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Microplastic Bioaccumulation in *Corbicula* sp. and Water: Allometric Relationships and Spatial Variability in selected areas of Batticaloa Lagoon and Negombo Lagoon, Sri Lanka

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Abstract *Corbicula sp.* is a bivalve species with a widespread global distribution. Originally identified as freshwater cockles, these organisms have since expanded into brackish water environments. In Sri Lanka, *Corbicula sp.* predominantly inhabits brackish ecosystems, particularly those with dense mangrove coverage. This study was conducted in two distinct locations—Kappungoda in the Negombo Lagoon (NL) and Kattankudy in the Batticaloa Lagoon (BL)—both of which are subject to considerable anthropogenic influence. The primary objective was to assess and compare microplastic (MP) concentrations in water and *Corbicula sp.* tissue samples from these two lagoon systems. It was hypothesised that MP contamination levels would vary between the lagoons due to differing degrees of human activity. Sampling was carried out in January 2024, with 30 water samples and 30 cockle specimens collected along a 100 m line transect at each site. Standardised protocols were followed for MP extraction and analysis. Results showed that MP concentrations in *Corbicula sp.* tissues were 1.31 ± 0.23 items g^{-1} wet weight (WW) in BL and 2.47 ± 0.64 items g^{-1} WW in NL. Surface water MP concentrations were $3{,}250 \pm 579$ items m^{-3} in NL and $4{,}722 \pm 1{,}448$ items m^{-3} in BL. The recovered microplastics were predominantly fibres, fragments, and pellets, with colours including black, blue, red, orange, and white. Fibres were the most common form, and black was the most dominant colour across both sample types and sites. A statistically significant negative correlation was observed between tissue MP concentration and the wet weight of *Corbicula sp.* across both regions (BL: $r = -0.684$, $p < 0.05$; NL: $r = -0.717$, $p < 0.05$). We may conclude that there is no significant variation in MP concentration levels between *Cobicula* sp. and the lagoon waters along the two coastal lines. Furthermore, no correlation was observed between MP contamination in water and in clam tissue at the two sampling locations during the study period. However, smaller clams tended to show higher MP concentrations.

Keywords: Corbicula sp, Lagoon, Microplastic, Trophic transfer, Batticaloa, Negombo, Water

INTRODUCTION

Microplastics (MPs) are an emerging group of environmental contaminants of growing global concern (Jambeck *et al.*, 2015). Plastic particles less than 5 mm and greater than 1 µm in size are termed MPs. They can originate from a wide range of sources (Cole *et al.*, 2011; Eerkes-Medrano *et al.*, 2015). Regardless of their origin, whether primary or secondary, MPs ultimately accumulate in marine ecosystems, posing risks to aquatic life (Thathsarani *et al.*, 2023). The intertidal zone is one of the most dynamic regions of the marine environment, both physically and chemically (Arudpragassam, 1984). Regular tidal fluctuations lead to alternating periods of inundation and exposure, affecting salinity, pH, temperature, and other ecological parameters of the zone. These fluctuations, combined with exposure to both inland runoff and open ocean currents, make intertidal ecosystems particularly vulnerable to MP contamination (Cole *et al.*, 2011). Therefore, it is essential to assess MP prevalence in both biotic and abiotic components of these environments.

Lagoon ecosystems, in particular, are known for their high productivity and biodiversity. However, they are also subject to significant anthropogenic and geomorphological pressures (Specchiulli *et al*., 2023). Sri Lanka, a tropical island with rich coastal ecosystems, hosts lagoon environments that support extensive mangrove forests. Among these, the Batticaloa Lagoon (BL) on the eastern coast and the Negombo Lagoon (NL) on the southwestern coast are particularly significant, owing to their ecological value and the livelihoods they support (Wijeratne *et al*., 1992; Harris and Vinobaba, 2013). Batticaloa Lagoon, the third largest estuary in Sri Lanka, is located between 7°36′0″N and 81°41′0″E, bordered by Kalmunai to the south and Eravur to the north. In contrast, Negombo Lagoon lies between 7°08′60″N and 79°50′59.99″E and receives freshwater inputs primarily from the Dandugam Oya and Ja-Ela rivers (Dahanayaka and Wijeyaratne, 2006). While the NL is influenced by the Arabian Sea along the western coastline, the BL is affected by currents from the Bay of Bengal on the eastern coastline (Maduranga and Lewangamage, 2018). Both lagoons are connected to the Indian Ocean, rendering them susceptible to ocean-derived MP contamination, particularly during monsoon seasons.

Despite being situated in different coastal zones, these lagoons host overlapping species assemblages (Silva *et al*., 2013). Among the dominant macro-benthic invertebrates are clams, which play a vital ecological role by linking the water column with sediments (Dumbauld *et al*., 2009). These filter-feeding organisms contribute to nutrient cycling, support food webs, and provide a protein-rich food source for local communities. However, due to their non-selective feeding mechanisms, clams are highly susceptible to ingesting MPs, which can result in potential bioaccumulation (Su *et al*., 2018). In particular, burrowing bivalves such as clams are recognised as effective sentinel species for monitoring pollution (Boening, 1999). Their sedentary lifestyle, high filtration rates, and the ability to concentrate pollutants, including MPs, well above ambient environmental levels, make clams suitable indicators of ecosystem health (Jara-Marini *et al*., 2012). These species typically inhabit mangrove-rich areas, where sediments rich in organic matter, coupled with low pH and sufficient oxygen availability, support their physiological requirements.

