

Monsoonal Variation in Atmospheric Microplastics over Bandaraya, Kuala Lumpur: Concentration, Morphology, and Color Analysis

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KEYWORDS	ABSTRACT
Atmospheric microplastics Monsoon Morphology Fiber Kuala Lumpur	Atmospheric microplastics (AMPs) are emerging airborne pollutants with growing implications for human health and environmental quality. This study examines the concentration, morphological features (shape and color), and seasonal variation of AMPs during the Northeast Monsoon (NEM) and Southwest Monsoon (SWM) in Bandaraya, Kuala Lumpur. Active air sampling was conducted using a high-volume air sampler fitted with quartz fibre filters over 12 weeks for each monsoon season. Samples were filtered and analyzed via a stereomicroscope and characterized by physical morphology. Results showed significantly higher AMP concentrations during NEM, with fibers being the dominant shape observed across both monsoon periods. The most common colors were blue, transparent, and red. Seasonal variation in AMP distribution suggests that meteorological factors associated with monsoon systems may influence airborne microplastic abundance and deposition. These findings contribute to the limited dataset on atmospheric MPs in tropical monsoonal climates and provide a foundation for further investigation into their sources and impacts.

1. INTRODUCTION

Microplastics (MPs), defined as plastic particles smaller than 5 mm, have been widely studied in various ecosystems, but their presence in the atmosphere as airborne microplastics (AMPs) is a growing concern due to potential inhalation risks. While research on AMPs is increasing globally, data from tropical regions, particularly Southeast Asia, are limited. The seasonal monsoon systems in Malaysia present a unique opportunity to explore how these meteorological changes affect AMP concentrations.

Recent studies have detected airborne MPs in several countries, including Seoul, Ningbo (Nafea et al., 2025) Bangkok (Dahal & Babel, 2025), São Paulo (Amato-Lourenço et al., 2022), and Chengdu, showing significant variability in concentration and morphology based on factors like urbanization and wind patterns. However, atmospheric MP research in Malaysia is still minimal.

This study aims to quantify the concentration, shapes, and colors of AMPs during both monsoonal periods to provide insights into seasonal atmospheric dynamics and pollution trends.

2. MATERIALS AND METHODS

The study was conducted in Kuala Lumpur, Malaysia, at 3.15°N latitude and 101.69°E longitude. This densely populated urban center has a tropical climate influenced by the Northeast Monsoon (November to March) and the Southwest Monsoon (May to September), each affecting airborne particle dynamics.

Atmospheric microplastics (MPs) were collected with a high-volume air sampler operating at 1.1 m³/min for 24 hours, with weekly sampling during both monsoon periods.

Samples were digested with 30% hydrogen peroxide to remove organic matter, then separated by density using zinc chloride and vacuum filtered through fiberglass paper. Microplastics were identified under a Leica stereomicroscope, counted, and categorized by shape and color.

To minimize contamination, all equipment was rinsed with filtered distilled water, and procedures were conducted under a laminar flow hood.

3. RESULT AND DISCUSSION

3.1 Concentration of AMPs

The concentration of atmospheric microplastics (AMPs) in Bandaraya, Kuala Lumpur, varied between the Northeast Monsoon (NEM) and the Southwest Monsoon (SWM). Mean concentrations were higher during the NEM (0.0213 ± 0.00364 count/m³) than in the SWM (0.0164 ± 0.00149 count/m³), with significant differences noted ($p < 0.05$).

The NEM is characterized by stronger winds and lower rainfall, which may enhance the suspension and transport of microplastics. Conversely, the SWM, with its heavier rainfall, likely promotes wet deposition and reduces airborne particles.

The concentration range found in this study (0.0164–0.0213 count/m³) is lower but comparable to levels in cities like Seoul (0.33–1.21 count/m³) and Bangkok (103–263 MP/m²/day deposition). These findings highlight the impact of climate and meteorology on AMP levels in urban environments.

