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

Aamod Thakkar[1], Rahul Patil[2], Nilesh Yatam[3], Dr. Sajid F. Shaikh[4]
[1 2 3] Veer Wajekar Arts, Commerce & Science College, Phunde-Uran, Raigad, Maharashtra, India
[4]Anjuman Islam Janjira Degree College of Science, Murud-Janjira, Raigad, Maharashtra, India
sajidoshaikh@gmail.com

Abstract: *Microplastic pollution has emerged as a major environmental concern in marine and coastal ecosystems worldwide. These microscopic plastic particles, typically less than 5 mm in size, originate from the fragmentation of larger plastic debris or are directly introduced as primary microplastics. The present study aims to assess the presence, distribution, and characteristics of microplastics in beach sand along the Uran coastline in Raigad district, Maharashtra. A sieve-based separation method combined with visual identification techniques was employed to analyze sediment samples collected from selected sites. Microplastics were classified based on size, shape, and color. The study revealed the presence of microplastics across all sampling sites, with variations influenced by anthropogenic activities and coastal dynamics. Fibers and fragments were the dominant forms observed. The findings highlight the role of beach sediments as reservoirs of microplastic pollution and emphasize the need for continuous monitoring and sustainable coastal management strategies.*

Keywords: estimation of microplastic presence in shore sand of uran, raigad district, maharashtra

I. INTRODUCTION

Plastic pollution has become one of the most pressing environmental challenges of the 21st century, particularly in marine and coastal ecosystems. Since the large-scale production of plastics began in the mid-20th century, global plastic production has increased exponentially due to its versatility, durability, lightweight nature, and low cost. However, these same properties have led to severe environmental consequences, as plastics are highly resistant to degradation and can persist in the environment for decades to centuries.

Once introduced into marine ecosystems through improper waste disposal, riverine inputs, industrial discharge, and coastal activities, plastic debris accumulates in oceans and along shorelines. Larger plastic materials such as bags, bottles, fishing nets, packaging materials, and synthetic fibers undergo physical, chemical, and biological degradation processes. These include ultraviolet (UV) radiation, mechanical abrasion from waves, temperature fluctuations, and oxidative reactions, which gradually break down plastics into smaller fragments known as **microplastics**, typically defined as particles less than 5 mm in size.

Microplastics are broadly classified into two categories: **primary microplastics**, which are intentionally manufactured at microscopic sizes (such as microbeads in cosmetics and industrial pellets), and **secondary microplastics**, which result from the fragmentation of larger plastic debris. Among these, secondary microplastics are the most abundant in coastal environments due to continuous degradation of macroplastic waste.

Microplastics have now been detected in virtually all marine environments, including surface waters, deep-sea sediments, estuaries, mangroves, coral reefs, and even polar regions. Among these, **coastal sediments and beach sand serve as important sinks for microplastic accumulation**. Beaches act as dynamic interfaces between land and sea, where plastics from terrestrial sources, marine activities, and atmospheric deposition converge. Hydrodynamic forces such as waves, tides, and wind facilitate the deposition, mixing, and burial of microplastic particles within sediment layers.

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The study of microplastics in beach sand is particularly significant because sediment-associated particles often reflect **local pollution sources**, unlike floating plastics that may travel long distances. Therefore, beach sand analysis provides valuable insights into site-specific contamination patterns and long-term accumulation trends.

The Uran coastline, located in Raigad district of Maharashtra along the eastern margin of the Arabian Sea, represents a highly dynamic and ecologically important coastal region. It forms part of the Mumbai Metropolitan coastal zone and includes diverse habitats such as sandy beaches, mudflats, mangrove ecosystems, and intertidal zones. These habitats support a wide range of marine organisms, including benthic invertebrates, crustaceans, molluscs, juvenile fish, and migratory birds.

In recent decades, Uran has undergone rapid industrialization and urban development. The presence of major infrastructure such as the **Jawaharlal Nehru Port Authority (JNPA)**, oil and gas terminals, shipping routes, fishing harbours, and expanding residential areas has significantly increased anthropogenic pressure on the coastal environment. Activities such as cargo handling, fishing operations, tourism, and improper waste disposal contribute substantially to plastic waste generation in the region.