The present study focuses on *Corbicula sp.*, a species initially classified as a freshwater clam but has become widespread in brackish water environments as a non-indigenous invasive organism (Sousa *et al*., 2008). Due to its global distribution and high abundance in both BL and NL, *Corbicula sp.* provides a valuable model for comparative pollution assessments across diverse geographic regions. Investigating the prevalence and bioavailability of MPs in edible, mangrove-associated clams has significant implications. Not only do these contaminants pose health risks to the clams themselves, but they may also threaten higher trophic levels, including humans. MPs can serve as vectors for toxic chemicals, which may leach into surrounding waters and even be absorbed by mangrove plants (Deng *et al*., 2021). Therefore, using *Corbicula sp.* as a bioindicator may provide early warnings of ecosystem degradation in mangrove-dominated environments.

This study investigates MPs contamination levels in Corbicula sp. and adjacent water samples collected from two clam burrowing sites within the Batticaloa Lagoon (BL) and Negombo Lagoon (NL). It is hypothesised that MP concentrations in both water and tissue samples will differ significantly between the two locations, which represent distinct eastern and western coastal lagoon environments in Sri Lanka. Furthermore, the study examines the relationship between MP concentrations and the whole wet weight (WW) of *Corbicula* sp. specimens, as well as the correlation between MP levels in cockle tissues and those detected in surrounding water samples. Thus, it aims to contribute to a broader understanding of the environmental toxicology of MPs. In contrast to previous studies that primarily focused on water or sediment, this research underscores the potential of clams to serve as sentinel species for monitoring ecosystem health in Sri Lanka's intertidal zones.

METHODOLOGY

Obtaining Ethical Approval and Research Permit

Ethical approval was obtained from the Institute of Biology (IOB), Sri Lanka (ERC IOBSL 259 01 2022) and a research permit was obtained from the Department of Wildlife Conservation (WL/3/2/28/22) before conducting the research.

Sampling sites

Kattankudy, located in the Batticaloa Lagoon, and Kapungoda, situated in the Negombo Lagoon, are the specific sampling locations for this study. Kattankudy is in close proximity to a municipal garbage dumping site. Kapungoda is noteworthy because it is near a large accumulation of trash, including significant amounts of macroplastics. These plastics have washed away from the mangrove areas and become trapped among the mangrove roots, disrupting the shallow water habitat. Various sources of pollution affect these sites, including inland runoff, river discharge, inflow of industrial waste, and tourist-related impacts. Figure 1 illustrates the two sampling locations within their respective lagoon environments.

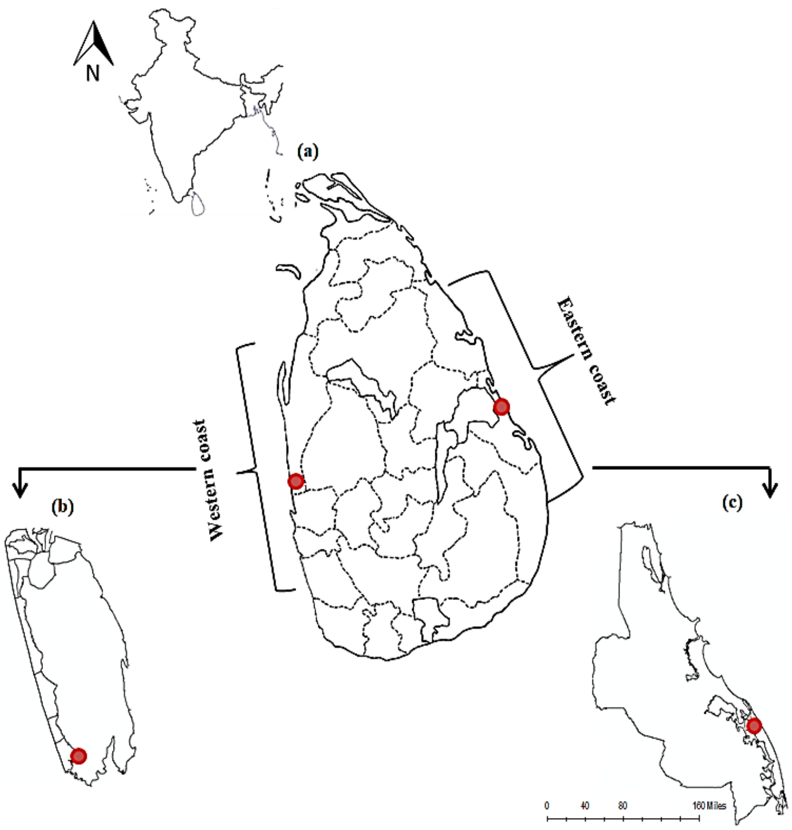

Fig 1. (a) Map of Sri Lanka representing the eastern and the western coast of the island, (b) Study site Kapungoda at Negombo Lagoon, Sri Lanka, (c) Study site at Kattankudy, Batticaloa Lagoon, Sri Lanka. The red dot indicates the specific sampling location. Source (The maps have been generated using ArcMap 10.4, the WGS 1984 coordinate system was employed, map ratios are (a)1:40,000, (b) and (c) 1:800,000).

