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MICROPLASTIC PRESENCE AND ITS DISTRIBUTION PATTERN IN AN INDUSTRIAL AREA IN CHATTOGRAM

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ABSTRACT

Microplastics have emerged as a serious environmental threat, extending from landfill soils to various organs of the human body. In Bangladesh, due to the widespread use of plastic products, there is a high potential for the presence and spread of microplastics. This study aims to assess the presence of microplastics and their horizontal distribution pattern in the industrial environment. With this concern in mind, our study focused on an industrial zone located in the Bayazid Thana of Chattogram city, an area characterized by frequent and unregulated use of plastic-based materials in daily industrial operations. To investigate the potential presence of microplastics (MPs) in such an environment, we collected samples from three different locations, 250 m south and 250 m north of the selected central location. These included samples of soil, air dust, water, and plant roots. The collected samples were then analyzed using Fourier-Transform Infrared (FT-IR) spectroscopy. Although the quantity of plastic particles could not be determined, the analysis revealed the significant presence of microplastics. The classification of MPs detected in the order of PVC>PS>PET>. In addition to PVC, PS, and PET, other synthetic polymers such as polystyrene and polyacrylamide were also identified. PVC and PS types of microplastic were found in all four samples. In addition, PET and polyacrylamide were found in plant roots, and polychloroprene was found in soil samples. We found PVC, PS, PET, polychloroprene, and polyacrylamide in the central location. PVC, PS, and polychloroprene in 250m north of the centre location. Along with PVC and the PS type of microplastic, we found the PET type of microplastic 250m south of the centre location. This study revealed the presence of MPs that may pose human health and environmental hazards if not well managed. Quantification of MPs and the study area might be expanded to gain a comprehensive understanding of microplastic pollution.

Keywords: *Microplastics, Industrial pollution, FT-IR, Environmental contamination, Chattogram*

1. INTRODUCTION

Microplastics are having a bigger and bigger effect on the environment, which is bad news for ecosystems all over the world. These tiny plastic bits are in soil, water, air, dust, and plants. They are slowly getting into natural systems and, eventually, the human body, which is very bad for health. Microplastics are pieces of plastic that are less than 5 millimeters long. They mostly come from the breakdown of bigger plastic items by physical, chemical, or biological processes. Microplastics have become a big problem in the last few years, and their harmful effects have gotten a lot of attention around the world. This is especially true because they are so common in marine environments and wastewater systems.. However, their presence extends beyond aquatic habitats into rivers, lakes, soil, dust, air, and sediments, highlighting a broad ecological footprint. Microplastics are generated through complex processes such as weathering, degradation, and fragmentation, while interactions with environmental components and microbial communities further increase their ecological risks (Harrison et al., 2011). The physical and chemical characteristics of microplastics, such as their size, shape, surface features, density, type of polymer, and capacity to absorb other materials, have a significant impact on their behavior and effects. These characteristics dictate the movement and persistence of microplastics in the environment. Therefore, a thorough understanding of their physical characteristics and chemical structure is necessary to fully comprehend their risks. Microplastics have probably already contaminated many areas of the environment in nations like Bangladesh, where plastic use is widespread. This study focuses on the identification and qualitative analysis of microplastics in environmental components such as soil, air dust, water, and plant roots within an industrial zone. Plastic pollution in Chattogram has become increasingly alarming in recent years. Massive amounts of plastic products are used daily, and improper disposal is causing serious harm to the environment and affecting the lives of city residents. Because it is located in an industrial zone in Chattogram, one of Bangladesh's most significant centers for business and industry, the selected study area is especially pertinent. Such a high concentration of industrial activity produces significant amounts of plastic waste in addition to hazardous waste. Nevertheless, there aren't many thorough studies that measure this plastic waste or examine its makeup. The environmental risk posed by industrial plastic waste in Chattogram is further complicated by the possible presence of microplastics. Identification and analysis of microplastics in soil, air dust, water, and plant roots in the industrial zone, as well as an evaluation of their possible entry points into the food chain through soil and plant absorption, are the main objectives of this study. Major objectives to address the aim of the studies are as follows :

- To check the presence of MPs in soil, water, plant roots, and air dust of an industrial zone.
- To portray the spatial distribution of microplastics in air dust, plant roots, water, and soil samples.

It is hoped that the findings of the study will help further improve the knowledge on the interaction of microplastics with environmentally prominent elements and will provide better guidance in terms of further analysis and prevention measures for this serious issue around the world.

