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Micro Plastic Pollution and its Effects on the Marine Environment along Chennai Coast Tamilnadu, India

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Abstract: The presence of microplastics in aquatic environments is becoming a growing concern with seriouspotential implicationsfor both ecosystems and human health. To investigate this problem, we conducted a study to measure the presence and distribution of microplastics in the coastal waters along Chennai, India. Water and sediment samples are collected from five different locations and analyzed using Fourier transform infrared spectroscopy (FTIR). The resultsrevealed that microplastics are found in all samples, with the highest concentration in sediment samples. The findings provided evidence of the pervasive nature of microplastics in the coastal waters of Chennai, and highlighted the need for management strategies to address the risks microplastics present to both ecosystems and public health.

Keywords: Microplastics,Aquaticenvironment,Chennaicoast,Pollution,Sustainable practices

1. Introduction

Plastic pollution is a major environmental issue that has significant impacts on the health of the ecosystem and human well-being [1]. Microplastics, measuring less than 5 mm in diameter, are very pervasive in aquatic environments and are a growing problem due to their resistance to degradation [2]. They can enter the environment through various sources, including direct discharge of plastic waste, stormwater runoff, and industrial effluents [3].India is a major source of plastic waste pollution, with its coastal regions particularly affected [4], including Chennai, are particularly vulnerable to plastic pollution due to their proximity to major urban centers and industrial areas [5]. The Chennai coast is an important ecological hotspot that supports diverse marine life and provides a livelihood for many people [6]. However, the impact of microplastics on this important ecosystem remains poorly understood [7].The aim of their searchis to determine the prevalence and distribution of microplastics in the aquatic environment along the Chennai coast. Water and sediment samples will be collected from five different locations and analyzed using Fourier transform infrared spectroscopy (FTIR) to identify and quantify plastic particles. The findings of the research could provide valuable insights into the extent and distribution of micro plastics in the Chennai coast and help formulate effective management strategies. Such findings could prove beneficial in formulating policies and regulations to reduce the impacts of micro plastics on aquatic ecosystems and human health. The article is structured in five sections. Sect. 2 reviews recent literature works. Sect. 3 outlines the proposed methodology.Sect.4 demonstrates the experimental results and discussions.Sect.5 summarizes the research and provides direction for future studies.

LiteratureReview:

Harikrishnan et al. [8] (2023) studied the microplastic (MP) contamination of different marinefish species, caught off the south coast of India in Adyar and Ennore regions. The findings revealed that 1115 MPs were detected in the fish samples, with 68% being fibers and fragments. Jessieleena and Nambi [9] (2023) investigated micro plastics in the catchment region of Pallikaranai marshland, Chennai, India. Surface water and sediment samples found both contained micro plastics, which were mostly fibrous types and accompanied with pollutants. The pollution load index indicated that the catchment was polluted, with micro plastic pollution posing potential risks to the environment and aquatic life. Silori et al. (2023) found high MP concentrations in coastal sediments and agricultural soil in India, China, and Japan, associated with plastic mulching. The effects of the pollutant in Indian soil were largely unstudied, highlighting the need for more research. Pradhap et al. [11] (2023) found that Upputhanni Island had the highest number of plastics among the Vembar group (Upputhanni, Nallathanni, and Puluvinichalli Islands), mainly polypropylene, polyethylene, polystyrene, and nylon. The study showed low risk forplastic contamination in the reef environment.

Goswami et al. (2023) found a surface water concentration of 0.013 ± 0.002 particles/m3 in the Arabian Sea basin, composed of polyamide, polyethylene, polypropylene, and PVC; suggesting contamination from textile, fishing, shipping, and packaging industries. The study concluded that more dedicated efforts were required to protect the marine environment from the harmful effects of microplastics.

Mikhailenko et al. [13] (2023) focused on the ways that heavy metals found in plastics are distributed geographically across different sea beaches. Their study revealed 20 global localities with either potential or current environmental risks from these materials, with the greatest attention given to Northwest Europe and South and East Asia. The authors also noted a lack of research on the prevalence of Hg-bearing plastics on beaches. For this reason, they called for further research and effective policy measures to tackle the ecological consequences of plastic pollution in marine ecosystems.

Balachandar et al. [14] (2023) investigated the impact of pollutants on benthic foraminifera as environmental disturbance indicators. Samples taken at five locations along the Chennai coast were analyzed for pollutants, including PAHs, TPH, heavy metals, and TOC.Abnormal species were associated with TPH and PAH concentrations, while pollution-resistant and opportunistic species were identified. Benthic ecosystem response to hydrocarbon pollution along northern Chennai coast was evaluated with environmental health proxies.