Clam sampling

Corbicula sp. specimens (n = 30) were hand-picked along a 100 m line transect established parallel to the mangrove-associated lagoon banks at each of the two study sites: Kattankudy in the Batticaloa Lagoon and Kapungoda in the Negombo Lagoon, Sri Lanka. Sampling was conducted within 1 meter of the transect line, extending toward the centre of the lagoon. Fieldwork was carried out during the northeast monsoon period in January 2024, scheduled to coincide with the lowest low tide of the day to maximise accessibility. Collected clams were immediately wrapped in aluminium foil and transported in an ice box to maintain sample integrity. Upon arrival at the laboratory, all specimens were stored at –20 °C until further processing. Before analysis, samples were thawed for 1 hour at room temperature and subsequently rinsed with distilled water to remove any adhering debris. Each clam's shell was weighed, and its length was measured and recorded. Before dissecting the soft tissue, any residual water inside the shell was carefully drained. The soft tissue was then extracted using a clean knife on a disinfected surface, and the WW of each specimen was measured using a precision electric balance (AE ADAM, M 17250, Germany), accurate to two decimal places (Sathish *et al*., 2020).

Water sampling

Due to the typically low concentrations of MPs in aquatic environments, environmental sampling often requires large water volumes (bulk sampling) for reliable detection. In this study, approximately 50 L of surface water was filtered per sample using a plankton net with a mesh size of 300 µm (n = 30). Water was collected using a 5 L stainless steel bucket and gently poured into the plankton net from a location approximately 5 meters away from the lagoon bank, toward the centre of the lagoon. This method was employed to minimise disturbance to the bottom sediment, particularly in areas associated with *Corbicula sp.* burrowing activity. All water filtration procedures were conducted within an anchored sampling vessel to maintain stability and reduce the risk of external contamination. During each sampling cycle, the bucket was gently submerged to collect only surface water, avoiding contact with the lagoon floor. The filtered volume collected at the cod end of the plankton net was approximately 250 mL per sample. To prevent cross-contamination between samples, the plankton net was thoroughly rinsed with filtered distilled water between each sampling event. The collected water samples were immediately transferred into 250 mL screw-capped glass jars, labelled appropriately, and transported to the laboratory. The, samples were stored frozen at –20 °C until further analysis (Hidalgo-Ruz *et al*., 2012; Sathish *et al*., 2020).

Extraction and fractionation of microplastics in clam tissues

The dissected soft tissues were first examined under a dissection microscope to identify and manually remove any visibly detectable MPs. Subsequent extraction procedures were conducted following the protocols described by Li *et al* (2015) and Zhang and Wang (2020), with slight modifications. Excised tissues were digested using a 10% (w/v) potassium hydroxide (KOH) solutionat a volume three times that of the tissue. The samples were incubated at 40 °C for approximately 48 hours, until the solution became visibly clear, indicating effective digestion of organic material. The resulting solution was then filtered through cellulose nitrate filter paper (Whatmann 10410212, Germany; pore size: 0.45 µm; diameter: 47 mm). To further isolate MPs, the remaining residue was subjected to density separation using a saturated sodium chloride (NaCl) solution (1.2 g/mL). The mixture was stirred thoroughly and left to settle at room temperature overnight. The supernatant was then transferred to a density separator, and the beaker was rinsed multiple times with saturated NaCl to ensure the complete transfer of particles. The floating particles were collected and passed through a 0.45 µm pore-sized cellulose nitrate membrane filter using a vacuum filtration apparatus (47 mm, borosilicate glass; Analysis Instruments, Maharashtra, India). A positive control was included to validate the effectiveness of the density separation procedure. The resulting filter papers were carefully transferred into individual covered Petri dishes and left to dry at room temperature until further analysis.

Extraction and fractionation of microplastics in lagoon water samples

Microplastics were extracted from water samples following the procedures outlined by Masura *et al* (2015). Each sample was filtered directly through a stacked stainless steel sieve set comprising mesh sizes of 5 mm and 20 µm, thereby establishing a minimum MP cutoff size of 20 µm. Particles retained on the 5 mm sieve were examined, and recorded, while materials larger than 5 mm were discarded to align with the operational MP definition. The particulate matter retained on the 20 µm sieve was gently rinsed into a clean beaker using a squirt bottle filled with filtered distilled water. The beaker was then placed in a drying oven (Gallenkamph, Hotbox oven, Germany) set at 90 °C for 24 hours or until a constant dry weight was achieved. Once dried, the weight of the total residual material was recorded. While NOAA guidelines recommend gravimetric analysis, expressing MP concentrations as a function of MP count per unit mass of extracted MPs, this approach is less practical when only small quantities of MPs are recovered, particularly particles less than 1 mm in size. In such cases, MP mass is often negligible, and manual separation of extremely fine particles can introduce variability and error in gravimetric assessments.

To address these limitations, the present study introduces a refined interpretation approach for MP concentration. Rather than expressing MPs per unit mass of extracted synthetic material, we quantify the number of extracted MPs relative to the total mass of natural residue retained after wet sieving and drying. This method reflects the proportion of synthetic particles (MPs) within the total natural particulate matter collected from the water sample. It offers a more meaningful and practical representation of MP contamination, particularly in scenarios where MP counts are low and particle sizes are minute, enhancing both the accuracy and reproducibility of the results.