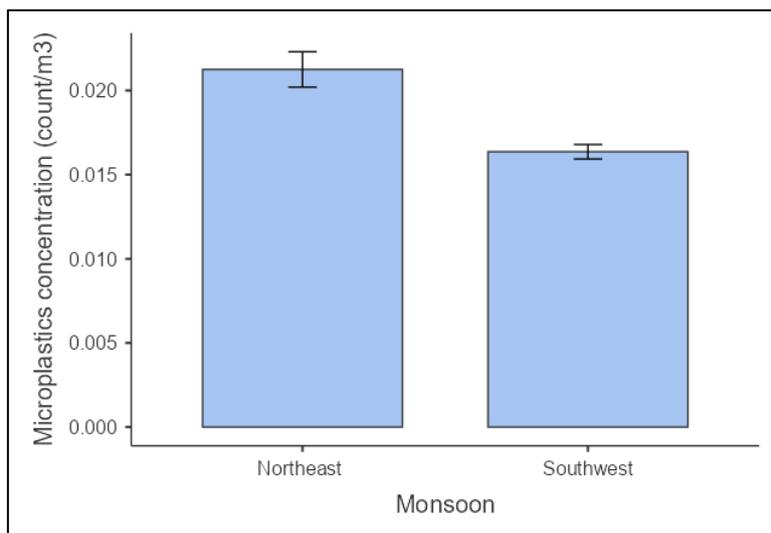


Figure 1. Atmospheric microplastics concentration during the Northeast and Southwest Monsoon.

3.2 Shape Distribution

The distribution of microplastic shapes varies between the Northeast and Southwest monsoon seasons (Figure 2). During the Northeast monsoon, fiber-shaped microplastics dominated at 96%, followed by film at 3% and fragments at 1%. This prevalence aligns with findings that fibers are commonly released from synthetic textiles via wastewater and atmospheric deposition, especially in urban areas like Kuala Lumpur.

In the Southwest monsoon, fibers remained dominant at 90%, but the proportion of film-shaped microplastics increased to 9%, while fragments stayed at 1%. This rise in films may result from increased surface runoff and urban discharge during the rainy season, which transports packaging materials into sediment environments. A Malaysian study found that monsoonal wind patterns significantly influence microplastic deposition, with higher fiber inputs during the Northeast monsoon and increased films during the Southwest monsoon (Hee et al., 2023).

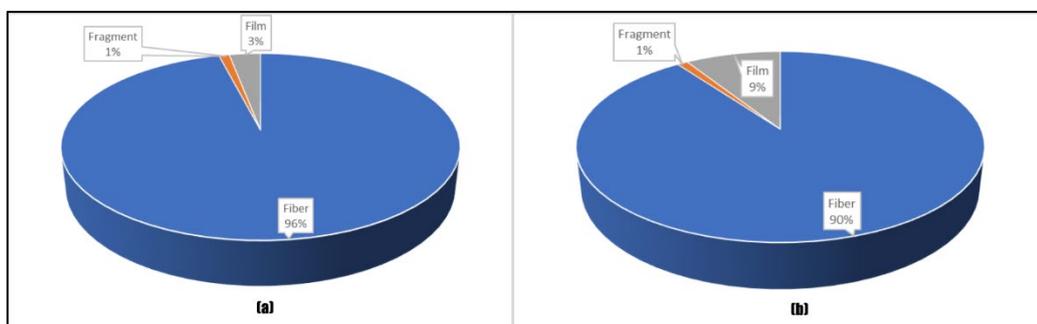


Figure 2. Shape distribution during (a) Northeast and (b) Southwest Monsoon.

3.3 Color Distribution

Atmospheric microplastic particles collected in Bandaraya, Kuala Lumpur, during the Northeast and Southwest Monsoon seasons exhibited significant variations in shape and color. Fibers were the most dominant shape, with Fiber Blue and Fiber Transparent leading in counts. In the Northeast Monsoon, Fiber Blue had the highest abundance (167 particles), followed by Fiber Transparent (101) and Fiber Red (45). Conversely, in the Southwest Monsoon, Fiber Transparent was most abundant (166), with Fiber Blue (92) and Fiber Red (13) following. Other shapes like films and fragments were found in minimal quantities.

This prevalence of fibrous microplastics aligns with previous research, which identified them as the most common type, primarily from synthetic textiles and urban dust (Klein et al., 2023; Shruti et al., 2022). Their lightweight nature allows them to remain airborne longer, enhancing atmospheric transport (Fox et al., 2024).

