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Short Communication: First report on the occurrence of microplastic contamination in mariculture *Eucheuma cottonii* from Lancang Island, Kepulauan Seribu National Park, Jakarta, Indonesia

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Abstract. *Cham M, Yasman Y. 2024. Short Communication: First report on the occurrence of microplastic contamination in mariculture* Eucheuma cottonii *from Lancang Island, Kepulauan Seribu National Park, Jakarta, Indonesia. Biodiversitas 25: 3995-3999.* Microplastics (MPs) contamination in marine environments significantly threatens marine ecosystems and human health. This study presents the first recorded occurrence of MP contamination in the macroalga *Eucheuma cottonii* Weber Bosse, 1913, specifically in samples collected from Lancang Island, Kepulauan Seribu National Park, Jakarta, Indonesia. Fibrous blue MPs, measuring approximately 400 µm, were identified in two samples, each weighing 15 g (wet weight). This finding aligns with previous studies reporting fibrous MPs as the global contaminants in macroalgal populations. Despite the similarity, our findings contrast with those from nearby regions, where fragment MPs were observed as the most abundant form. The interaction between MPs and macroalgae is influenced by factors such as surface texture, chemical composition, and the presence of mucilage. Additionally, MPs have been shown to impact macroalgal health, reducing growth rates and photosynthetic efficiency and increasing oxidative stress, highlighting the need for further research. Considering *E. cottonii* as an edible macroalga and a critical habitat provider in marine ecosystems, regular monitoring of MPs contamination is essential. This research contributes to a broader investigation of MP contamination, growth patterns, and secondary metabolite production in macroalgae under different cultivation techniques, underscoring the importance of sustainable practices in marine resource management.

Keywords: *Eucheuma cottonii*, fibrous microplastics, Kepulauan Seribu National Park, marine macroalgae, microplastic contamination

Abbreviations: KSNP: Kepulauan Seribu National Park, MPs: Microplastics

INTRODUCTION

Indonesia is one of the world's largest producers of macroalgae, commonly known as seaweed, playing a pivotal role in meeting global demand and expanding export opportunities (Basyuni et al. 2024). The country is one of the leading exporters of macroalgae in Asia, with the primary cultivated species being *Eucheuma cottonii* Weber Bosse, 1913, *Gracilaria* sp., and *Gelidium* sp. (Gumilar et al. 2024). Nevertheless, Microplastics (MPs) pose a growing environmental challenge to marine ecosystems, including Indonesia's coastal waters, especially in aquaculture areas dominated by seaweed farming (Zhang et al. 2022). These tiny plastic particles (<5 mm), often less dense than water, tend to accumulate on the ocean's surface due to human activities (Xiang et al. 2022). In South Asia, MP pollution affects marine, terrestrial, and atmospheric environments, with species like fish, seaweed, and oysters being especially vulnerable, which raises concerns about human exposure through seafood consumption (Sin et al. 2023). While Indonesia's coastal macroalgae, consumed as sea vegetables, show differing levels of MP contamination compared to seawater and sediments, the broader impact on marine biodiversity is a global concern (Patria et al. 2023).

In Indonesia, ocean currents mainly drive the presence of MPs in open seas, reflecting global averages. MPs concentrations are closely linked to population density. They are distributed through various human activities, including laundry, waste disposal, wastewater management, irrigation, organic fertilizers, coatings, and mulch (Setyaningsih et al. 2023). Water currents also play a role, with stronger currents able to transport larger quantities of MPs. These hazardous particles transpire through ecosystems due to domestic, industrial, and coastal activities, with domestic runoff containing microbeads and MPs fragments a significant contributor (Ahmad et al. 2020). Unmanaged domestic plastic waste disposal remains the principal source of MPs contamination in Indonesia’s marine ecosystems, with fragments and fibers being the most frequently found forms (Sari et al. 2021).

