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A Study of Microplastic Detection in Local Water Sources in the Marathwada Region

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Abstract

Microplastic contamination has emerged as a critical environmental and public health issue worldwide, affecting freshwater, marine ecosystems, soil, and even atmospheric systems. In recent years, regions with rapid urbanization and inadequate waste management have become particularly vulnerable to plastic debris accumulation. This study investigates the presence, distribution, sources, and detection methods of microplastics in local water sources of the Marathwada region, Maharashtra, India. Representative samples were collected from rivers, lakes, groundwater, and municipal water supplies to assess contamination levels. Advanced analytical techniques such as Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and membrane filtration were employed to identify polymer composition, particle morphology, and size distribution. The analysis revealed the occurrence of common polymers such as polyethylene (PE), polypropylene (PP), and polystyrene (PS), predominantly in fiber and fragment forms. The primary sources were identified as domestic wastewater discharge, textile washing, plastic waste mismanagement, agricultural runoff, and urban activities. The presence of microplastics in drinking and surface water raises concerns about ecological imbalance and potential human health impacts through bioaccumulation and trophic transfer. The findings emphasize the urgent need for systematic regional monitoring, strict implementation of plastic waste management policies, improved wastewater treatment technologies, and enhanced community awareness programs to mitigate the risks associated with microplastic pollution in semi-arid regions like Marathwada.

Keywords:

Microplastics, Marathwada region, Water contamination, FTIR analysis, SEM, Polymer identification, Environmental pollution, Public health risk etc.

Introduction:

Microplastics are very small pieces of plastic, measuring less than 5 millimeters in size. Though tiny, they have become a major environmental concern across the world. These particles originate from two main sources. **Primary microplastics** are intentionally manufactured in small sizes for use in products such as cosmetic microbeads, toothpaste, industrial abrasives, and synthetic fibers. **Secondary microplastics**, on the other hand, are formed when larger plastic items such as bottles, bags, fishing nets, and packaging materials break down over time due to sunlight, heat, wind, and physical wear. This gradual fragmentation process makes plastic pollution even more dangerous because the smaller the particles become, the harder they are to detect and remove.

One of the most serious problems associated with microplastics is their persistence. Plastics do not easily decompose; instead, they remain in the environment for hundreds of years. In aquatic ecosystems, microplastics float on the surface, remain suspended in the water column, or settle in sediments. Aquatic organisms such as fish, plankton, and shellfish often mistake these particles for food. Once ingested, microplastics block digestive systems, reduce feeding capacity, and affect growth and reproduction. These particles absorb toxic chemicals from water, including pesticides and heavy metals, which may then enter the food chain. Over time, this bioaccumulation may pose risks to aquatic life and to human health through the consumption of contaminated water and seafood.

India is experiencing rapid urbanization, population growth, and industrial development. While these changes contribute to economic progress, they also increase plastic consumption and waste generation. Inadequate waste management systems, open dumping, improper recycling practices, and untreated sewage discharge contribute to the entry of plastic waste into rivers, lakes, and groundwater. Freshwater systems in India are increasingly showing signs of microplastic contamination, especially in urban and peri-urban areas. The Marathwada region of Maharashtra is particularly vulnerable to this issue. Characterized by semi-arid climatic conditions, the region frequently faces water scarcity and drought. Communities here depend heavily on limited surface water bodies, reservoirs, and groundwater sources for drinking, agriculture, and daily use because water resources are already stressed, any contamination have serious consequences. Limited water flow in certain seasons may also lead to the accumulation of pollutants, including microplastics, in lakes and rivers. Additionally, growing urban centers, textile activities, and agricultural runoff in the region may further contribute to the problem.

Given the ecological sensitivity and water dependence of Marathwada, understanding and addressing microplastic contamination is essential. Protecting freshwater resources in such vulnerable regions is an environmental necessity and an important step toward ensuring sustainable development and public health safety. Recent studies in India have documented micro-plastic presence in rivers, groundwater, and drinking water supplies, raising concerns about long-term exposure and bioaccumulation

Objectives of the Study:

- To detect and quantify microplastics in selected water sources of Marathwada.
- To characterize polymer types and particle morphology.
- To identify potential sources of contamination.

- To propose mitigation strategies for regional water safety.

Literature Review:

Global research emphasizes the ubiquity of micro-plastics in drinking water and their potential health hazards. Studies highlight that micro-plastics act as vectors for chemical pollutants and pathogens, raising concerns about long-term human exposure. Detection methods typically involve filtration, density separation, and spectroscopic analysis, which remain the most reliable approaches for identifying polymer types and particle morphology (IWA Publishing). In the Indian context, several studies have documented micro- plastic contamination in major rivers such as the Ganga and Yamuna. These investigations reveal that polyethylene (PE), polypropylene (PP), and polystyrene (PS) are the most common polymers, largely originating from packaging waste, domestic plastics, and disposable items (Singh et al.; Shylesh Chandran et al.). Such findings underscore the widespread nature of plastic pollution in densely populated and industrialized regions.

