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Microplastics contamination in Coban Kethak and its flow

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Abstract. This study aims to identify the distribution and frequency of microplastics in the sediment and water of Coban Kethak, a water source in the Malang, Indonesia. Recreation, recreation with sanitary facilities, durian plantation, and paddy fields were the four sites from where samples were taken, and each represented a distinct set of human-caused features. Wet peroxide oxidation and density separation procedures were used to extract microplastics, which were seen and identified using stereomicroscopy. PCA and clustering were analyzed using PAST software to identify the main patterns of variation in microplastic density among locations. This study found that microplastics, all smaller than 3 μm in size, were found in four different shapes: fibers, pieces, films, and microbeads. Microplastic concentrations in sediment (84 particles/100g) and water (68 particles/50L) were highest at the recreational location and lowest in the paddy field region (0 microplastic in sediment sample and 44 particles/50L in water sample, respectively). According to principal component analysis and cluster analysis, the study shows that microplastic contamination is associated with human activities, with recreational areas being the most affected. According to these findings, further study and targeted solutions are needed to decrease microplastic contamination in freshwater ecosystems, especially in places with heavy human activity.

1 Introduction

Microplastics, plastics with a size of less than 5 mm [1], are pervasive contaminants that impact a wide range of ecosystems, including estuary habitats [2–4], rivers [5], lakes [6], soil [7], atmosphere [8], and even the Antarctic [9]. The persistence and ability of these particles, primarily formed by the biological, chemical, and physical degradation of meso- and macro-plastics [2], to transport hazardous substances make them a pressing environmental concern [10]. Several studies provide evidence of the harmful effects of microplastics on ecosystems and human health, such as changes in the intestinal microbiome [11], initiation of pulmonary diseases [12], and endocrine disruption [13], as they can infiltrate the food chain [14], emit dangerous chemicals, and persist in the environment for extended periods. The whole environmental effects and long-term ramifications for human health, especially their role in

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polluting water resources, are still mostly unknown despite rising awareness. Because of this ambiguity, additional study is required in this field.

Afterwards, a number of researchers have shifted their attention from coastal areas to studying microplastics in freshwater ecosystems, including lakes and rivers around the globe. But there needs to be more investigation because the results do not add up. Urbanization and industrialization, according to several research, are positively correlated with river microplastics [2, 4, 7]. One of the rivers that are frequently exposed to human activities, which can contribute to microplastic production, is Coban Kethak. Although there is a disturbing abundance of microplastics in rivers, the findings are equivocal, as various studies have failed to establish a clear causal association between human activities or land use patterns and microplastic contamination. To develop effective measures to limit the impact of microplastics, it is critical to have a thorough understanding of their sources, particularly in freshwater systems, where both urban and rural areas contribute significantly to this global issue. This study aimed to examine the microplastic shapes and distribution in the water and sediment of Coban Kethak, as well as its flow in relation to various anthropogenic activities.

2 Materials and methods

2.1 Locations

Coban Kethak is a water source and part of the Brantas River watershed in Malang, Indonesia. The study area is situated in a region characterized by a mix of ecosystems, with the river flowing through (1) recreation site, (2) recreation with sanitation facilities, (3) durian plantations, and (4) paddy fields. This watershed is influenced by various anthropogenic activities, making it an ideal location to investigate the impact of human activities on microplastic contamination.

Fig. 1. The locations of samples collected from Coban Kethak and its flow. The locations are surrounded by different anthropogenic activities, such as (1) recreation, (2) recreation with a sanitation facility, (3) agriculture, and (4) paddy field.

2.2 Water and sediment sampling

For the study, a ten-liter bucket was put into the surface water, and as much as 50 L water was filtered using a modified net with a mesh size of 50 µm. After sampling, twelve samples of filtrates from three replicates in each place were moved to glass containers and then taken to the lab to be analyzed further. However, samples of sediment, especially the top 5–10 cm of the surface, were taken using a stainless steel soil drill. There were three replications per site, each with a kilogram of sediment sample [4, 15, 16].