The ingestion or absorption of MPs has harmful effects on aquatic organisms. At the population level, MPs can reduce species diversity and biomass. In contrast, on an individual level, they can impair survival, reproduction, growth, feeding behavior, emergence, embryonic development, mobility, and even photosynthesis (Koelmans et al. 2022). Plastic is the most widespread form of marine debris globally, with MP pollution posing an increasing challenge for marine ecosystems. Although extensive research has been conducted on marine plastic waste, few studies focus on aquaculture in Southeast Asia, where MP regulations often overlook coastal aquaculture pollution (Albasri et al. 2024). A comprehensive approach is needed to analyze and assess MP pollution in aquaculture, including proper sampling, extraction, and qualitative and quantitative analyses (Xiang et al. 2022). Research on MP contamination in macroalgae remains limited globally, particularly in Indonesia (Purayil et al. 2024). Even Sari et al. (2021), who specifically addressed MP contamination in Indonesia's aquatic environments, did not report any MP contamination in macroalgae. Furthermore, a review by Lima et al. (2024) that assessed the density of MPs associated with macroalgae across different ecosystems and countries identified only ten articles; none focused on the macroalgae species *E. cottonii*.

Given the importance of macroalgae as a substrate for MPs accumulation and the significant biomass of mariculture macroalgae alongside the abundance of MPs in Kepulauan Seribu National Park, Jakarta (Patria et al. 2023), this study aims to fill the information gap on the interactions between macroalgae and MPs. It focuses on detecting and characterizing the MPs found in *E. cottonii* seaweed samples collected from Lancang Island, Kepulauan Seribu National Park, Jakarta, including their color, size, and shape. This research is part of a more extensive investigation comparing the effects of floating and bottom cultivation techniques on seaweed growth, MPs contamination, and secondary metabolite content in Pramuka Island, Kepulauan Seribu National Park, Jakarta.

MATERIALS AND METHODS

Study area

Seaweed samples were from Lancang Island, Kepulauan Seribu National Park (KSNP), Jakarta, Indonesia (Figure 1). Samples preparation and MPs assessment were done at the Biology Department, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Indonesia.

Procedures

Sample origin

Seaweed samples (*E. cottonii*) (Figure 2) were purchased from a seaweed farmer. The samples were brought to the Biology Department, FMIPA, Universitas Indonesia, Indonesia, for a preliminary examination of MPs contamination.