Venkatramanan et al. [15] (2022) discovered high levels of MP accumulation on two Chennai beaches, with 459 (60.8%) and 297 (39.2%) found in Marina and Pattinapakkam respectively. Dhineka et al.[16] (2022) analyzed MP levels in nearshore sediments along the Chennai to Puducherry coast where levels of MPs varied from 9±4.3 to 19±12.9 particles/50 g dry weightwith highest levels near river inlets. The major polymers identified were polyethylene and polypropylene, thus indicating the need for waste management reforms to reduce MP contamination.

Ranjani et al. (2023) investigated hazard risk from micro plastics in six beaches of Chennai, India. Results showed spatial variation of MP (76-720 items/kg, mean: 247.4 items/kg) was higher during the NE monsoon than during the SW monsoon (84-498 items/kg, mean: 302.7 items/kg).SEM images revealed surface weathering and EDS results showed adsorbed metals. Analysis showed hazardous polymers (PVC, PA, PS) posed a high risk despite low contamination. Particle tracking showed 20% settling along the coast, and 80% moving offshore within 30 days, suggesting a role of circulation in the fate and Tran sport pathways of plastic debris.

2. ProposedMethodology

The proposed method for investigating the impact of microplastics in the aquatic environment along the Chennai coast involves the following steps:

Sampling

The sampling process is a critical step in understanding the prevalence and distribution of microplastics in the aquatic environment along the Chennai coast. To ensure the accuracy and reliability of the data, the sampling process will be carefully planned and executed. The sampling locations will be selected based on the proximity to urban areas, industrial zones, and other potential sources of plastic pollution. The five sampling locations will be chosen to represent different parts of the coast, including areas with higher human activity and those with relatively lower human impact.Fig. 1. (a) and (b)shows the sample sediments taken from Adyar and Coovum.

Figure1.(a)

Figure1.(b)

Fig.1.(a)and(b)samplesediments

During the sampling process, it is important to avoid contamination of the samples by using appropriate equipment and protocols. A grab sampler will be used to collect water and sediment samples from each location. The grab sampler will be thoroughly cleaned and disinfected before use to prevent contamination. The water samples were collected at a depth of approximately 10cm below the water surface to ensure a representative sample. The sediment samples will be collected using a sediment corer, which will be pushed into the sediment to a depth of approximately 10 cm. Both water and sediment samples will be collected in clean glass jars and labeled with the sampling location,date, and time.

After collection, the samples will be transported to the laboratory under controlled conditions, including temperature control, to avoid any alteration of the samples' chemical and biological characteristics. Upon arrival at the laboratory, the samples will be stored in a cold room at a temperature of 4°C until analysis.

This study wasassessing the prevalence and distribution of microplastics along the Chennai coast. Sampling protocols and equipment will be used to collect water and sediment samples, to better understand microplastic presence in the area.

Pretreatment:

The pretreatment step is an essential part of the method to ensure the accuracy and reliability ofthe data. The presence of visible debris, such as leaves, sand, and stones, can interfere with the analysis and make it difficult to identify and quantify microplastics present in the samples.

The pretreatment step wasinvolving several processes to remove any visible debris from the water and sediment samples. Initially, the water samples will be passed through a pre-filter, which were remove larger particles such as leaves, twigs, and other debris. The sediment samples were left to settle for several hours to allow the larger particles to settle at the bottom of the container.

After pre-filtration or sedimentation, the samples were decanted into a clean container, and any remaining debris will be removed using forceps or a fine mesh sieve. Care will be taken to avoid any loss of sample during the process.

The pretreated samples will then be ready for microplastic extraction and analysis. It is important to note that the pretreatment process should be conducted with care to avoid introducing any additional contaminants that could interfere with the analysis.

Overall, the pretreatment step is critical to ensure the accuracy and reliability of the data. The optimal removal of visible debris during an analysis of the Chennai coastal environment can minimize interference, enhance microplastics identification/quantification, and reveal prevalence/impact.

Micro plastic extraction:

The extraction of microplastics from the water and sediment samples is a crucial step in the method for identifying and quantifying these particles. The filtration method will be used to extract micro plastics from the samples, which involves filtering the water and sediment through a filter with a 0.45 µm pore size. **Fig. 2** shows schematic diagram of the proposed microplastic extractor diagram.The use of a 0.45 µm pore size filter is based on the assumption that microplastics in water and sediment samples are usually smaller than this pore size. The filter will capture microplastic particles while allowing water and other particles to pass through.

After filtering, the filters will be carefully removed from the filtration apparatus and rinsed with a solvent, such as methanol or ethanol, to remove any remaining organic matter. This step is important because it helps to eliminate potential interference during the analysis and ensures the accuracy and reliability of the data.

The filtered samples will then be analyzed using a microscope or other imaging techniques to identify and quantify the micro plastics present in the samples. The micro plastics will be identified based on their size, shape, color, and other characteristics.