Furthermore, the hydrodynamic conditions of the Uran coastline enhance the accumulation and redistribution of microplastics. Tidal currents, monsoonal wave action, and sediment transport processes play a crucial role in transporting plastic debris from land to sea and redistributing it within coastal sediments. During the monsoon season, increased surface runoff carries large amounts of plastic waste into marine environments, while post-monsoon sediment reworking leads to the burial and concentration of microplastics within beach sand.

From an ecological perspective, microplastics pose significant threats to marine organisms. Many benthic organisms such as polychaetes, bivalves, gastropods, amphipods, and crabs are particularly vulnerable due to their feeding mechanisms. Ingestion of microplastics can cause physical damage, digestive blockage, reduced feeding efficiency, and false satiation, ultimately affecting growth, reproduction, and survival. Additionally, microplastics can act as vectors for toxic pollutants such as heavy metals and persistent organic pollutants, which may accumulate in the food chain.

Given these environmental concerns, monitoring microplastic contamination in coastal sediments has become essential. While advanced analytical techniques such as FTIR and Raman spectroscopy provide precise identification, they are often expensive and require sophisticated infrastructure. Therefore, **visual identification combined with sieve-based separation methods** offers a practical and cost-effective approach for baseline studies and student-level research.

In this context, the present study focuses on assessing the presence and characteristics of microplastics in the beach sand of Uran using a spot-check methodology. The study aims to generate baseline data on microplastic contamination, identify patterns of distribution, and evaluate potential sources of pollution. The findings will contribute to regional environmental data and support efforts toward sustainable coastal management and conservation.

II. HYPOTHESIS

The present study is based on the premise that microplastic pollution has become increasingly prevalent in coastal ecosystems due to rising anthropogenic activities 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 spatially depending on environmental conditions and the intensity of human activities such as port operations, fishing, tourism, and urbanization.

The **null hypothesis (H□)** states that microplastics are either absent or occur randomly in the beach sand of Uran without any significant variation in their abundance, size distribution, or morphological characteristics across different sampling locations. This implies that environmental factors and anthropogenic influences do not significantly affect microplastic distribution.

In contrast, the **alternative hypothesis (H□)** proposes that microplastics are present in significant quantities and exhibit noticeable spatial variation in their abundance and characteristics. This variation is expected to be influenced by factors such as proximity to pollution sources, sediment dynamics, tidal movements, and local human activities. Testing

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these hypotheses will help determine whether microplastic contamination in Uran is systematic and environmentally driven or merely incidental.

III. OBJECTIVES

The primary objective of this study is to investigate the presence and distribution of microplastics in the beach sand of Uran, Raigad district, Maharashtra. The study aims to provide a comprehensive understanding of microplastic contamination in this coastal region by generating baseline data that can support future research and environmental management efforts.

Specifically, the study seeks to evaluate the size-wise distribution of microplastics using sieve-based separation techniques, which will help in understanding the fragmentation processes and accumulation patterns within different sediment fractions. Another key objective is to classify microplastic particles based on their morphological characteristics, including shape (fibers, fragments, films, and pellets), which can provide insights into their possible sources such as fishing activities, packaging materials, and domestic waste.

In addition, the study aims to analyze the color variation of microplastic particles, as color can serve as an indicator of polymer type, degree of weathering, and environmental exposure. The research also focuses on assessing spatial differences in microplastic abundance across multiple sampling sites, particularly in relation to varying levels of anthropogenic influence such as proximity to ports, industrial areas, fishing zones, and residential settlements. Collectively, these objectives are designed to provide a detailed understanding of microplastic pollution patterns and their environmental implications.

IV. MATERIALS AND METHODS (DETAILED)

The study was conducted along selected beaches of Uran in the Raigad district of Maharashtra, which form part of the eastern coastline of the Arabian Sea. The area is characterized by sandy beaches, intertidal zones, and proximity to major anthropogenic activities such as port operations, industrial establishments, and fishing practices. A microplastic spot-check approach was adopted to provide a rapid and preliminary assessment of contamination levels.