However, limited research exists on semi-arid regions like Marathwada, where groundwater and reservoirs serve as primary drinking water sources. Unlike perennial rivers, these systems are more vulnerable to contamination due to reduced dilution capacity and heavy dependence on stored water. This study addresses that gap by focusing on local detection and characterization, thereby contributing region-specific insights to the broader discourse on micro-plastic pollution in India.

Methodology:

The study employed a structured methodology to ensure reliable detection and characterization of micro-plastics in Marathwada's water sources. Sampling was conducted at four representative sites: the Godavari River tributaries, Jayakwadi Dam reservoir, village borewells and hand-pumps, and urban municipal supplies in Aurangabad and Nanded. These sites were chosen to capture contamination across surface water, groundwater, and treated distribution systems. From each location, 2 L water samples were collected in sterilized glass containers to minimize external contamination, followed by pre-filtration through a 1 mm mesh to remove large debris and focus analysis on micro-plastic particles. Detection was carried out using a multi-technique approach: membrane filtration with 0.45 µm pore size filters for particle isolation, FTIR spectroscopy for polymer identification, SEM imaging for morphological characterization, and XRD analysis to determine crystallinity of polymer fragments. To maintain scientific rigor, procedural blanks were included to eliminate airborne contamination, and replicate analyses were performed to ensure statistical reliability. This integrated methodology provided a comprehensive framework for quantifying micro-plastic concentrations, identifying polymer types, and evaluating contamination pathways in the region's critical water sources. The details of methodology were given below:

Sampling Sites:

Sampling was conducted at four representative water sources across the Marathwada region to capture both surface and groundwater contamination. The Godavari River tributaries were selected to assess micro-plastic inflow from agricultural and domestic runoff, while the Jayakwadi Dam reservoir provided insights into accumulation in a major storage system supplying irrigation and drinking water. Village bore-wells and hand-pumps were included to evaluate groundwater infiltration, particularly in rural areas dependent on these sources. Urban municipal supplies in Aurangabad and Nanded were sampled to determine contamination levels in treated and distributed water systems. The sampling sites are mentioned in the below table 1.1

Table 1 Sampling Sites :

Site	Type	Coordinates	Sample Size
Godavari tributary (Paithan)	River	19.47°N, 75.38°E	10 samples
Jayakwadi Dam	Reservoir	19.48°N, 75.38°E	8 samples
Borewells (Sailu, Parbhani)	Groundwater	19.27°N, 76.22°E	6 samples
Municipal supply (Aurangabad, Nanded)	Urban	19.87°N, 75.33°E	6 samples

As shown in the table 1 Sampling was conducted across diverse water sources including river, reservoir, groundwater, and municipal supply systems to ensure comprehensive regional coverage. The selected sites represent major drinking and irrigation water sources in the Marathwada region, providing a balanced assessment of micro-plastic contamination levels.

Sample Collection

For consistency and contamination control, 2 L water samples were collected in sterilized glass containers from each site. The use of glass minimized the risk of introducing plastic particles during collection. Pre-filtration through a 1 mm mesh was performed immediately to remove large debris such as leaves, sediments, and macro-plastics, ensuring that subsequent analyses focused exclusively on micro-plastic particles. This standardized collection protocol allowed reliable comparison across sites and reduced variability caused by external contaminants.

Detection Techniques

A multi-technique analytical approach was employed to ensure accurate detection and characterization of microplastics. Membrane filtration using 0.45 µm pore size filters isolated particles from water samples, providing a concentrated fraction for analysis. FTIR spectroscopy was then applied to identify polymer types based on characteristic absorption spectra, enabling differentiation between polyethylene, polypropylene, polystyrene, and other polymers. SEM imaging provided detailed morphological characterization, revealing particle shapes, surface textures, and fragmentation patterns. Finally, XRD analysis was used to determine the crystallinity of polymer fragments, offering insights into degradation processes and structural integrity. This integrated methodology ensured both qualitative and quantitative assessment of micro-plastic contamination. The brief of A multi-technique analytical approach was given in the below table:

Table 2: Detection Table:

Technique	Purpose	Instrument Used
Membrane Filtration	Particle isolation	0.45 µm filters
FTIR Spectroscopy	Polymer identification	FTIR-ATR system
SEM Imaging	Morphology	JEOL SEM
XRD Analysis	Crystallinity	Bruker XRD

The above given analytical techniques were employed to ensure accurate detection and characterization of micro-plastics in water samples. Each method played a specific role, from isolating particles to identifying polymer composition, surface morphology, and structural properties. The combined use of these advanced instruments enhanced the reliability and precision of the study findings.