The research is concerned with the occurrence and the identification of MPs in the environmental components (soil, water, air dust, and plant roots) of an industrial zone in Chattogram. Furthermore, the qualitative analysis of the plastic particles found in the samples. some important issues in relation to this research are as follows :

Sample collection in the industrial zone was challenging due to its location and the geometry of the specific site. We collected four types of samples (Soil, Effluent water, Air dust, and Plant root) from each location. We maintained a specific distance between the three locations of our total collection site. The distance between the two locations is approximately 250 meters. We didn't use a chain or tape accurately for measuring the distance; rather used Google maps and footsteps.

Limited access to the testing apparatus precluded the quantification of MPs.Only the presence of various types of MPs (i.e, polymers, rubbers, fibers, etc.) could be analysed.

The field investigations were limited to a particular zone in Bayazid Road, Chattogram. This limits the wider applicability of some of the results. Seasonal variability was not considered during the investigation, even though it might influence the results. For example, the rainy season can accelerate the leachate flow, including a higher accumulation rate of MPs in the soil and plant roots.

2. METHODOLOGY

3. We have divided the total methodology into three important sections: (2.1), sample collection (2.2), and sample preparation (2.3) to maintain a logical and consistent framework aligned with the research objectives. We have chosen the study area in the industrial zone of Chattogram to analyse the potential risk of microplastics. In the sample collection segment, we collected soil, air dust, water, and plant roots to cover a whole environmental picture. Finally, the sample preparation section explains the standardized drying, sieving, and filtration processes conducted to obtain reliable and comparable analytical results. This structured approach strengthens the methodological integrity and ensures that the findings accurately reflect the extent of microplastic contamination in the study area.

2.1 Sampling Area and Site Description

We have conducted the study in the industrial zone along Textile Gate Road under Bayazid Bostami Thana, Chattogram (approx. 22.3794°N, 91.8203°E). The reason behind choosing the area is that it has several plastic and metal industries. There is a chance to get a high amount of plastics here, so the sampling locations are divided into three zones: Location 1 (center), Location 2 (250 m north), and Location 3 (250 m south) to ensure representative spatial coverage.

2.2 Sample Collection

We have collected four types of samples: soil, air dust, water, and plant root from each location. Soil samples are taken manually with local tools like a thong. The process was quite in cautious so that other wastes would not enter the samples. Water samples were collected from drainage outlets near industrial discharge points using clean jars. Then we preserved the water in airtight containers. Airborne dust was gathered by gently brushing particles from nearby plant leaves at heights of about 2–2.3 meters, while plant root samples were obtained from fast-growing species (e.g., Chenopodium album, Solanum virginianum, and Syzygium cumini) to reflect recent contamination. Then we sealed, labeled all types of samples for a reactionless preservation.

2.3 Sample Preparation and Processing

Firstly, the collected samples are air-dried to remove all the moisture from them in ambient conditions. Soil, dust, and root samples were subsequently oven-dried at approximately 95°C for 24 hours to ensure complete removal of water. Then the soil and plant roots are ground to pass the No. 200 sieve, but the air dust particles are just ground for better inspection. We kept the water sample for some days to settle the larger particles without any chemical coagulation. Then it was filtered by standard filter paper. All prepared samples were then sealed in clean, labeled plastic bags and transported to the laboratory for microplastic analysis under controlled conditions.

2.4 Analytical Method (FT-IR Analysis)

A widely used approach for detecting and categorizing MPs in soil, water, air, and plant roots is Fourier Transform Infrared (FT-IR) analysis. Target MPs in a sample and their constituent polymer types can be identified by comparing referenced spectrum libraries. Attenuated total reflection (ATR-FTIR) and micro FT-IR are two FT-IR techniques. The former escalates the identification of irregular MP particles (greater than 500 micrometers) while the latter permits high-resolution maps of the samples without a pre-selection(Azim et al,1970).

Working principle:

Covalent bonds in molecules will selectively absorb light of particular wavelengths, changing the vibrational energy in the bond. The atoms in the bond determine the sort of vibration (stretching or bending) facilitated by the infrared radiation. The transmittance pattern varies for different molecules because different bonds and functional groups absorb various frequencies. The flipside of absorption is transmittance. Wavenumber is plotted on the X-axis, and transmittance is plotted on the Y-axis to present the spectrum. (Wavenumber is 1/wavelength and represents the energy of the molecular bond's vibrational motion).