2.3 Microplastic extraction and observation

Microplastics were isolated from air-dried sediment samples using digestion (wet peroxide oxidation (WPO)) and density separation. The digesting method involves adding 50 mL of 30% hydrogen peroxide (H_2O_2) to 25 g of sediment in a glass beaker to remove organic particles. Following 20 minutes of 100 rpm agitation, the mix was heated at 60°C for 24 hours. Density separation tests in a saturated sodium chloride (NaCl) solution helped to gather microplastics. The supernatant was next vacuum-filtered using 45 µm Whatman filter paper and dried on a sterile, clean Petri dish. Water samples were subjected to sieve and density separation techniques; WPO pre-treatment helped to lower interference with organic contaminants. Mixing 50 mL of surface water samples from 50 L filtered water samples with 40 mL of 30% H_2O_2 and then swirling for 15 min at room temperature resulted in. The mixture was filtered using 45 µm Whatman filter paper and a vacuum pump, followed by adding saturated NaCl to the samples, swirling for 15 min, and letting it settle for 24 h. It was then dried and examined under a clear glass cover [4, 15, 17, 18]. The quantification of microplastics in sediment and water samples using a stereo microscope Olympus SZ61 (20×) was classified based on their shape: fibers, foams, microbeads, fragments, pellets, and film [3].

2.4 Data Analysis

Microsoft Excel 365 tallied, and IBM SPSS Statistics v.25 analyzed MPs data. The study compared MP abundances in water and sediment in different sites. The least significant difference method was used for post-hoc testing. Principal Component Analysis in PAST 4 was used to identify the main patterns of variation in microplastic density among locations.

3 Results and discussions

3.1 Shapes and abundance of microplastics in Coban Kethak

This study found four forms of microplastics identified in Coban Kethak's water and sediment, including fiber (Figures 2a and b), fragment, film (Figure 2c), and microbead. We suggested that the fiber came from clothing fibers, which were produced by human activities. Other studies suggest that fiber comes from monofilament fragmentation from fishing nets, ropes [19], and synthesis cloth [20]. Meanwhile, this study observed that the film type looked like it came from a plastic bag, and it supports a study conducted by Ismanto and Hinata. Low-density polyethylene (LDPE) includes chemical tank linings, general packaging plastics, gas and water pipes, beverage bottles, abandoned jars, mica maps, gallon flakes, rice packs, fast food packaging, and office garbage degraded into fragments [19–21]. The size of each microplastic observed in this study was < 3 um, which resulted from mechanical properties and the fabrication process [22].

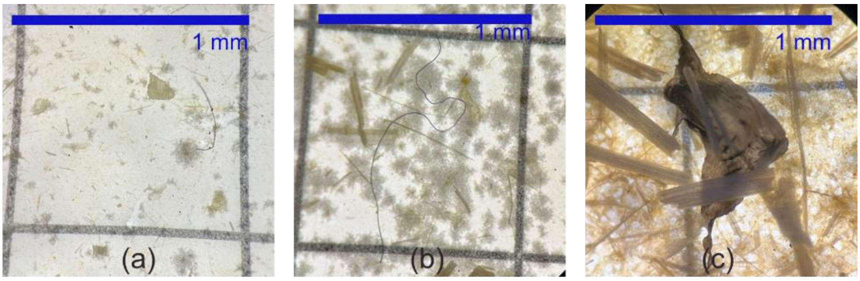
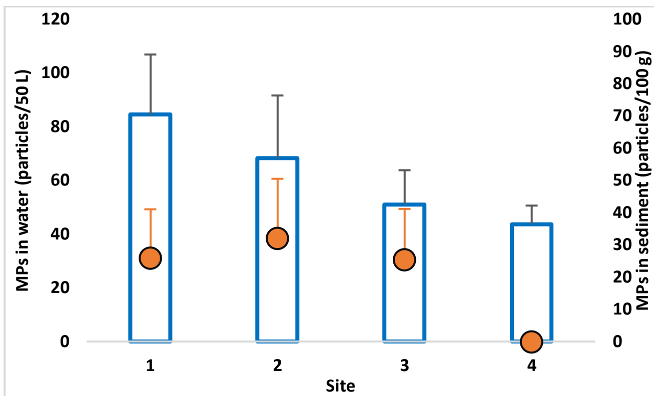
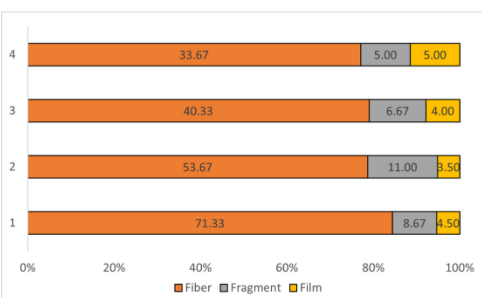