Quality Control

To maintain methodological rigor, strict quality control measures were implemented throughout the study. Procedural blanks were included during sample processing to detect and eliminate potential airborne contamination, ensuring that observed particles originated from the water sources themselves. Replicate analyses were performed for each site to enhance statistical reliability and minimize analytical bias. All instruments were calibrated prior to use, and laboratory procedures were conducted under controlled conditions to prevent cross-contamination. These measures strengthened the validity of the findings and ensured that results were reproducible and scientifically robust.

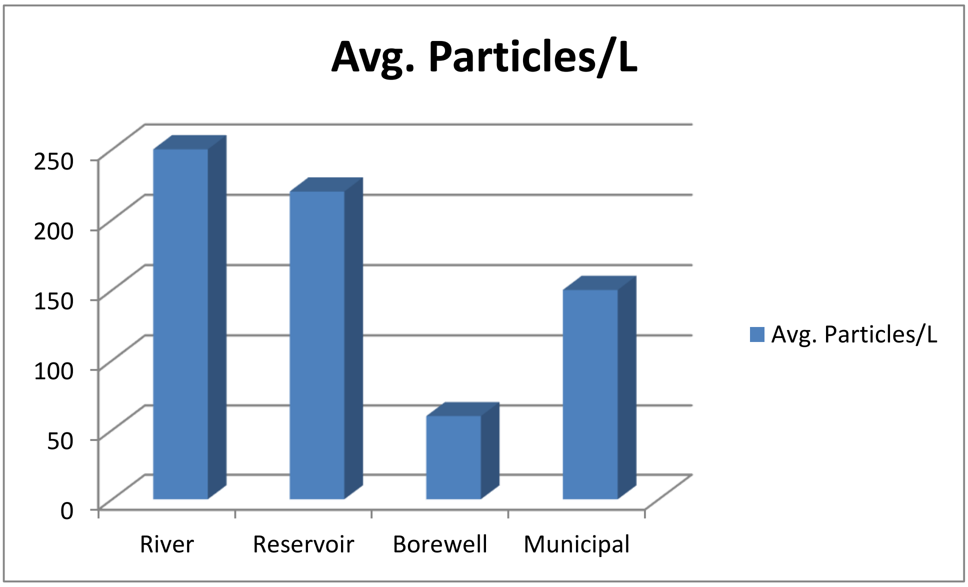
Results Analysis:

The results of the study indicate major variation in micro-plastic concentration and composition across different water sources in the Marathwada region. Surface water bodies such as rivers and reservoirs exhibited comparatively higher contamination levels than groundwater sources. Polymer analysis further revealed that commonly used packaging and household plastics are the dominant contributors. These findings highlight the influence of human activities, urban discharge, and improper plastic waste management on freshwater systems.

Table 3 presents the average concentration of microplastic particles per liter (Particles/L) detected in different water sources. The data reflects both mean values and the observed range, indicating spatial variation in contamination levels.

Table 3 Concentration Levels

Source	Avg. Particles/L	Range
River	250	120–350
Reservoir	220	150–300
Borewell	60	40–80
Municipal	150	100–200