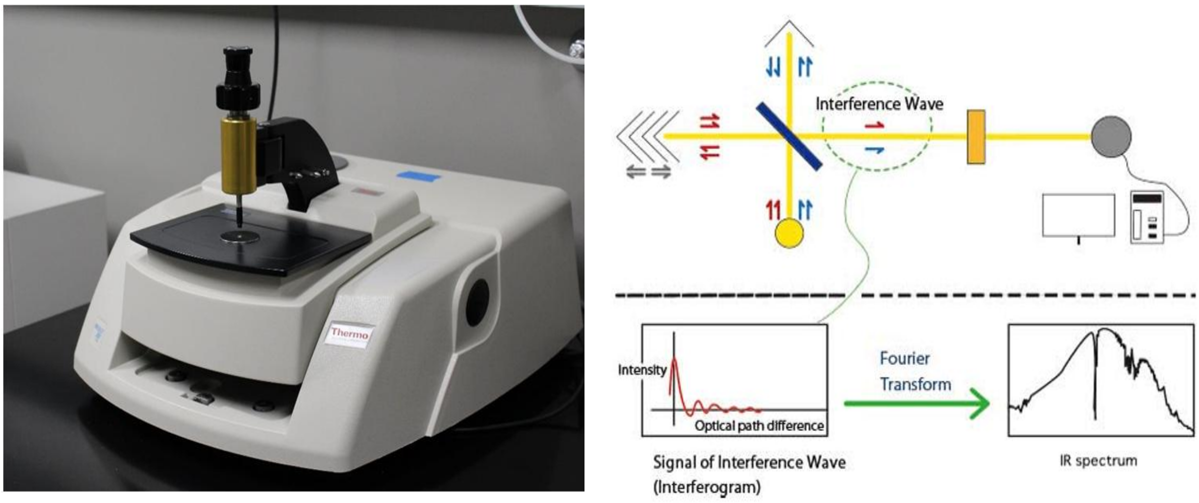

Figure 1: FT-IR spectrometer(a) and its working principle (b)

Data analysis :

• Utilizing the FT-IR software offered by the instrument manufacturer and Spectrogryph software, the collected spectra were processed.
• The spectra were enhanced by using baseline correction and normalization approaches.
• The sample spectra were compared to reference spectra or a library of spectra for recognized plastic materials, such as polymers like polyethylene(PE), Polypropylene(PP), Polystyrene(PS), and Polyethylene terephthalate (PET).
• The distinctive peaks and absorption bands that signify the presence of MPs in the sample spectra were identified.

4. RESULT AND DISCUSSION

4.1 Figures and Graphs

The figures and graphs in this section present the FT-IR analysis results for the collected samples of soil, air dust, water, and plant roots. They visually display the spectral patterns that confirm the presence of different polymer types identified in the study. These visual outputs make the analytical findings easier to follow and help in understanding the variation in absorbance peaks across different samples. Overall, the figures provide a clear and concise representation of the laboratory results, supporting the explanations discussed in the following description.