Figure 2. Macroalga of the species *Eucheuma cottonii*

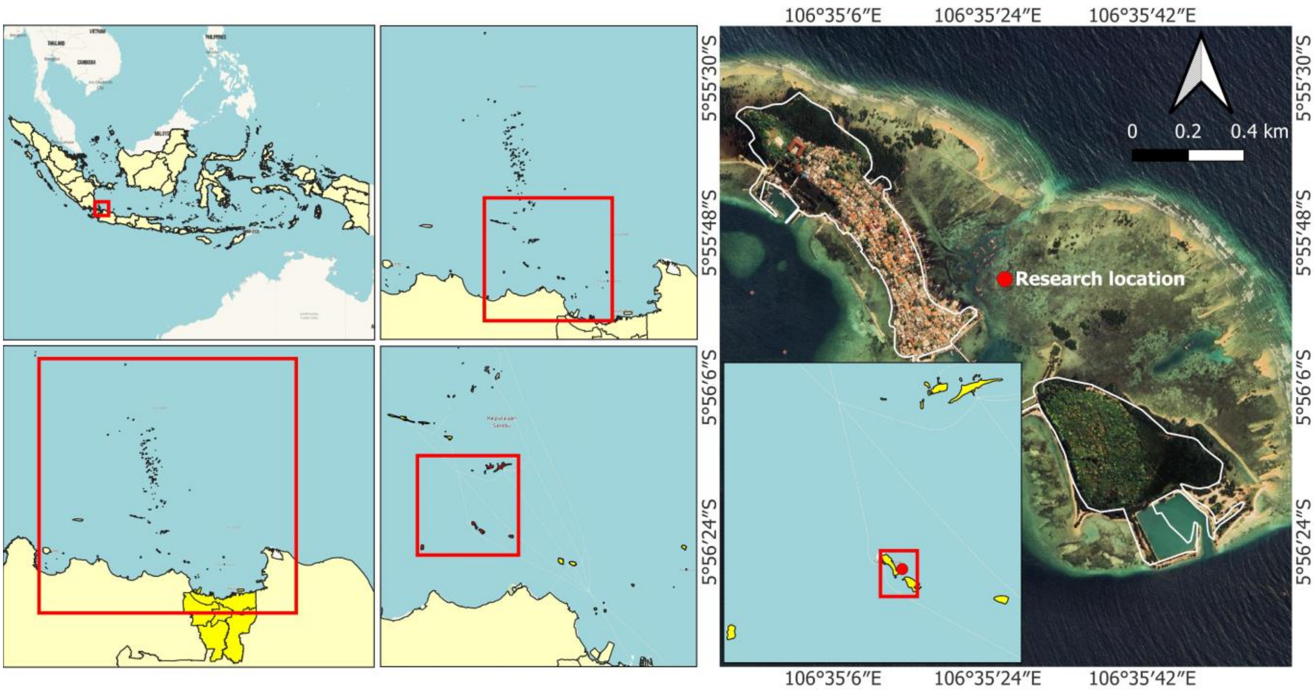

Figure 1. Original location of purchased seaweed samples in Lancang Island, Kepulauan Seribu National Park, Jakarta, Indonesia

Sample preparation, microplastic extraction, and examination

A volume of 200 mL of distilled water was added to a 500 mL beaker and then placed on a magnetic stirrer. A stir bar was gently placed into the beaker using forceps, and a 15 g sample of seaweed was added. The magnetic stirrer was switched on, and the stir bar was set to a speed of 3 on the magnetic stirrer scale for 15 minutes. After the allotted time, the stir bar and the seaweed sample were removed from the beaker, and the water was poured into a separating funnel for MP isolation using filter paper. In the final stage, the filter paper was examined under a stereomicroscope for microplastic detection, using a 10× magnification lens to observe the MPs on the filter paper (Patria et al. 2023). the extraction process and analysis were conducted in a controlled investigation room, with gloves and lab coats worn throughout to prevent airborne contamination. Once isolated and detected, the MPs were counted, photographed, and measured, and their shape and size recorded. A laboratory technician and another postgraduate student then double-checked and confirmed the findings.

Data analysis

The collected data, encompassing the quantity, color, size, and shape of MPs, were recorded and described qualitatively. Additionally, secondary data on MP content in macroalgae were gathered by searching relevant literature in Google Scholar using the keywords “microplastic,” “macroalgae,” and “*E. cottonii*.” All acquired data were then used for comparative analysis and further discussion.

RESULTS AND DISCUSSION

This study identified a blue, fibrous MP particle with an irregular shape, measuring 400 µm (Figure 3), in two samples of *E. cottonii*, each weighing 15g (wet weight). This discovery aligns with findings by Sari et al. (2021), Huang et al. (2023), Lima et al. (2024), and Purayil et al. (2024), marking the first documented occurrence of MP contamination in *E. cottonii*, both in Indonesia and globally.

This present research finding has directly aligned objectives and goals with Purayil et al. (2024), in their research, who has reported that fibrous MPs have become one of the most predominant contaminants in marine macroalgal populations. Additionally, in regards to fibrous MPs, Lima et al. (2024) in their study have also highlighted that blue fibers were the most investigated contaminant in various stranded marine macroalgae populations on estuarine beaches in Brazil. Blue is among the most ubiquitous and widespread MP colors found in marine environments (Rossi et al. 2024), notwithstanding certain transparent MPs being the most common type found in marine ecosystems. Various shades of blue have been detected in different macroalgae species (Seng et al. 2020; Esiukova et al. 2021; Li et al. 2022).