Units of measurement: items/g (Number of MPs in the sieved natural sample)

$$\text{Microplastic concentration} = \frac{\text{Number of microplastics in the sieved sample residue}}{\text{Dry mass of the sieved residue}} \times 100$$

$$\text{Microplastic percentage} = \frac{\text{Number of microplastics}}{\text{Mass of the natural samples}} \times 100$$

Wet Peroxidase Oxidation (WPO)

Wet peroxide oxidation (WPO) was performed on the oven-dried residues obtained from the water samples to remove natural organic matter and isolate MPs. The procedure followed the guidelines of Masura *et al* (2015) with slight modifications. Each dried sample was first treated with 20 mL of an aqueous 0.05 M iron(II) (Fe^{2+}) solution (lab-grade, Sigma-Aldrich, USA). Subsequently, 20 mL of 30% hydrogen peroxide (H_2O_2) solution (Euclid, India) was added. The mixture was allowed to react at room temperature for 5 minutes, then heated to 75 °C on a hot plate. Once bubbles appeared at the surface, indicating the decomposition of organic matter, the beaker was promptly removed from the hotplate and placed under a fume hood until bubbling ceased. The sample was then returned to the hotplate and reheated at 75 °C for an additional 30 minutes to facilitate further oxidation of residual organic material. If visible organic matter remained in the solution, an additional 20 mL of 30% H_2O_2 was added, and the heating cycle was repeated. This stepwise addition continued until the sample was free of visible organic material. All chemical preparations and reactions were performed under a laminar flow hood to minimise the risk of airborne MP contamination.

Density separation

Sodium chloride (NaCl) was used as the flotation medium for density separation because of its non-toxic and environmentally safe properties . A saturated NaCl solution with a density of 1.2 g cm^{-3} was prepared by dissolving 12 g of lab-grade NaCl (Euclid, India). The solution was heated to 75 °C to ensure complete dissolution of the salt. Following preparation, the solution was transferred into a density separator. The original beaker was thoroughly rinsed with additional saturated NaCl solution to ensure the complete transfer of all residual particles. This step was crucial for maintaining consistent solution density, thereby enhancing the efficiency of MP separation (Masura *et al*., 2015). The density separator was left undisturbed overnight to allow adequate settling of denser particles. Although Masura *et al* (2015) recommend discarding the settled solids, in this study, they were retained and subsequently examined under a microscope to check for the presence of MPs that may not have floated during the separation process. This additional step was taken to minimise the risk of underestimating MP concentrations during enumeration. The supernatant was then collected and filtered through a 0.45 µm pore-sized cellulose nitrate filter paper using vacuum filtration. A positive control was included throughout the density separation steps to validate the reliability of the procedures.

Visualisation and quantification of microplastics

The extracted MPs were examined and enumerated under the binocular dissecting microscope equipped with a camera at ×5, ×10 and ×40 magnification (Optika, Italy). The suspected particles were initially identified as MPs by conducting a hot needle test, and according to a visual guide of MPs as a reference key (Marine and Environmental Research Unit guide to visually identify microplastics; Hidalgo-Ruz *et al*., 2012). Identified MPs were classified by colour, form, and shape following the criteria of Hidalgo-Ruz *et al* (2012) and photographed and measured using the software Optika. Quantification of MPs was done visually, counting the total number of MPs extracted onto the filter paper under the stereomicroscope. The length of the identified MPs was measured with an ocular micrometre, respectively, as per the procedures of Hossain *et al* (2020).

Quality assurance and quality control

Glass laboratory equipment was used to meet the requirement of plastic-free laboratory equipment following the protocols of Masura *et al* (2015). Blank samples were run using tap and distilled water and other solutions, including the Fenton solution, alkaline digestion reagent and the saturated NaCl solutions for each batch of samples (n = 12). Glassware and laboratory equipment were washed with a concentrated detergent and rinsed in triplicate with filtered distilled water. The samples were immediately covered with aluminium foil when not in use and even during sample processing. At all times, personnel wore 100% cotton lab coats. Sample processing was done inside a laminar flow cabinet to avoid airborne contamination. Working surfaces were cleaned with ethanol prior to experimentation. Procedural blanks were run during the sample analysis to avoid secondary contamination. Positive controls were carried out with three polymer types: LDPE, PVC and PET. Fragment sizes ranging from 20 μm to 2500 μm were selected for testing.

RESULTS AND DISCUSSION

The present study elucidates the persistence and bioavailability of MPs and their associated allometric relationships in the edible bivalve *Corbicula sp.* [Figure 1 (a)] sampled from two ecologically distinct lagoon systems in Sri Lanka: Kapungoda at Negombo Lagoon on the western coastline and Kattankudy at Batticaloa Lagoon on the eastern coastline. The investigation primarily quantified the MP concentrations within soft tissues of *Corbicula sp.* and in adjacent surface water samples. Furthermore, the study assessed the correlation between tissue MP concentration and the organisms' whole WW, and also explored the relationship between ambient MP concentrations in the overlying water column and those bioaccumulated in the bivalves inhabiting respective burrowing zones. These findings offer critical insights into the trophic transfer potential and ecological implications of MP contamination in estuarine intertidal ecosystems, while underscoring the utility of *Corbicula sp.* as a sentinel species for monitoring MP pollution.