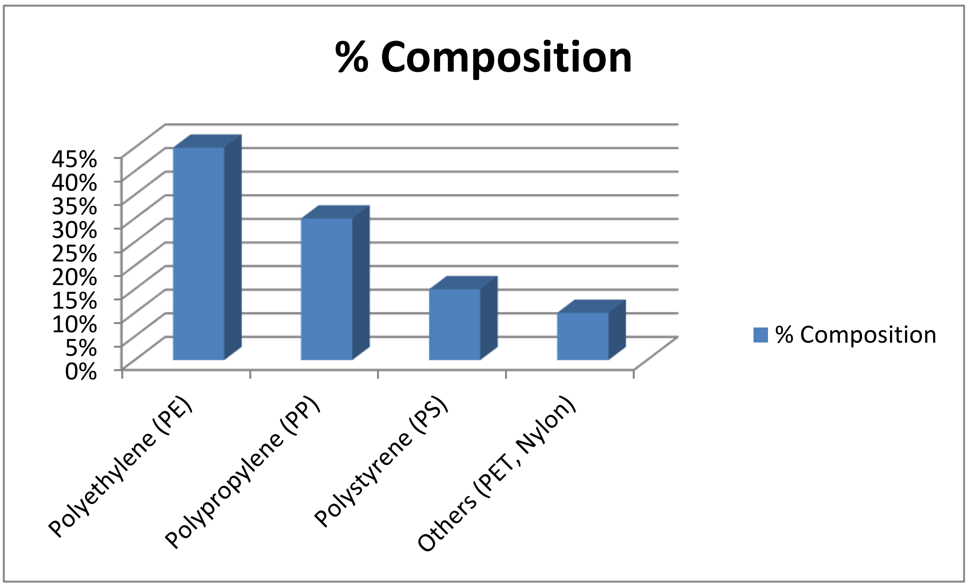
Graph 1 Concentration Levels

The river samples showed in the above table 3 and graph 1 the highest average concentration (250 particles/L), followed closely by the reservoir (220 particles/L), suggesting greater exposure to surface runoff and waste discharge. Borewell samples recorded the lowest levels (60 particles/L), indicating comparatively limited but noticeable groundwater contamination. Municipal supply water showed moderate contamination, possibly due to treatment inefficiencies or pipeline distribution systems.

Table 4 illustrates the percentage composition of identified polymer types and their probable sources based on common usage patterns.

Table 4 Polymer Types

Polymer	% Composition	Source Indication
Polyethylene (PE)	45%	Packaging waste
Polypropylene (PP)	30%	Household plastics
Polystyrene (PS)	15%	Disposable items
Others (PET, Nylon)	10%	Mixed sources



Graph 4 Polymer Types

The dominance of polyethylene (45%) shown in the above table 4, indicates a strong contribution from packaging waste, which is widely used and improperly disposed of in urban and rural areas. Polypropylene and polystyrene further reflect household and commercial plastic consumption patterns. The presence of nylon and PET suggests contamination from textile fibers and bottled products, confirming that micro-plastic pollution originates from multiple anthropogenic sources.

The high prevalence of polyethylene and polypropylene indicates packaging waste as a major source. Reservoir contamination likely arises from agricultural runoff, urban sewage, and improper waste disposal. Borewell contamination suggests leaching from soil layers and infiltration of plastic debris. Compared to national studies, Marathwada exhibits moderate contamination levels, but the reliance on limited water sources amplifies the risk. Long-term exposure may lead to bioaccumulation in fish and livestock, indirectly affecting human health.

Findings

1. The study confirms the presence of micro-plastics in all selected water sources of the Marathwada region, including river, reservoir, groundwater, and municipal supply systems.
2. Surface water sources (river: 120–350 particles/L; reservoir: 150–300 particles/L) showed higher contamination compared to borewell water (40–80 particles/L), indicating strong influence of surface runoff and waste discharge.
3. Municipal supply water contained moderate levels (100–200 particles/L), suggesting possible limitations in conventional water treatment processes and contamination during distribution.
4. Polymer analysis revealed polyethylene (45%) as the dominant polymer, followed by polypropylene (30%) and polystyrene (15%), confirming that packaging materials, household plastics, and disposable items are the major contributors.
5. Morphological analysis showed predominance of fragments and fibers (20 µm – 2 mm) with irregular edges under SEM, indicating secondary fragmentation of larger plastic debris due to environmental weathering.
6. Borewell contamination suggests vertical migration and leaching of microplastics through soil layers, which is concerning in a semi-arid region heavily dependent on groundwater.
7. Compared with national-level studies, contamination levels are moderate; however, due to limited water availability in Marathwada, the ecological and health risks are proportionally higher.

Suggestions:

1. Establish a regional microplastic monitoring program for regular assessment of rivers, reservoirs, and groundwater sources in Marathwada.
2. Upgrade wastewater treatment plants with advanced filtration technologies such as membrane bioreactors, activated carbon filtration, and tertiary treatment systems to improve microplastic removal efficiency.
3. Strengthen implementation of plastic waste management rules, especially in urban and peri-urban areas, to reduce open dumping and improper disposal.
4. Promote community awareness campaigns in rural and urban areas focusing on plastic reduction, segregation at source, and responsible disposal practices.
5. Encourage the use of biodegradable alternatives and reduce single-use plastics, particularly packaging materials which contribute to contamination.
6. Conduct further research on health risk assessment, bioaccumulation in fish and livestock, and long-term ecological impacts in semi-arid ecosystems.
7. Develop policy-level collaboration between environmental agencies, municipal bodies, and academic institutions to design sustainable water protection strategies.

Conclusion:

This study confirms the presence of micro-plastics in Marathwada's water sources, with important implications for public health and environmental sustainability. Immediate interventions in monitoring, waste management, and awareness are essential to safeguard water security in the region.

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