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Assessment of microplastics in municipal solid waste landfill components in an Indian Urban city and its ecological impact

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Landfills act as major repositories for microplastics (MPs), an emerging contaminant that pose potential risks to humans and ecosystem. In lower-middle income countries like India, municipal solid waste (MSW) management rely heavily on non-sanitary landfills, devoid of waste segregation and recycling, resulting in 80% of direct plastic disposal. This is the first comprehensive study of MPs pollution in MSW landfill components (landfill soil, sludge, compost soil, and leachate), in order to understand the sources, occurrences, and potential ecological risk. Samples were collected for a year in 2024. Highest MPs count was observed in landfill soil, ranging from 600-7000 MPs/kg, thus serving as a hotspot of MPs for the surrounding atmosphere, marine and terrestrial ecosystems. On the other hand, treated leachate showed lower MPs (87 MPs/L) than raw leachate (187 MPs/L). The study revealed dominance of black and white colour MPs across all the samples. Fibre-shape accounted for 50% of MPs indicating major sources from synthetic textiles-derived materials and fishing nets. Compost soil and sludge exhibited high MPs concentration with dominance of smaller MPs sizes (<500 μm). This raises a concern and potential increase in ecological risk when incorporated into agricultural soils as fertilizer, as they may act as vector for organic pollutants. Further, fibres and smaller MPs are more frequently ingested by terrestrial and marine organisms. Polyethylene-based polymers were the most abundant polymer type. However, polystyrene was prevalent in the sludge, probably due to its higher density. The polymer hazard index indicates low risk/hazard level III for all landfill components, except landfill soil (medium risk/hazard level IV). The pollution load index (PLI) indicated low risk for all the sample type (PLI<10), with an overall PLI of 6.94. However, the potential ecological risk index indicated medium to high ecological risk across the samples. With MPs having high specific surface area and hydrophobicity, they facilitate transmission of various toxic pollutants from landfills including heavy metal, pesticides, ultimately threatening terrestrial and marine biota. Therefore, assessment of MPs is critical especially when landfill sites like this are located near socio-economically important river like Ganga, considered the lifeline for nearly 400 million people.