The results detected from this research has identified only fibrous MPs, which considerably defer from those of Patria et al. (2023), who reported in his study that fragment MPs as the most prevalent consisting of (34%), followed by fibrous MPs consisting of (31%) in *Caulerpa racemosa* (Forssk.) J.Agardh samples that were collected from Semak Daun Island, Kepulauan Seribu National Park, Jakarta. According to extensive research from Purayil et al. (2024), nevertheless, the most common shapes of microplastics that were found in targeted marine macroalgae are fibers wand consisting of (50%), followed by beads of (29%), while fragments and other forms each account for only 7%.

Rossi et al. (2024) have made a distinction between MPs, which encompass various types such as fragments, films, and pellets, and Microfibers (MFs), which were defined as thin, elongated MPs with a high length-to-width ratio of 3:1 to 5:1. Their report highlighted that MFs are the most common type found in the marine sediments of the Vesuvian Coast, Southern Italy. They also suggested that marine sediments not only serve as a reservoir for MPs but also act as a source, supplying MPs to various marine organisms due to turbulence encountered during waves or other physical factors of seawater in the marine ecosystem.

Studies and research have discovered and quantified the numerous interactions between MPs and marine macroalgae and seagrasses in different marine settings (Feng et al. 2020a,b; Huang et al. 2020). An example of Macroalgae species, *Ulva prolifera* O.F.Mull., has been detected as a prospective bio-trapper for MPs as a result of its adequate trapping capacity, indicating its appropriateness as a bio-organic material for the recovery of MP-polluted seawater (Gao et al. 2020). The prolific connection of MPs to macroalgae is influenced by certain factors such as chemical composition, texture, and as well as the presence of mucilage. For instance, Peller et al. (2021) have observed in their study that senescent *Cladophora* spp. of macroalgae, which has experienced chemical changes in their cell walls, in less interaction with MPs as paralleled to younger individuals. Nevertheless, further examination and analysis are necessary, as the withholding of MPs by macroalgae has greatly depended on their morphological and physiological features regarding the polymeric composition and shape of the MPs (Feng et al. 2020a; Cozzolino et al. 2022).

Figure 3. Microscopic image of the observed blue fibrous MPs (red arrow)

Vis-à-vis the observance capacity of macroalgae, MPs can still put forth toxic effects in a species-specific manner (Jung et al. 2023). Various research studies have highlighted that MPs can seriously hinder growth suppression and lead to a reduction of photosynthesis in certain macroalgal species in contaminated marine ecosystems. For example, declining factors include growth and Net Photosynthetic Rates (NPRs) in *Chondrus* sp. Moreover, *U. prolifera* significantly decreased when microalgae were exposed to higher concentrations of MPs (Feng et al. 2020a; Jung et al. 2023; Li et al. 2023). Similarly, polystyrene MPs inhibited photosynthetic oxygen evolution rates, increased Malondialdehyde (MDA) content, and reduction in Extracellular Polymeric Substance (EPS) levels in *Caulerpa lentillifera* J.Ag. and *Gracilaria tenuistipitata* C.F.Chang & B.M.Xia, 1976 (Feng et al. 2020a; Li et al. 2023). In *U. pertusa* and *Gigartina* sp., a dose-dependent reaction to MPs led to substantial rises in enzymatic antioxidant accomplishments and oxidative stress markers at concentrations of 50,000 MPs/mL (Post, 2021). Elevated levels of Reactive Oxygen Species (ROS) have also been investigated in *Chondrus* sp. when subjected to high levels of MPs (Jung et al. 2023). The interaction of MPs to the algal surface can lead to light blockage and impede the activity of photosynthetic reaction centers, acting against electron transfer rates (Jung et al. 2023). This interference can result in electron accumulation, increasing ROS production and the likelihood of oxidative stress in macroalgae. Advanced research study is required to address the current knowledge gap on the effects of MPs on macroalgae in marine ecosystems.

