal)