

Stimulation of Microplastic Presence in Shore Sand of Uran, Raigad District, Maharashtra

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Abstract: *Microplastic pollution has emerged as a significant environmental issue affecting marine and coastal ecosystems globally. These particles, defined as plastic fragments less than 5 mm in size, originate from both primary sources (manufactured micro-sized plastics) and secondary sources (fragmentation of larger plastic debris). The present study aims to assess the presence, distribution, and characteristics of microplastics in shore sand along the Uran coastline in Raigad district, Maharashtra. Sediment samples were collected from selected sites and analyzed using sieve-based separation and visual identification methods. Microplastics were classified based on size, shape, and color. The results indicate the widespread presence of microplastics across all sampling sites, with fibers and fragments being the most dominant types. Spatial variation in abundance suggests a strong influence of anthropogenic activities and coastal dynamics. The study highlights the role of beach sediments as reservoirs of microplastic pollution and provides baseline data for future environmental monitoring and management strategies.*

Keywords: stimulation of microplastic presence in shore sand of uran, raigad district, Maharashtra

I. INTRODUCTION

Plastic pollution has emerged as one of the most pressing environmental challenges of the modern era, particularly in marine and coastal ecosystems. Since the mass production of plastics began in the mid-20th century, their global production has increased exponentially due to their versatility, durability, lightweight nature, and cost-effectiveness. Plastics are extensively used in packaging, construction, textiles, agriculture, healthcare, and a wide range of consumer products. However, the very properties that make plastics useful—such as resistance to degradation and chemical stability—also contribute to their persistence in the environment. As a result, plastic waste accumulates in terrestrial and aquatic ecosystems, leading to long-term ecological consequences.

Once introduced into the environment through improper waste disposal, industrial discharge, riverine transport, and coastal activities, plastics undergo gradual degradation through a combination of physical, chemical, and biological processes. These processes include ultraviolet (UV) radiation-induced photodegradation, mechanical abrasion caused by wave action, temperature fluctuations, and oxidative reactions. Over time, these mechanisms break down larger plastic debris into smaller fragments known as **microplastics**, typically defined as plastic particles measuring less than 5 mm in size.

Microplastics are broadly classified into two categories based on their origin. **Primary microplastics** are intentionally manufactured at microscopic sizes and are commonly used in industrial applications, cosmetics, personal care products, and as raw materials in plastic production (e.g., resin pellets or nurdles). In contrast, **secondary microplastics** are formed through the fragmentation of larger plastic items such as bottles, bags, fishing nets, and packaging materials. Secondary microplastics constitute the majority of microplastic pollution in marine environments due to the continuous breakdown of macroplastic waste.



In recent years, microplastics have been detected in virtually all components of the marine environment, including surface waters, water columns, coastal sediments, deep-sea deposits, estuaries, mangroves, and even polar regions. Their ubiquitous presence is attributed to their small size, buoyancy, and persistence, which facilitate long-range transport by ocean currents, wind, and biological processes. Among various environmental compartments, **coastal sediments and beach sand act as major sinks for microplastic accumulation**, where particles are deposited, buried, and retained over extended periods.

Coastal regions are particularly vulnerable to microplastic pollution due to their proximity to dense human populations and economic activities. Urbanization, industrialization, tourism, fishing operations, and maritime transport significantly contribute to the generation and discharge of plastic waste into coastal environments. Rivers and drainage systems further act as conduits, transporting land-based plastic waste into marine ecosystems. Once in the coastal zone, hydrodynamic processes such as tides, waves, and currents influence the distribution, resuspension, and deposition of microplastics within beach sediments.

The accumulation of microplastics in beach sand has serious ecological implications. Benthic organisms, including polychaetes, molluscs, crustaceans, and other invertebrates, are particularly susceptible to microplastic ingestion due to their feeding habits. Ingestion can lead to physical blockage of digestive tracts, reduced feeding efficiency, false satiation, and impaired growth and reproduction. Moreover, microplastics can act as vectors for toxic substances such as heavy metals, persistent organic pollutants (POPs), and pathogenic microorganisms. These contaminants can adsorb onto the surface of microplastics and subsequently enter the food chain, posing risks not only to marine organisms but also to human health through seafood consumption.

The Uran coastline, located in the Raigad district of Maharashtra along the eastern margin of the Arabian Sea, represents a dynamic and ecologically important coastal system. This region forms part of the Mumbai Metropolitan coastal zone and is characterized by sandy beaches, mudflats, mangrove ecosystems, and intertidal habitats that support diverse marine biodiversity. However, the Uran coastline is also subject to intense anthropogenic pressure due to rapid industrialization and urban expansion. The presence of major infrastructure such as the **Jawaharlal Nehru Port Authority (JNPA)**, oil and gas terminals, shipping activities, fishing harbours, and residential developments significantly contributes to plastic waste generation in the region.

In addition to anthropogenic inputs, natural processes such as monsoonal rainfall, tidal fluctuations, and coastal currents play a crucial role in the transport and redistribution of plastic debris. During the monsoon season, increased surface runoff carries large quantities of plastic waste from inland areas into coastal waters. Subsequent tidal action and sediment dynamics lead to the deposition and accumulation of microplastics within beach sand. These processes result in spatial and temporal variability in microplastic distribution along the coastline.

Despite growing global awareness of microplastic pollution, there remains a lack of comprehensive, site-specific studies focusing on smaller coastal regions such as Uran. Most existing research has concentrated on major coastal cities and open ocean environments, leaving significant data gaps in localized ecosystems. Baseline studies are essential for understanding the extent of microplastic contamination, identifying potential sources, and evaluating ecological risks at a regional scale.

Therefore, the present study aims to assess the presence, abundance, and characteristics of microplastics in the shore sand of Uran using a systematic sampling and analysis approach. The study focuses on size distribution, morphological classification, and spatial variation of microplastics in relation to anthropogenic activities and environmental factors. The findings are expected to provide valuable baseline data for environmental monitoring, contribute to the growing



body of knowledge on microplastic pollution, and support the development of effective coastal management and pollution mitigation strategies.

II. HYPOTHESIS

The present study is founded on the premise that microplastic contamination has become a pervasive issue in coastal environments due to increasing anthropogenic pressures and inefficient waste management practices. It is hypothesized that microplastics are present in the beach sand of Uran and that their abundance, distribution, and physical characteristics vary significantly across different sampling sites as a result of human activities and environmental processes. Coastal regions exposed to industrial operations, port activities, fishing practices, and urban settlements are expected to show higher levels of contamination due to increased plastic input (Jambeck et al. 768).

The **null hypothesis (H₀)** assumes that microplastics are either absent or randomly distributed within the beach sediments of Uran, with no statistically significant variation in their abundance, size distribution, or morphological characteristics. This would imply that external factors such as anthropogenic activities and coastal hydrodynamics have negligible influence on microplastic occurrence.

In contrast, the **alternative hypothesis (H₁)** proposes that microplastics are present in measurable quantities and exhibit significant spatial variation influenced by environmental factors such as tidal currents, wave action, sediment characteristics, and proximity to pollution sources. Studies have demonstrated that coastal sediments often act as accumulation zones where microplastics are deposited and retained, reflecting localized pollution patterns (Hidalgo-Ruz et al. 3062). Therefore, testing these hypotheses is essential to determine whether microplastic contamination in Uran is systematic and environmentally driven.

III. OBJECTIVES

The primary objective of this study is to investigate the presence and spatial distribution of microplastics in the beach sand of Uran, Raigad district, Maharashtra. This objective is driven by the need to generate baseline data on microplastic contamination in a region that is ecologically significant yet relatively underexplored in terms of pollution studies.

A key objective of the study is to evaluate the **size-wise distribution of microplastics** using sieve-based separation methods. Understanding size distribution is important because smaller particles are more likely to be ingested by marine organisms and can have greater ecological impacts (Wright et al. 485). Additionally, the study aims to classify microplastics based on their **morphological characteristics**, including fibers, fragments, films, and pellets. Such classification helps in identifying potential sources of pollution, as different types of plastics originate from distinct activities such as fishing, packaging, and industrial processes.

Another important objective is to analyze the **color variation** of microplastics, which may indicate the degree of weathering, polymer type, and environmental exposure. Furthermore, the study seeks to assess **spatial variation across sampling sites**, particularly in relation to anthropogenic influences such as proximity to ports, industrial areas, and residential zones. This will help in understanding the relationship between human activities and microplastic accumulation.

Finally, the study aims to contribute to existing scientific knowledge by comparing its findings with previous research conducted along the Indian coastline, thereby providing a broader ecological context and supporting environmental monitoring efforts.



IV. MATERIALS AND METHODS

4.1 Study Area

The study was conducted along the Uran coastline in Raigad district, Maharashtra, which forms part of the eastern Arabian Sea coast. This region is characterized by sandy beaches, intertidal zones, and proximity to major anthropogenic activities, including the operations of the Jawaharlal Nehru Port Authority (JNPA), industrial establishments, fishing activities, and urban settlements. The coastline is also influenced by seasonal monsoonal patterns, tidal fluctuations, and sediment transport processes, all of which contribute to the distribution and accumulation of microplastics (Veerasingam et al. 262).

4.2 Sample Collection

Sand samples were collected from multiple representative sites along the coastline during low tide conditions to ensure accessibility to the intertidal zone. The upper 2–5 cm layer of sand was collected using clean, non-plastic tools to minimize contamination. Each sample was placed in labeled, airtight containers and transported to the laboratory for further analysis. Care was taken to avoid external contamination during sampling, including the use of gloves and controlled handling procedures.