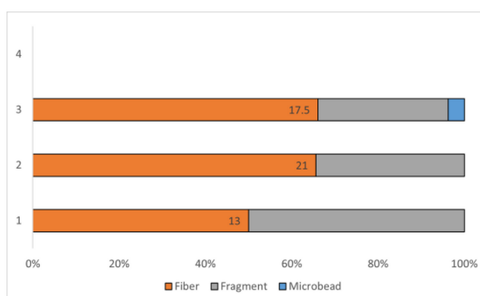
Fig. 2. There are several shapes of microplastics in water and sediment from Coban Kethak: (a & b) fiber and (c) fragment.



(a)



(b)



(c)

Fig. 3. Comparison of total abundance of microplastics in water and sediment among four locations (a), which is detailed as a percentage (b) for the water sample & (c) for the sediment sample.

The number of microplastics at four distinct locations: a recreational site (1), a recreational site with sanitation (2), a durian plantation (3), and paddy fields (4) varied (Figure 3a). Site 1 had the highest quantity of microplastics in sediment (84 particles per 100g) and in water (68 particles per 50L). This signifies that the recreational area is significantly polluted with microplastics, perhaps due to human actions such as littering and improper plastic waste disposal. Site 2 exhibited a marginally reduced concentration of microplastics in sediment (68 particles/100g) relative to Site 1, although it maintained a comparatively elevated concentration in water (34 particles/50L). Site 3 exhibited a diminished concentration of microplastics in soil (52 particles/100g) and in water (26 particles/50 L) relative to the initial two locations. Site 4 exhibited the lowest concentration of microplastics, with 44 particles/100g in sediment and 1 particle/50 L in water. This suggests that the paddy fields have a lower level of microplastic contamination than the other three locations.

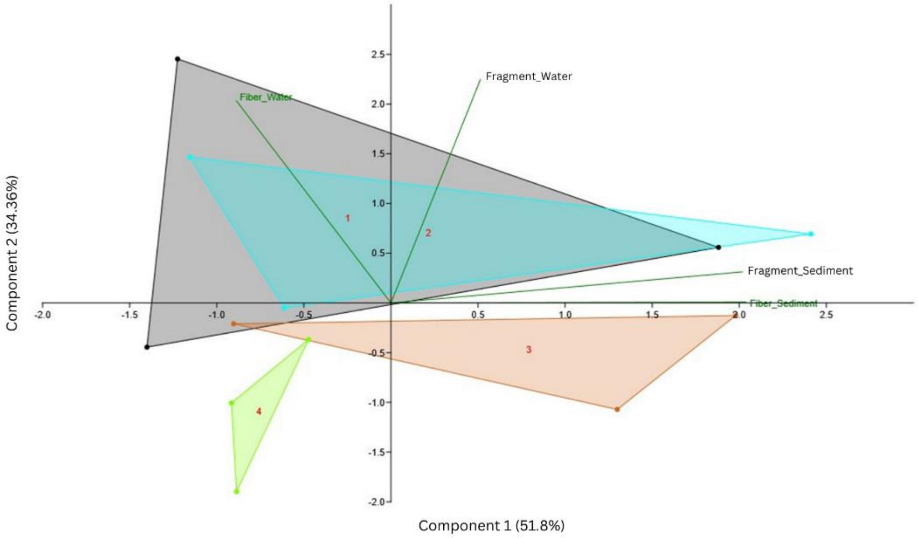
The different amounts of microplastic detected at the four sites and it provides vital information about the distribution and potential sources of these contaminants. The recreational and recreational sanitation sites (Sites 1 and 2) had greater amounts of microplastics in both sediment and water, highlighting the significant influence of human activities and probably inadequate waste management procedures in areas with intense anthropogenic activity. Several studies suggest that human activities and population have a significant impact on the amount of microplastic in aquatic ecosystems, including rivers, reservoirs, and lakes [23–25].