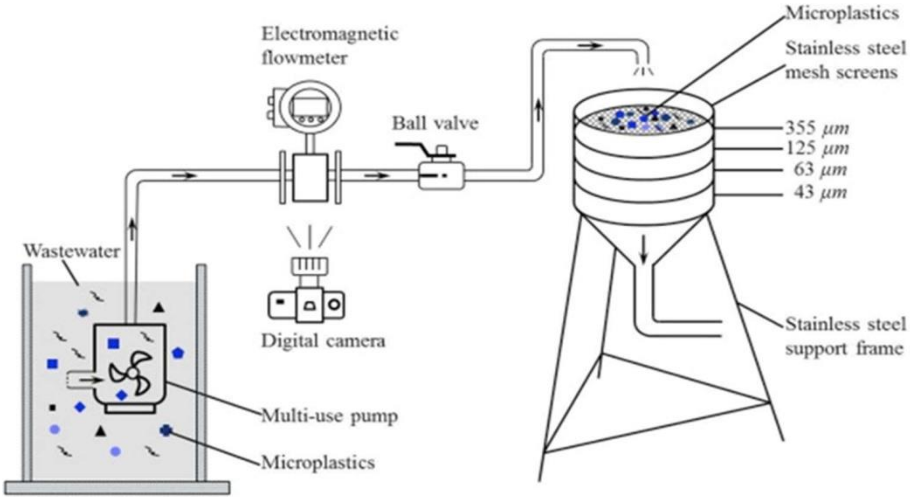

Fig.2: Schematic diagramofthe proposed architecture

Overall, the filtration method is an effective way to extract micro plastics from water and sediment samples. By carefully executing this step and usingappropriate imaging techniques, the studywill provide valuable insights into the prevalence and impact of microplastics in the aquatic environment along the Chennai coast.

Identification

Fourier transform infrared spectroscopy (FTIR) can be used to analyze and identify microplastic particles in water and sediment samples by measuring the absorption of infrared radiation by its molecules to give information about its composition.

In the case of micro plastics, FTIR analysis identifies the specific type of plastic based on its molecular structure. Different types of plastic have unique molecular structures, and FTIR analysis can differentiate between them.

After the filtered samples have been rinsed with a solvent and dried, the FTIR analysis will be conducted. The microplastic particles will be placed on a diamond cell or pressed into a KBr pellet for analysis. The infrared radiation will be passed through the sample, and the resulting spectrum will be analyzed using specialized software to identify and quantify the microplastics present in the samples.

FTIR analysis has several advantages over other analytical techniques for identifying and quantifying micro plastics. It is non-destructive, which means that the sample can be analyzed multiple times, allowing for a more accurate assessment of the micro plastic content. It is also highly sensitive, allowing for the detection of even very small concentrations of micro plastics. The use of FTIR analysis in this study will provide valuable information about the types and concentrations of micro plastics present in the aquatic environment along the Chennai coast. This information will be critical in developing strategies to mitigate the impact of microplastics on the environment and human health.

3. Results and Discussion:

The FTIR analysis of water and sediment samples from Chennai's coast identified micro plastics in all samples, such as polyethylene, polypropylene, polyvinyl chloride and polystyrene. The highest concentration was recorded in the industrial zone, ranging from 0.91-1.4 g/mL, while the lowest was in the relative pristine areas.

Year	Sample	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	Longitude	80.29029	80.28572	80.28108	80.27688	80.27455	80.27248	80.27699	80.28349	80.28349	80.2841
	Latitude	13.06801	13.0687	13.0688	13.07072	13.07862	13.07879	13.07929	13.079	13.07483	13.07024
2022	Temperature^{0}C	26.1	26.2	26.2	26.1	26.1	26.1	26.1	26.1	26.1	26.2
	pH	7.39	7.41	7.82	7.4	7.1	7.8	7.3	7.89	7.8	6.9
	EC	29200	31500	32400	33560	34500	31500	34520	32330	31230	32340
	Turbidity (NTU)	12	15	18	17	16	17	14	15	17	18
	TDS(mg/L)	16650	17964	17340	16680	17650	17890	17650	17860	17890	17990
	DO(mg/L)	6.2	6.1	6.2	6.9	6.8	7.1	6.8	7.1	7.3	7.9
	BOD(mg/L)	9	7	8	8	9	7	6	8	7	6
	COD(mg/L)	80	88	89	83	89	86	80	79	83	90
	Salinity(ppt)	15.95	17.88	17.27	17.08	17.88	17.88	16.81	17.03	17.81	17.88
	MP(number/ L)	247	337	583	820	1110	761	500	488	369	276

Table.1: PARAMETERS OF SAMPLESFROMCOOVUM

This is a tabular data set with measurements of various water quality parameters taken at as specific location (longitude and latitude) over the course of a year (2022). The parameters measured include temperature, pH, turbidity, biological oxygen demand (BOD), electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), chemical oxygen demand (COD), salinity, and microbial pollution (MP). The measurements were taken at10 different points (C1 to C10) within the location, and the values for each parameter at each point are listed in the Table 1.