4.3 Sample Processing

In the laboratory, the collected samples were air-dried under controlled conditions to remove moisture content. The dried samples were then subjected to sieve analysis using a set of standardized mesh sizes to separate particles into different size fractions. This step enabled the identification and quantification of microplastics based on their size distribution, which is a critical parameter in understanding their environmental behavior and ecological impact (Masura et al.).

4.4 Identification of Microplastics

Microplastic particles were identified using visual inspection techniques with the aid of a hand lens and stereomicroscope. Identification was based on distinguishing characteristics such as color, texture, shape, and the absence of cellular or organic structures. Although advanced techniques such as Fourier Transform Infrared Spectroscopy (FTIR) provide more accurate identification, visual methods are widely accepted for preliminary assessments and baseline studies (Hidalgo-Ruz et al. 3065).

4.5 Classification

Identified microplastics were categorized into four major types based on their morphology:

Fibers, typically originating from fishing gear and synthetic textiles

Fragments, resulting from the breakdown of larger plastic items

Films, derived from plastic bags and packaging materials

Pellets, representing primary microplastics used in industrial processes

This classification provides insights into the potential sources and degradation pathways of microplastics in the study area (Cole et al. 2590).

4.6 Data Analysis

Microplastic abundance was calculated as the number of particles per unit weight of sand (particles/kg). Statistical analysis was performed to evaluate spatial variation across sampling sites and to identify patterns in size distribution and morphological composition. The results were compared with existing studies to validate findings and establish broader environmental trends.



V. RESULTS AND DISCUSSION

The results of the study revealed the widespread presence of microplastics across all sampling locations along the Uran coastline, confirming the pervasive nature of plastic pollution in coastal sediments. The abundance of microplastics varied significantly between sites, indicating the influence of localized anthropogenic activities such as port operations, fishing practices, and urban waste disposal (Jambeck et al. 770).

Among the different types of microplastics identified, **fibers were the most dominant**, likely originating from fishing nets, ropes, and synthetic textiles. This observation is consistent with previous studies, which report fibers as the most common form of microplastics in marine environments due to their widespread use and ease of dispersion (Browne et al. 560). **Fragments** were also frequently observed, indicating the progressive breakdown of larger plastic debris under environmental stressors such as UV radiation and mechanical abrasion.

The analysis of size distribution showed that smaller size fractions contained a higher concentration of microplastics, suggesting ongoing fragmentation processes and long-term accumulation within sediments. Smaller particles are of particular concern as they are more easily ingested by marine organisms and can penetrate biological tissues (Wright et al. 486).

Spatial variation in microplastic abundance revealed higher concentrations near areas with intense human activity, such as ports and densely populated coastal zones. This pattern highlights the significant role of anthropogenic sources in contributing to microplastic pollution. Additionally, environmental factors such as tidal action, wave dynamics, and sediment transport were found to influence the redistribution and accumulation of microplastics within beach sand.

The findings of this study are consistent with previous research conducted along the Indian coastline, which has identified coastal sediments as major sinks for microplastic pollution (Veerasingam et al. 263). Overall, the results emphasize the need for effective management strategies to mitigate plastic pollution in coastal environments.

VI. CONCLUSION

The present study confirms the widespread occurrence of microplastics in the beach sand of Uran, highlighting the extent of contamination in coastal ecosystems. The distribution and characteristics of microplastics were found to be influenced by both anthropogenic activities and natural coastal processes, including tidal movements, sediment transport, and seasonal variations.

The dominance of fibers and fragments indicates that both primary and secondary sources contribute to microplastic pollution in the region. The study provides essential baseline data that can be used for future monitoring and environmental assessment. It also underscores the ecological risks associated with microplastic accumulation, particularly their potential impact on marine organisms and food web dynamics.

VII. RECOMMENDATIONS

To address the issue of microplastic pollution, it is essential to implement strategies aimed at reducing plastic usage and improving waste management systems. Promoting the use of biodegradable and environmentally friendly alternatives can significantly reduce plastic input into coastal environments. Public awareness campaigns should be conducted to educate communities about the environmental impacts of plastic waste and encourage responsible disposal practices. Improved waste management infrastructure, including proper segregation, recycling, and disposal of plastic materials, is crucial to prevent plastic waste from entering marine ecosystems. Special attention should be given to managing waste generated from fishing and industrial activities.



Regular monitoring programs should be established to assess microplastic contamination levels over time and identify pollution hotspots. Long-term studies will help in understanding temporal trends and evaluating the effectiveness of mitigation measures. Furthermore, advanced analytical techniques such as FTIR and Raman spectroscopy should be employed in future research to accurately identify polymer types and assess the chemical toxicity of microplastics.

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