The mean MP concentration in *Corbicula* sp. tissue samples collected from Kattankudy was 1.31 ± 0.23 items/g, with a corresponding mean WW of 1.48 ± 0.24 g. In comparison, samples from Kapungoda exhibited a higher mean MP concentration of 2.47 ± 0.64 items/g, with a lower average tissue WW of 0.88 ± 0.09 g (Figure 2a). However, statistical analysis revealed that these differences were not significant between the two sites (Non-parametric t-test, Mann–Whitney U test, $p > 0.05$). To date, no published studies have specifically assessed MP contamination in the tissues of *Corbicula* sp. from the Batticaloa Lagoon, limiting direct comparisons with the current research. In contrast, data from Kapungoda Negombo Lagoon can be compared to findings by Thathsarani *et al* (2023), conducted by the same research group, which reported a considerably lower MP concentration (0.03 items/g) during the 2023 Southwestern monsoon season, with a mean tissue WW of 0.91 ± 0.09 g for the same species. Notably, the concentrations recorded in the present study, conducted during the Northeastern monsoon of 2024, were higher at both sites. These differences may be attributable to seasonal variability in MP contamination levels. However, the sampling duration and limited sample size in the present study were insufficient to robustly assess seasonal trends. However, the sampling duration and the limited sample size in the current study were insufficient to robustly assess seasonal trends. It is important to note that while the Negombo Lagoon typically experiences drier conditions during the Northeastern monsoon, the Batticaloa Lagoon receives higher rainfall during the same period (Jayawardena *et al*., 2005). Despite this variation in precipitation, MP concentrations in *Corbicula* sp. tissues did not differ significantly between the two distinct locations in the current study.

Owing to the lack of native studies on MP contamination in *Corbicula* sp., further comparisons are currently restricted to a limited number of non-native or unrelated studies. Pham *et al* (2024) reported that *Corbicula baudoni* collected from the Mekong River in Vietnam showed MP abundances of 15.8 ± 9.9 items/g wet weight (WW) in smaller individuals (with a mean length of 14 mm and weight of 1.1 g), and 18.2 ± 14.2 items/g WW in larger individuals (mean length: 21 mm; weight: 3.6 g). These values were notably higher than the concentrations recorded in the present study. In a separate investigation, Ditlhakanyane *et al* (2023) found that *Corbicula fluminea* from Bostwan Dam contained MPs ranging from 2.2 to 8.0 counts per site. However, meaningful comparison with their findings was not possible, as their results were expressed in a different unit of measurement. Such differences in MP concentrations may reflect species-specific traits, including feeding behaviour and physiology, as well as variation in individual size and the characteristics of the local environment in which the organisms were sampled. The characteristics of MPs identified in clam tissues in the present study varied across locations. In samples collected from Kattankudy, the majority of MPs (63%) fell within the size range of 6 µm to 17 µm. Black was the predominant colour (56%), followed by blue, red, orange, purple, and white. Morphologically, the majority of particles were classified as fibres (78%), as illustrated in Figure 4. In contrast, *Corbicula* sp. specimens from Kapungoda exhibited a dominant MP size class of 30 µm to 50 µm (67%). Fibre MPs were again prevalent (87%), with black particles representing the most common colour (42%), as shown in Figure 4. Despite the observed differences in particle size distributions between the two sites, the colour profiles of MPs in this study were consistent with those reported by Ditlhakanyane *et al* (2023) and Pham *et al* (2024). Characterising the colour, size, and type of MPs is important for tracing their potential sources, which often exhibit distinctive profiles. Additionally, colour can influence ingestion rates by marine organisms, as many species are attracted to specific colours that resemble their prey (Wright *et al*., 2013). Moreover, MP contamination in clam tissues may be influenced not only by direct ingestion from the water column but also by exposure to MPs present in surrounding habitat substrates, such as surface water and sediments (Huffman and Ringwood, 2021). This underscores the importance of concurrently evaluating MP concentrations and morphological characteristics across multiple environmental matrices to better understand their potential pathways and ecological impacts on benthic invertebrates within contaminated habitats.

Surface water MP concentrations recorded in the present study were 3,250 ± 578.99 items/m³ (0.69 ± 0.28 items/g) at Kapungoda and 4,722.22 ± 1,448.22 items/m³ (0.75 ± 0.48 items/g) at Kattankudy. Statistical analysis indicated no significant difference between the two sites (Mann–Whitney U test, $p > 0.05$), as illustrated in Figure 2(b). The maximum MP size observed in water samples from both locations was 4 mm, with black and blue emerging as the dominant colours. Figure 3 illustrates the extracted MPs from the environmental samples. The mean MP concentration recorded for Kapungoda aligns with the surface water MP values (3,200 ± 1,306.39 items/m³) previously reported by Thathsarani *et al* (2023). In contrast, Jahan *et al* (2023) reported a considerably higher surface water MP concentration at Kattankudy in the Batticaloa Lagoon, with values reaching 1,028.33 ± 73.73 items/L. These discrepancies indicate that the MP concentrations observed in the current study are lower than those reported by Jahan *et al* (2023) for the same region. Furthermore, Jahan *et al* (2023) noted that films were the predominant MP type in surface waters, with particles in the 2–4 mm range being most common. In comparison, the present study found fibres to be the dominant form in both sites, particularly in Kattankudy. The observed size classes were similar in both studies, although dominant colours differed. While Jahan *et al* (2023) identified white and black as the most prevalent MP colours, the present study reported black and blue as dominant. These variations could be attributed to differences in sampling time, sampling size, environmental conditions, or pollution sources influencing the composition and concentration of MPs in surface waters.

