Impacts of Microplastic Contamination on Carbon Sequestration and Ecosystem Functioning in Mangrove Forests of Sri Lanka: A Systematic Review and Meta-analysis

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Microplastic (MP) pollution is a critical global environmental issue, with severe impacts on sensitive coastal ecosystems such as mangrove forests. These ecosystems are vital for "blue carbon" storage but are increasingly threatened by plastic pollution. This study presents a systematic review and meta-analysis exploring how microplastics influence carbon sequestration and ecosystem functioning in mangroves, with a specific focus on Sri Lanka. Following PRISMA 2020 guidelines, it synthesizes findings from major electronic databases, including Web of Science, Scopus, PubMed, Google Scholar, ScienceDirect, and ResearchGate. Alongside grey literature from Sri Lankan institutional repositories. Studies were selected based on clear inclusion criteria. In total, 850 records were identified from database searches, along with an additional 150 records from other sources. After duplicates were removed, 720 records remained for screening. From these, 450 were excluded based on initial review, leaving 270 full-text articles to be assessed for eligibility. Of these, 120 articles were further excluded for various reasons. In the end, 150 studies were included in the systematic review, of which [X] studies were included in the qualitative synthesis and [Y] studies with sufficient quantitative data were included in the meta-analysis (X+Y=150). The review investigates the occurrence, distribution, and characteristics of microplastics (including size, polymer composition, and abundance) across mangrove sediments, water, and biota. Furthermore, it evaluates MP impacts on key ecological processes such as carbon storage, microbial activity, nutrient cycling (N, P, and K), and biodiversity. The findings indicate that microplastics alter the physical and chemical properties of mangrove sediments, slow down organic matter decomposition, and potentially increase methane emissions. These changes may ultimately reduce the long-term carbon sequestration capacity of mangrove ecosystems. Additionally, MP contamination negatively affects mangrove organisms and associated fisheries, posing socio-economic risks to local communities. Overall, the results emphasize the urgent need for effective conservation strategies and evidence-based policies to reduce plastic pollution and protect mangrove ecosystems. Key research gaps in Sri Lanka include limited field data on microplastic abundance and polymer composition in mangroves, insufficient understanding of their effects on sediment carbon storage and microbial communities, and a lack of long-term monitoring of ecosystem impacts. Future research should prioritize site-specific assessments of microplastics in sediments, water, and biota, investigate their influence on carbon sequestration, evaluate their movement through mangrove food webs and impacts on fisheries, and establish standardized detection and monitoring methods. Addressing these gaps will provide stronger scientific evidence to support effective mangrove conservation and policy development in Sri Lanka.

Keywords: *Carbon sequestration, Ecosystem functioning, Mangrove forest, Microplastic pollution*