The agricultural locations, notably the durian plantation (Site 3) and paddy fields (Site 4), had lower levels of microplastic contamination than the other two sites. This trend might be explained by a reduction in direct human activity, the filtration of farming plants, or long-distance urban pollution sources. Farming practices, distance from urban pollution sources, and less human activity are some of the factors that affect microplastic pollution [26, 27], prompting concerns about the effects on soil health, crop productivity, and food safety [28]. The notably reduced levels in Site 4, particularly concerning water, prompt important inquiries regarding the potential filtration impacts of rice cultivation methods [29]. These findings underscore the complexity of microplastic pollution in various environments and highlight the necessity for targeted strategies to mitigate this widespread environmental concern.

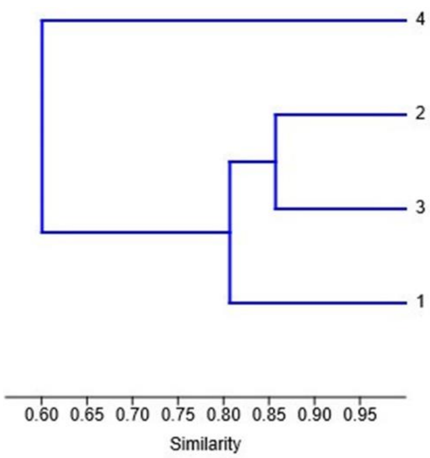
3.2 Unveiling microplastic pollution trends: cross-site comparisons

The PCA findings reveal that Site 4 exhibits a minimal concentration of microplastics (Figure 4a). Site 3 exhibits a comparatively elevated quantity of pieces in both sediment and water samples across two replicates. The findings indicate that regions with reduced human activity generally have diminished levels of microplastic pollution in their ecosystems.

A clustering study of microplastic abundance and shapes indicates that Sites 2 and 3 exhibit the greatest similarity, succeeded by Site 1. Site 4 is the most distinctive (Figure 4b). This clustering pattern offers insights regarding the distribution and attributes of microplastics across the study Sites. Research on microplastic pollution in Sagarmatha National Park, Nepal, revealed an average of 2.0 ± 1.7 microplastic particles per liter of water [30]. Significantly, places with elevated human activity had greater amounts of microplastics than upstream areas. This discovery corroborates the findings of the current investigation, strengthening the association between human activity and microplastic contamination. These findings underscore the significance of accounting for human activity levels when evaluating microplastic pollution across various habitats. They emphasize the necessity for focused conservation initiatives and pollution reduction techniques, especially in regions with greater human influence.



(a)



(b)

Fig. 4. Characteristic of each site (a) and clustering (b) of all sites based on abundance and types of microplastic.

4 Conclusion

The study found four types of microplastic in Coban Kethak's water and sediment: fiber, fragment, film, and microbead, across four sites with different human activity. Microplastic content was correlated with human presence, with recreational locations having the highest contamination and agricultural sites, especially paddy fields, the lowest. PCA and clustering analysis confirmed that human activities cause microplastic contamination. The report emphasizes the necessity for focused conservation and pollution reduction in high-impact locations. Future research should focus on long-term ecological effects, trash reduction, and public awareness of human impact on marine microplastic pollution.

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