When evaluating surface water MP concentrations at Kapungoda, the levels observed in the present study were notably lower than those reported by Rathnayake *et al* (2025). According to their comprehensive study, MP concentrations in the Negombo Lagoon, particularly within macrophyte meadows, ranged from 24 to 42 items/L, indicating moderate levels of plastic pollution. Microplastics were consistently detected across multiple sampling sites, with particularly high concentrations observed in surface waters near mangrove habitats, which are known to support a diverse range of bivalve species. While much of the existing research has focused on MP contamination in commercially important lagoon fish and shellfish species, studies targeting burrowing bivalves such as *Corbicula* sp. remain limited. Therefore, the present investigation contributes to addressing this knowledge gap by providing data on surface water MP concentrations in a key habitat within the Negombo Lagoon, where *Corbicula* sp. is commonly found. These findings offer a baseline for future ecological assessments of MP exposure in benthic invertebrates inhabiting mangrove-associated burrowing zones.

Lagoon clams are filter-feeding, low-trophic-level bivalves that play a crucial role in maintaining ecosystem functionality through nutrient cycling and sediment stability (Dame and Kennish, 2012). However, both direct and indirect impacts of MP pollution on these burrowing bivalves have been increasingly recognised (Zhang *et al*., 2020). Their feeding strategy and benthic lifestyle make them particularly susceptible to MP bioaccumulation. Although MP contamination has been reported in numerous coastal bivalve species, the biological mechanisms underlying MP uptake and retention remain insufficiently understood. Among the factors believed to influence MP bioaccumulation in bivalves, shell size and tissue wet weight (WW) are considered important physiological parameters (Wu *et al*., 2022). Investigating these relationships is therefore critical for understanding the dynamics of MP accumulation in these organisms. In the present study, a statistically significant and strong negative correlation was observed between *Corbicula* sp. tissue MP concentrations and tissue WW in specimens collected from both the eastern and western coastal lagoons of Sri Lanka. Specifically, correlation coefficients were recorded as $r = -0.684$ (Non-parametric, Bivariate, Spearman correlation analysis, $p < 0.05$) for Batticaloa and $r = -0.717$ (Non-parametric, Bivariate, Spearman correlation analysis, $p < 0.05$) for Negombo (Figure 1(b)). These results suggest that smaller individuals with lower tissue WW tend to accumulate higher concentrations of MPs. As noted by Sathish *et al* (2020), this may be attributed to a higher surface area-to-volume ratio in smaller clams, potentially enhancing their susceptibility to MP ingestion and retention.In contrast to the findings of the present study, Pham *et al* (2024) reported a positive correlation between MP abundance and both the size and weight of *Corbicula* cockles. It is generally understood that as the surface area-to-volume ratio increases, so does the water filtration rate. Filtration efficiency in bivalves is jointly influenced by both species and size; however, size is often the more dominant factor. While species identity can govern physiological characteristics, it also strongly predicts size (Cohen, 2018). With respect to tissue WW, it has been noted that each unit of soft tissue has a relatively higher capacity for water filtration (Cohen, 2018). This relationship offers a key perspective for interpreting the results of the present study. Moreover, our study observed a negative correlation between tissue MP concentrations and WW across two distinct populations from Kapungoda and Kattankudy, from both the NL and BL. During analysis, specimens from the two locations were considered as separate clusters. Within each cluster, a strong inverse relationship between MP concentration and tissue WW was observed, suggesting that individuals with smaller tissue masses were more prone to MP accumulation. This finding supports the hypothesis that *Corbicula* sp. may exhibit increased MP ingestion and retention rates when tissue mass is reduced, possibly due to a higher surface area-to-volume ratio, enhancing their filtration activity. However, further empirical validation is required to confirm this pattern, particularly through testing correlations between tissue mass and MP size fractions using larger sample sizes. In Sri Lanka, *Corbicula* sp. typically inhabits brackish water zones near mangrove ecosystems (Fernando, 2018), and it is commonly harvested for human consumption. The presence of MPs in these cockles not only raises ecological concerns for lagoon environments but also poses a potential food safety risk, particularly for tourists and consumers who prefer to eat these cockles raw. It is therefore essential to understand MP exposure pathways in this species. Although both the water and clam tissues in the cockle-burrowing zones were found to be contaminated with MPs, the current study did not reveal a statistically significant correlation between MP concentrations in water and those in *Corbicula* sp. tissues. At Kapungoda, no correlation was detected

($p > 0.05$, $r = -0.003$), and similarly, no correlation was observed at Kattankudy ($p > 0.05$, $r = -0.12$), based on non-parametric Spearman bivariate correlation analysis. Thus, these results suggest that, at the time of sampling, surface water MP concentrations were not a direct predictor of MP accumulation in *Corbicula* sp. tissues. This may be partly due to the spatial mismatch between clam and water sampling locations. Thus, while water contaminated MPs may still represent a likely route of exposure, no direct relationship could be established within the limitations of this study.