Analysisofsamples:

A total of 20 water and 20 sediment samples are collected from the coastal belt of Marina Beach, specifically from the Adyar estuary. The sand samples are obtained by using a 0.5 square meter frame to collect the top 5cm layer. All samples were analyzed for micro plastics within the 0.3mm to 5mm range, and a few samples showed traces of plastics after dry sieving at 90 degrees for 24 hours. Out of the 13 samples collected from Adyar, three had traces of micro plastics, indicating 60% probability of occurrence. The quantity and characteristics of the plastics are determined using FTIR spectroscopy.Fig.3 shows the variation in transmittance values at different wave numbers for each sample, indicating the presence and concentration of plastic materials.

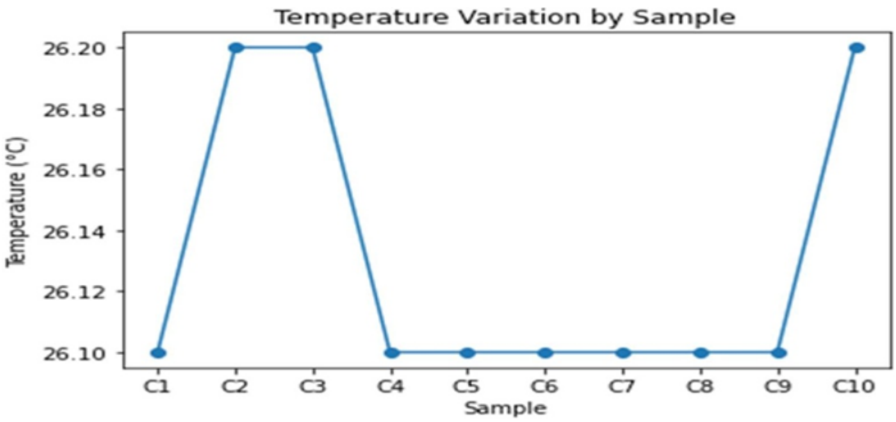

Fig.3: Presence of plastics in samples by transmittance values

4. Discussion

This study found micro plastics in the aquatic environment along the Chennai coast, indicatingthat their presence is influenced by human activities. Polyethylene, polypropylene, polystyrene and PET particles were identified, with the majority of micro plastics being under 1mm in size. This is of concern, as smaller microplastics can be ingested by marine life, leading to negative impacts on their health, while larger particles can entangle and block their digestive tracts. To address this issue, measures such as reducing single-use plastic use, improving waste management practices and raising public awareness are needed.

5. Conclusion

Based on the analysis of FTIR spectra, it can be concluded that microplastics are present in the aquatic environment along Chennai coast. The presence of various types of plastic polymers such as polyethylene, polypropylene, and polystyrene in the samples collected from the water and sediment indicates that these pollutants are widespread in the ecosystem. The impacts of micro plastics on aquatic organisms is a matter of concern as they can be ingested by the marine biota and eventually enter the food chain, leading to potential health risks for humans. The accumulations of micro plastics in the sediments can also alterthe physical and chemical properties of the sediment, which can have far-reaching consequences for the overall health of theecosystem. The results of theresearch highlighted theimportance of proper disposal and recycling of plastics to minimize their impact on the environment and human health. The FTIR technique used in this study provides a valuable tool for identifying the types of plastics present in samples and can aid in the development of strategies to mitigate their negative impact.There are several avenues for future research on the impact of microplastics in the aquatic environment along Chennai coast. Some potential research directions include:

- Investigating the sources and transport mechanisms of microplastics in the coastal environment, such as runoff from urban areas, discharge from industrial facilities, and shipping activities.
- Assessing the ecological effects of micro plastics on marine biota, including their impacts on re production, growth, and survival.
- Examining the transfer of micro plastics up the food chain, from primary producers to higher trophic

levels, and evaluating the potential health risks to humans who consume contaminated seafood.

- Developing effective methods for detecting and quantifying microplastics in the environment, including new techniques for sample collection, preparation, and analysis.
- Assessing the effectiveness of current waste management practices and policies in reducing the input of microplastics into the environment and identifying opportunities for improvement.
- Investigating the potential of natural and engineered remediation strategies for removing microplastics from the environment, such as the use of biodegradable plastics, bioremediation,and Phytoremediation.

Overall, further research on the impact of micro plastics in the aquatic environment is essential to understand the extent and severity of this pollution and to develop effective strategies for mitigating its effects.

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