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Editorial: Baselines, impacts and mitigation strategies for plastic debris and microplastic pollution in South East Asia

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Editorial on the Research Topic

[Baselines, impacts and mitigation strategies for plastic debris and microplastic pollution in South East Asia](#)

Plastic debris and microplastics are significant environmental issues globally, including Southeast Asia countries that were identified as a critical hotspot. This review synthesizes finding from studies in Penang, Malaysia; the south Java coastline, Indonesia; and the Flores Sea, Indonesia. These publications have established baseline on the contamination levels and assessed ecological and socio-economic impacts, and mitigation strategies. The highlighted finding was included in severe contamination in mangrove estuaries and coastal waters, plastic marine litter on beaches, and microplastic dispersion in ocean currents. Mitigation strategies that require integrated approaches involving policy reform, community engagement, technological innovation and regional cooperation.

Introduction

Microplastics have emerged as a pollution concern over the past two decades (Thompson et al., 2025). Microplastic contamination is pervasive across multiple ecosystem matrices. Microplastics predominantly originate, approximately 70-80%, from the degradation of larger plastics caused by UV exposure, weathering, and mechanical factors (Katare et al., 2022). The remainder originates from plastics manufactured in diminutive sizes, such as those used for personal care items or cleaning solutions (Boucher and Friot, 2017).

Microplastics are newly emerging contaminants anticipated to proliferate in the future. They present a significant hazard to environmental and public health (Makhdoumi et al., 2023). Therefore, understanding the sources, distribution, and impacts of microplastics, as

well as developing strategies to mitigate their release into the environment is crucial for the region's long term environmental and economic stability.

Southeast Asia's rapid urbanization, economic growth, and burgeoning population have firmly established the region as a critical player in the global plastic pollution narrative (Omeyer et al., 2022; Williams and Rangel-Buitrago, 2022; Ali et al., 2024). As one of the world's fastest-developing areas, Southeast Asia has emerged as a major contributor to the global plastic waste crisis, including within its own borders (Marks, 2022; Ng et al., 2023). Regrettably, studies investigating plastic waste and microplastics in this region remain scarce compared to other parts of the world (Lyons et al., 2019; Manullang et al., 2022; Omeyer et al., 2022, 2023; Nakano et al., 2025). To reconcile the region's development and environmental management needs, establishing a baseline is crucial for crafting more targeted policies. This review synthesizes findings from recent studies conducted in Penang, Malaysia; along the south Java coastline, Indonesia and the Flores Sea, Indonesia. The aim was to set baseline conditions, assessing ecological and socioeconomic impacts, and exploring mitigation strategies for the pressing issue of plastic and microplastic pollution in the region.

Baseline conditions

Malaysia

Tan and Mohd Zanuri's baseline study in Penang, Malaysia, highlights the vulnerability of tropical estuarine mangrove ecosystems to microplastic pollution, potentially driven by human activities and waste management challenges. Sampling across four sites revealed substantial microplastic contamination, with fragments being the dominant morphology, and indicating the breakdown of larger plastic debris. Their findings reported microplastic concentration ranging between $201 \pm 21.214 - 1,407 \pm 124.265$ items per liter (items/L) in coastal surface water, as well as $255 \pm 22.368 - 350 \pm 25.892$ items per kilogram (items/kg) in coastal sediment, and $430 \pm 7.234 - 4,000 \pm 29.174$ items/kg in estuarine sediments. Polyethylene was identified as the predominant polymer in all matrices. This study emphasizes the importance of mangrove estuaries as critical ecological zones that are susceptible to plastic pollution from urban and industrial sources, highlighting the need for targeted interventions to address this pressing environmental issue.

Indonesia

The studies by Yona et al. and Herawati et al. provide valuable baseline data on marine litter and microplastic pollution in Southeast Asia, highlighting the severity of the issue in coastal and marine environments. Yona et al. investigated beach litter across multiple sites in eastern Java, Indonesia, revealing a strong correlation between litter abundance, composition, tourism activities, and beach management practices. Their findings

indicate that plastic waste is the predominant pollutant, with approximately 90% originating from land-based sources, including tourism-related activities. The study area had an abundance of beach litter ranging from 0.4 items/m² to 6.1 items/m² with average of 2.0 ± 1.5 items/m². Furthermore, the Clean Coast Index (CCI) classified the surveyed beaches as "dirty" to "extremely dirty", suggesting that inadequate waste management and low public awareness contribute significantly to the pollution levels, thus highlight the urgent need for further research on sources, mitigation strategies, and sustainable waste management practices to address marine litter in the region effectively.