Monsoon influence appears to affect both the abundance and types of microplastics. The Northeast Monsoon, with stronger winds from the South China Sea, likely increases the transport of microplastics from coastal areas into the city, explaining the higher presence of blue fibers linked to marine pollution (Liu et al., 2023; Zhang et al., 2020). The Southwest Monsoon’s drier conditions may resuspend locally sourced microplastics, particularly transparent fibers from packaging and urban materials (Mandal et al., 2024).

Color analysis suggests blue and red fibers are associated with textiles, while transparent fibers and films likely originate from packaging (Mandal et al., 2024). The lower counts of colors like green and yellow may indicate less usage in urban products or higher degradation rates.

Meteorological factors, such as rainfall and wind speed, influence microplastic concentrations and deposition rates (Fox et al., 2024). The observed variations between monsoon seasons underscore the seasonal dynamics of atmospheric microplastic pollution in tropical cities like Kuala Lumpur.

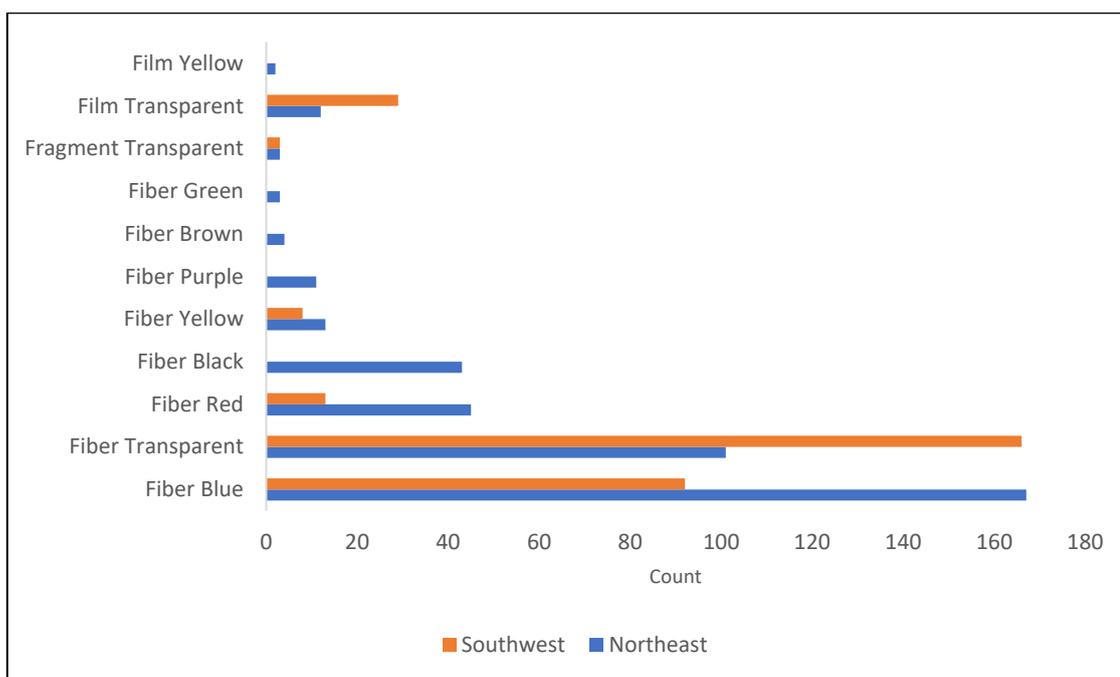


Figure 3. Shape and color distribution during Northeast and Southwest Monsoon.

4. CONCLUSION

This study reveals significant seasonal variation in atmospheric microplastic pollution over Kuala Lumpur, with fibers and dark-colored MPs dominating both monsoon seasons. The findings support the hypothesis that monsoonal meteorology influences AMP abundance and composition.

From this study, a concentration range was found (0.0164–0.0213 count/m³). Results showed significantly higher AMP concentrations during NEM, with fibers being the dominant shape observed across both monsoon periods. The most common colors were blue, transparent, and red.

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