However, it is important to consider the potential contribution of sediment-associated MPs to the bioaccumulation process, particularly given that *Corbicula* sp. are benthic, burrowing organisms. As noted by Su *et al* (2018), the abundance, size distribution, and colour profiles of MPs found in clam tissues often more closely resemble those present in sediments than those in the surrounding water column. This suggests that sediment may serve as a more direct source of MP exposure for these organisms. Accordingly, future research should aim to investigate the role of sediment-bound MPs in the bioaccumulation process. In addition, studies exploring the influence of trophic interactions and the potential for MP transfer through food webs are essential to understand the long-term ecological implications of MP contamination in estuarine and lagoonal environments in the long run.

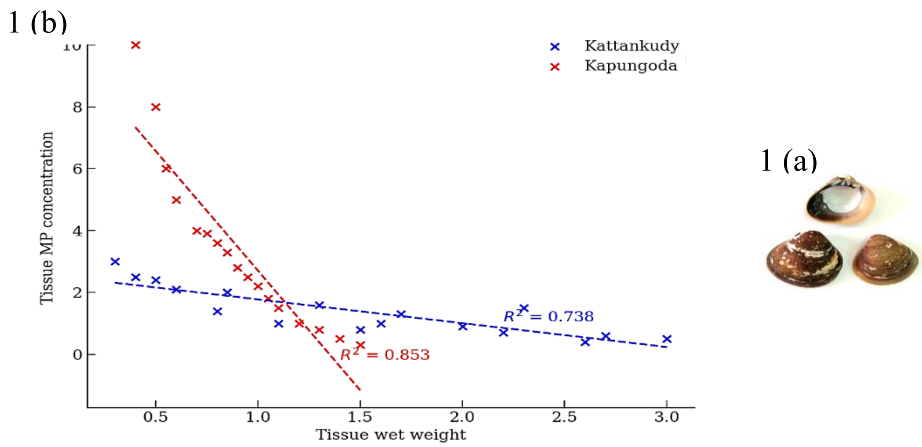

Fig 1. (a) *Corbicula* sp., (b) Correlations exist between the tissue wet weight to the tissue microplastic concentration of *Corbicula* sp. in Batticaloa Lagoon, (c) Correlations exist between the tissue wet weight to the tissue microplastic concentration of *Corbicula* sp. in Negombo Lagoon (r=-0.684, p<0.05 for Batticaloa clam, r=-0.717, p<0.05 for Negombo clam non-parametric bivariate, Spearman's correlation test).

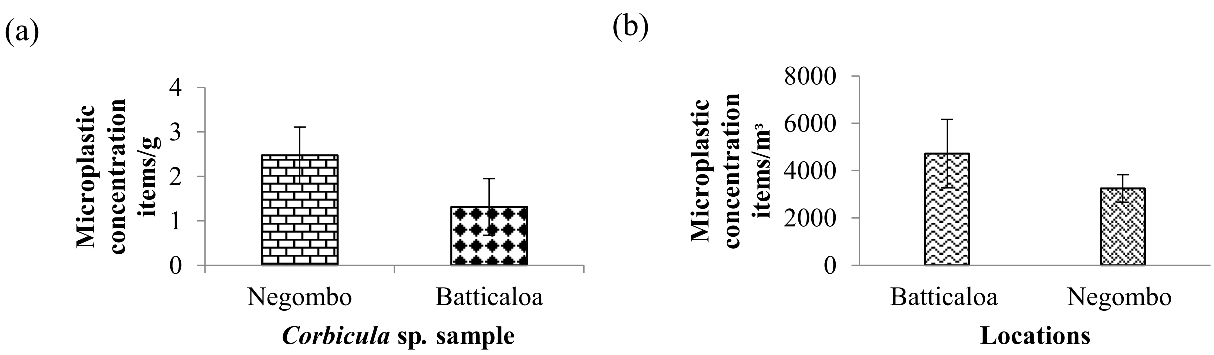

Fig 2. (a) Microplastic concentration in the tissue samples of *Corbicula* sp. in Negombo Lagoon samples and Batticaloa Lagoon samples. (b) Microplastic concentrations in the surface water samples where cockles were collected from Negombo Lagoon and the Batticaloa Lagoon. The Results were compared as Mean ± SEM, Mann-Whitney U test (p>0.05)