The prevalence of MPs in macroalgae has pursuit some researchers to predict that these primary producers act as traps for MPs (Huang et al. 2020; Seng et al. 2020), with the possibility of generating MPs within their biomass (de Smit et al. 2021). MPs interact with various forms of macroalgae in various environments, whether attached to substrates like rocky shores (Khosravi et al. 2022), floating in the water column, or stranded on beaches (Feng et al. 2020a). Nevertheless, macroalgae generate and assist in the transportation of MPs throughout various marine ecosystems and food webs (Saley et al. 2019; Feng et al. 2020a; Gao et al. 2020; Li et al. 2020). Macroalgae serve as habitat builders, i.e., rendering shelter and nutritional nourishment to various organisms in the marine ecosystem, including macrofauna and benthic megafauna, as well as terrestrial invertebrates, fish, and birds (Schlacher et al. 2017; Gallardo et al. 2021). Subsequently, contamination of macroalgae due to MPs could significantly impact the species that rely on them for habitat and food, including humans who consume these species as a food source (Feng et al. 2020b; Patria et al. 2023). According to Giri et al. (2024), MPs entering the human body may lead to a range of harmful health effects, including oxidative imbalance that disrupts cellular metabolism, inflammatory responses, immune toxicity, increased cancer risk, neurotoxic effects, gut microbiome imbalance, and disruptions in the reproductive system, among others. Furthermore, it is essential to actively monitor the presence of MPs, more especially in various macroalgae edible species.

This study, focused on detecting blue fiber Microplastic (MP) contamination in *E. cottonii*, represents the first documented occurrence of MP contamination in this species in Indonesia and globally. However, certain limitations should be acknowledged. The geographic scope was limited to samples from Lancang Island in Kepulauan Seribu National Park, which may not fully represent MP contamination levels in *E. cottonii* across other regions or cultivation sites. Moreover, while blue fiber MPs were identified, we did not analyze other types of MPs or investigate their chemical compositions and potential toxicities. Additionally, environmental factors such as water quality, pollution proximity, and specific cultivation methods were not thoroughly assessed. The study also did not explore the broader ecological impact of MP contamination on *E. cottonii* or its potential effects on organisms that consume it.

Future research should address these limitations by expanding the sampling range to include multiple regions and various cultivation environments, enabling a more comprehensive understanding of MP contamination in *E. cottonii* across Indonesia and beyond. More detailed MP analysis, covering diverse shapes, colors, chemical compositions, and toxicity, would provide further insight into contamination sources and risks. Additionally, studies on the impact of different cultivation techniques, such as floating versus bottom methods, could clarify their relationship to contamination levels. Ecotoxicological studies exploring MP effects on *E. cottonii* physiology and potential bioaccumulation in marine organisms consuming this macroalgae are also crucial for assessing ecological and food safety implications. Long-term monitoring of MPs in *E. cottonii* would help reveal trends and understand MP persistence and seasonal variations, enhancing our knowledge of the contamination's scope and impacts. Together, these future directions could yield a more holistic perspective on MP contamination and inform sustainable practices for *E. cottonii* cultivation and broader marine ecosystem health.

In conclusion, this research study represents the first ultimate recorded discovery of MP contamination in *E. cottonii* macroalgae, both in Indonesia and globally. The most common fibrous blue MPs observed aligns with findings from other studies, emphasizing broadly the extensive nature of fibrous MPs in marine environments. The results also highlight a contrast in MP types across different macroalgal species and locations, featuring the species-specific nature of MP interactions. MPs adhere to macroalgae based on various factors, including chemical composition, surface texture, and mucilage presence. While some macroalgae show latent as bio-trappers, MPs can still prevail toxic impacts on macroalgae, resulting to growth suppression, reduced photosynthesis, and increased oxidative stress. These effects emphasize the need for further investigation into the mechanisms of MP retention and the ecological impacts on macroalgae and associated marine species which leads to their loss of life. Given the role of macroalgae as habitat providers and food sources, monitoring MP contamination in edible species is very crucial to enhance protection to marine ecosystems and human health as a whole.

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