The study by Herawati et al. investigates the characterization and distribution of microplastics in the Flores Sea, which is influenced by the Indonesian Throughflow currents. Driven by a critical knowledge gap regarding the specific nature and distribution of microplastics in the Flores Sea, this work is revealing the baseline of microplastic contamination in the critical area. Their findings showed microplastic concentrations ranging from 0.84 to 2.24 items/L in surface waters and 0.84 items/g to 2.75 items/g in seabed sediments. The researchers found that microplastics predominantly consisted of polyethylene terephthalate and polyethylene polymers, with shapes including films, filaments, and fragments, and black and blue being the predominant colors. The study identified ocean currents as a key factor shaping the distribution and dispersal of microplastics in this ecologically significant region. The findings contribute to a better understanding of microplastic distribution and can inform future environmental assessments and policy development efforts.

Impacts

It is well established that microplastics pose significant environmental impacts by compromising marine ecosystem health and water quality, as well as entering food chains. In Penang, Malaysia, microplastics were found to contain hazardous chemicals like dimethylmercury, posing risks to estuarine organisms and their habitats (Tan and Mohd Zanuri). Similarly, a study on the Flores Sea, Indonesia, highlighted the potential of microplastics to disrupt biogeochemical processes and harm marine biodiversity (Herawati et al.). Beyond environmental concern, microplastics also have socio-economic implications. For instance, tourism-dependent regions such as the southern Java coastline suffer economic losses due to degraded beach aesthetics and reduced visitor satisfaction (Yona et al.). Furthermore, the presence of microplastics in fishery zones, as observed in the Flores Sea, raises concerns over seafood safety, potentially impacting both local livelihoods and public health.

Mitigation strategies

The ASEAN Regional Action Plan (2021–2025) was installed to improve plastic waste management capacity (Secretariat, A. S. E. A. N, 2021). Other initiatives, the ASEAN-Norway project focusing on

local sustainability and ASEAN+3 Marine Plastic Debris programs, emphasize regional collaboration (UN environment, 2017). In addition, public awareness campaigns targeting local communities and tourists can encourage responsible waste disposal. In Indonesia, a waste-bank program introduced in 2012 encourages households to sort waste into specific categories, which are then deposited in central waste banks that provide monetary returns (Loh, 2020). Such initiatives not only improved recycling rates but also engaged communities in waste management efforts (Ng et al., 2023). Innovative technologies, such as the ocean cleanup project by a non-profit organization, aimed to remove plastics from oceans and rivers using devices like interceptor units deployed in Southeast Asia (Omeyer et al., 2022). The 2021 UNEP report highlighted that the production, usage, and disposal of fossil fuel-derived plastics emitted approximately 1.7 gigatons of CO₂ equivalents in 2015, projected to rise to 6.5 gigatons by 2050 (Julius and Trajano, 2022). These estimates align with the concern raised by Karasik et al. (2023), who emphasized that plastic production not only accelerates fossil fuel dependency but also imposes disproportionate health and environmental burdens on communities, thus need to be urgently mitigated.

Future research directions

Future research in Southeast Asia and other locations should emphasize the investigation of microplastic contamination in aquatic habitats, particularly in estuarine systems and their many components, to inform successful conservation efforts, based on three studies (Tan and Mohd Zanuri; Herawati et al.; Yona et al.). Research should examine the nature, sources, and transport processes of marine trash, including buoyancy, to formulate specific mitigation strategies. Moreover, studies must evaluate the efficacy of remediation initiatives and create baseline data for marine debris, especially in underexplored areas such as the eastern region of South Java. The effects of microplastics on marine organisms and human health, particularly via the Indonesian Throughflow channels, necessitate additional research. This entails detecting microplastic particles within the water column and examining the impact of riverine contributions from adjacent regions. Standardized procedures and reporting requirements are crucial for guaranteeing comparability and reproducibility among the investigations.

Conclusion

Plastic and microplastic pollution in Southeast Asia is a complex issue requiring comprehensive solutions. Baseline studies from Malaysia and Indonesia reveal high contamination levels

linked to anthropogenic activities, with potentially severe ecological and socio-economic consequences. Effective mitigation demands an integrated approach involving policy reforms, community involvement, technological innovation and international collaboration to safeguard marine ecosystems and human well-being in the region.

Author contributions

SA: Conceptualization, Supervision, Writing – original draft, Writing – review & editing. AM: Writing – original draft. MC: Conceptualization, Writing – review & editing. CC: Conceptualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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