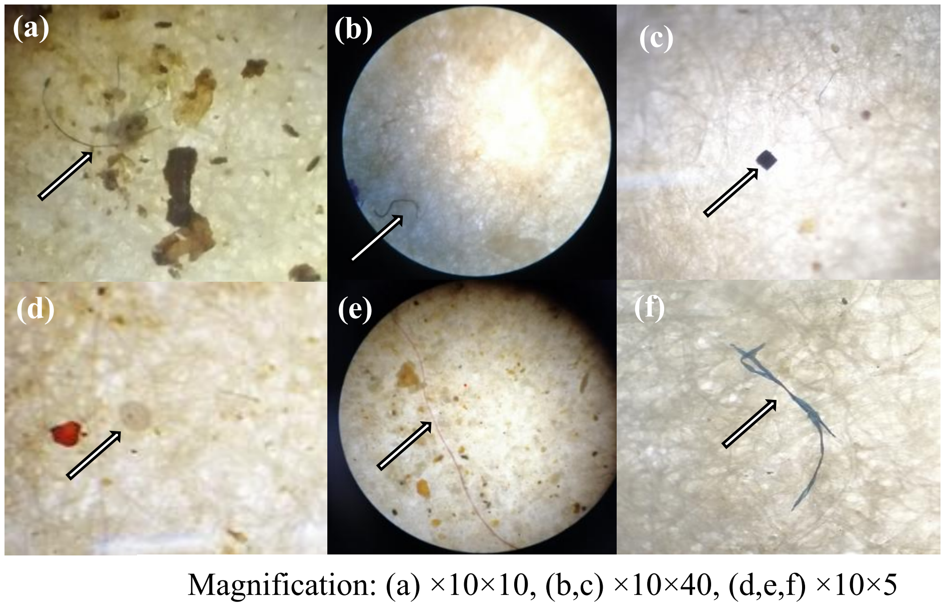

Fig 3. The extracted MPs from the tissue samples (a,b,c) and the surface water samples (d,e,f).

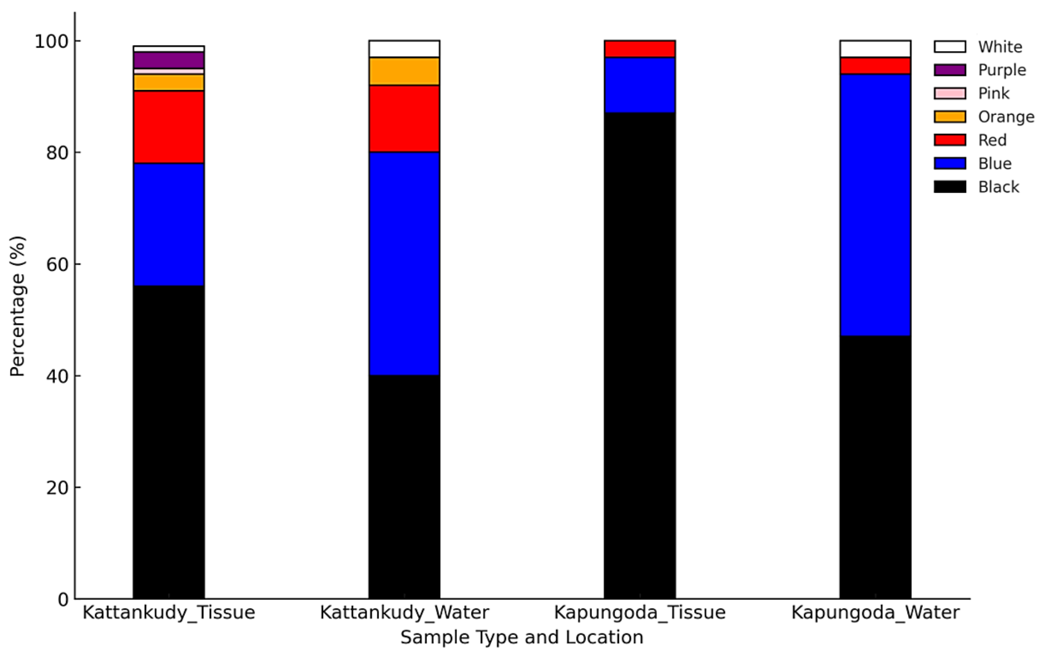

Fig 4. Colour-wise percentage of microplastics in tissues and water samples at Kattankudy at Batticaloa Lagoon and Kapungoda at Negombo Lagoon.

CONCLUSION

This study provides important insights into MP contamination in two distinct locations of ecologically significant lagoons in Sri Lanka: NL on the western coast and BL on the eastern coast. Water and *Corbicula* sp. tissue samples collected along 100 m transects in January 2024 were analysed for MPs. Despite their geographic and ecological differences, both lagoons exhibited similarly high levels of MP contamination, with no statistically significant difference in concentration between sites. Microplastics were identified in various forms, including fibres, fragments, and pellets, with black and blue being the most dominant colours in water. Black was the dominant colour of the tissue MPs. A significant negative correlation was found between MP concentration and wet tissue weight of *Corbicula* sp. across both locations, indicating that smaller clams, taken as a whole wet weight, tend to accumulate higher MP loads. However, no significant correlation was observed between MP concentrations in surface water and those in clam tissues, suggesting that factors beyond immediate water exposure, such as sediment-bound MPs or species-specific feeding behaviours, may play a critical role in bioaccumulation. These findings highlight the usage of *Corbicula* sp. as a sentinel species for monitoring MP pollution in mangrove-associated lagoon environments. Moreover, given the widespread human consumption of this species, particularly in coastal communities, the study underscores the need for food safety practices. It is recommended that clams, especially smaller individuals, be thoroughly washed and allowed to self-depurate in clean, filtered water before consumption to reduce the risk of MP ingestion. To further validate and characterise the nature of the MPs contaminants, future studies should incorporate polymer identification techniques such as Fourier-transform infrared spectroscopy (FTIR). This approach will provide a more comprehensive understanding of the sources, composition, and potential risks associated with MPs in these environments.

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