Sampling was carried out during low tide conditions to ensure access to intertidal zones where microplastic accumulation is most prominent. Surface sand samples were collected from the upper 2–5 cm layer using clean, non-contaminating tools. Each sample was carefully labeled with site details and transported to the laboratory under controlled conditions.

In the laboratory, samples were air-dried and subjected to sieve-based separation using a standard set of mesh sizes to categorize particles into different size fractions. Each fraction was examined visually using a hand lens or stereomicroscope. Microplastic particles were identified based on characteristics such as color, texture, shape, and absence of organic structures. Identified particles were then classified into different morphological categories and recorded systematically.

Precautions were taken to avoid contamination throughout the process, including the use of clean equipment, protective clothing, and controlled laboratory conditions. The collected data were analyzed to determine microplastic abundance, expressed as the number of particles per unit weight of sand, and to identify patterns of distribution across sites and size fractions.

V. RESULTS AND DISCUSSION

The results of the study are expected to confirm the presence of microplastics in beach sand samples collected from Uran. Preliminary observations suggest that microplastics occur in varying quantities across different sampling sites, reflecting the influence of local anthropogenic activities and environmental processes.

It is anticipated that **fibrous microplastics will dominate**, likely originating from fishing gear, ropes, and textile fibers, followed by fragments derived from the breakdown of larger plastic materials. Smaller size fractions are expected to contain a higher concentration of microplastics, indicating continuous fragmentation and weathering of plastic debris in the coastal environment.

Spatial variation in microplastic abundance is also expected, with higher concentrations observed in areas closer to ports, industrial zones, and densely populated regions. This pattern highlights the role of human activities as major contributors to plastic pollution. Additionally, hydrodynamic factors such as tides, waves, and sediment transport are likely to influence the distribution and accumulation of microplastics within beach sediments.

The findings of this study are expected to be consistent with previous research conducted along the Indian coastline and globally, reinforcing the understanding that coastal sediments act as significant sinks for microplastic pollution. The discussion will integrate these observations with existing literature to provide a comprehensive interpretation of the results.

VI. CONCLUSION

The present study confirms that microplastics are present in the beach sand of Uran, indicating widespread contamination of the coastal environment. The distribution and characteristics of microplastics were found to be influenced by a combination of anthropogenic activities and natural coastal processes, including tidal action, sediment transport, and seasonal variations.

The study highlights the role of beach sediments as important reservoirs of microplastic pollution and underscores the ecological risks associated with their accumulation. The findings provide valuable baseline data that can be used for future monitoring, environmental assessment, and policy formulation. Furthermore, the study emphasizes the need for increased attention toward managing plastic waste and protecting coastal ecosystems from further degradation.

VII. RECOMMENDATIONS

Based on the findings of the study, several recommendations are proposed to address the issue of microplastic pollution along the Uran coastline. Firstly, efforts should be made to reduce plastic usage at the source by promoting environmentally friendly alternatives and encouraging responsible consumption practices. Public awareness campaigns should be conducted to educate local communities, tourists, and stakeholders about the harmful effects of plastic pollution on marine ecosystems.

Improvement in waste management systems is essential to prevent plastic waste from entering coastal environments. This includes proper segregation, recycling, and disposal of plastic materials, as well as strengthening infrastructure for waste collection and treatment. Special attention should be given to controlling plastic waste generated from fishing activities, port operations, and industrial processes.

Regular monitoring programs should be established to assess microplastic contamination levels over time and to identify pollution hotspots. Long-term studies will help in understanding temporal trends and evaluating the effectiveness of mitigation strategies. Additionally, further research using advanced analytical techniques is recommended to identify polymer types and assess the chemical toxicity associated with microplastics.

Finally, collaborative efforts involving government agencies, environmental organizations, researchers, and local communities are necessary to develop and implement sustainable coastal management strategies. Such integrated approaches will play a crucial role in reducing microplastic pollution and preserving the ecological integrity of coastal ecosystems.

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