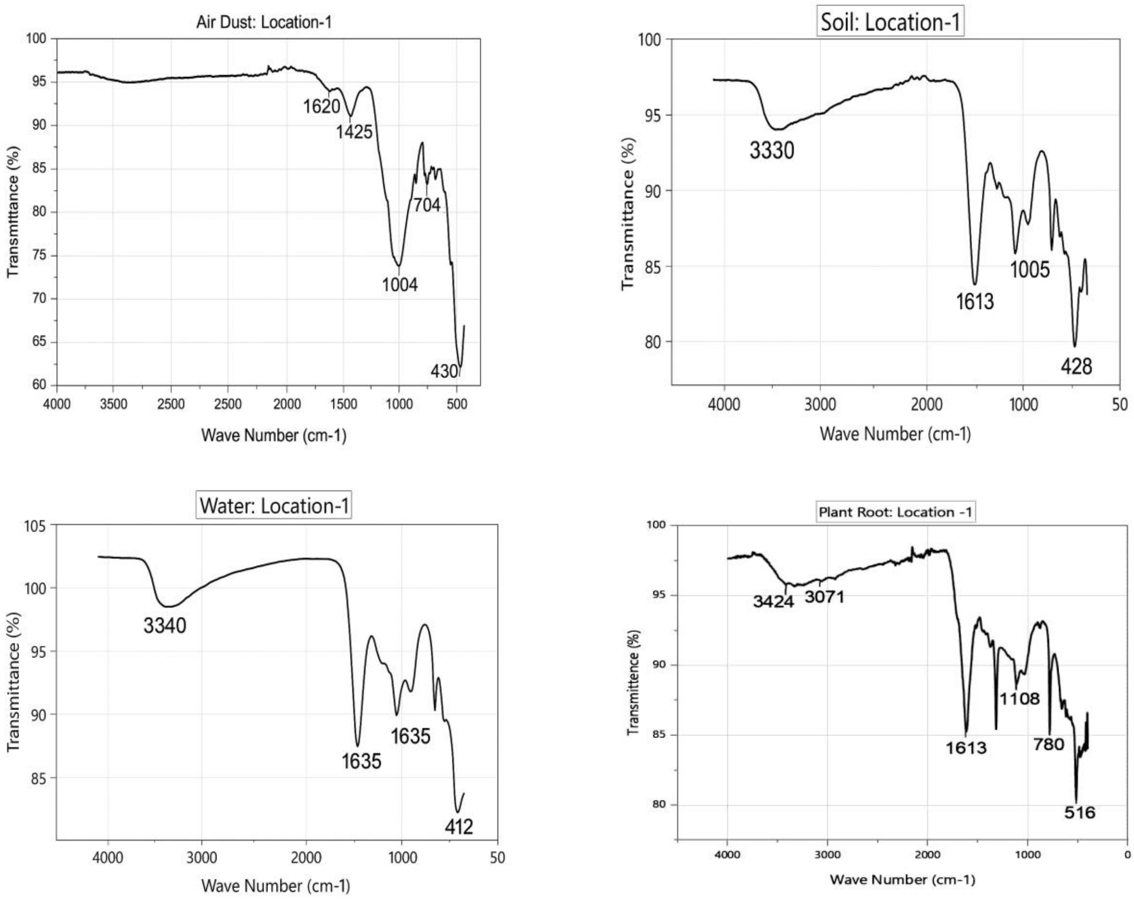

Figure 2: FT-IR spectrum for air dust, soil, water, and plant root of the central location

The study's figures and graphs show the FT-IR spectra of samples of soil, water, air dust, and plant roots that were taken from the industrial zone. The presence of multiple polymer types, including polystyrene (PS), polyvinyl chloride (PVC), polyethylene terephthalate (PET), and polyacrylamide, is confirmed by these spectral graphs, which show distinct absorbance peaks corresponding to different functional groups. The characteristic bonds of PS and PVC are represented by the particularly noticeable peaks around 1000 cm^{-1} and 430 cm^{-1}, which were present in every sample. The presence of PET and polyacrylamide polymers is indicated by additional peaks in the FT-IR curves for soil and plant roots that are associated with functional groups that contain nitrogen and oxygen. Additionally, the different concentrations and compositions of microplastics are reflected in the variation in peak intensity between the samples in each environmental medium. Overall, the figures visually confirm the spectral evidence of microplastic pollution and help to compare polymer types across sample categories, demonstrating a clear link between industrial emissions and environmental contamination in the study area.

4.2 Tables

The tables in this section summarize the FT-IR analytical results for all collected samples, showing the absorbance peaks, functional groups, and the corresponding types of plastics identified. Each table represents a different environmental component (air dust, soil, plant roots, and water), allowing a straightforward comparison among them. These tabulated data help to organize the spectral findings in a systematic way, making it easier to interpret the detected polymers and understand their occurrence across different sample types.

Table 1: Characterization of functional group and plastic type in air dust

Sample	Absorbance Peak (Wave number) (cm-1)	Functional Group	Type of Plastic
1 (center) BSRM Steel Manufacturing Industry	1619	C=C stretching (aromatic or alkene), possibly aromatic ring	Polystyrene (PS)
	1424.6	CH_2 bending or C–H bending (alkane or aromatic)	
	1004.7	C–H in-plane bending (aromatic), or C–O stretching	
	775.31	C–H out-of-plane bending (aromatic ring substitution)	
	692.72	C–Cl stretching / aromatic C–H bend	PVC / Polystyrene
	430.19	C–Cl stretching (common in PVC), or skeletal vibrations	Polyvinyl Chloride (PVC)
2 (250m North) Opposite of the Bangladesh Chemical Complex	1599.1	Aromatic C=C stretching	Polystyrene (PS)
	1421.5	CH_2 bending / Aromatic C–C stretching	
	1005.3	Aromatic C–H in-plane bending / C–O stretching (ester)	
	774.67	C–H out-of-plane bending (para-substituted benzene)	
	692.45	C–Cl stretching / aromatic C–H bend	PVC / Polystyrene
	427.43	C–Cl stretching	Polyvinyl Chloride (PVC)
3 (250m South) Chattogram Industries Ltd.	1622.3	Aromatic C=C stretching	PS
	1423.5	CH_2 bending / Aromatic ring vibration	
	1002.9	Aromatic C–H in-plane bending / C–O stretching (ester)	
	426.43	C–Cl stretching	Polyvinyl Chloride (PVC)

The FT-IR absorbance peaks discovered in air-dust samples from each of the three locations are shown in Table 1. It recognizes the functional groups connected to these peaks and categorizes them into different types of polymers, including polyvinyl chloride (PVC) and polystyrene (PS). Overall, it demonstrates that PS and PVC are regularly found in the industrial area's airborne dust.

Table 2: Characterization of functional group and plastic type in soil

Sample	Absorbance Peak (Wave Number) (cm-1)	Functional Group	Type of Plastic
1 (center) **BSRM Steel Manufacturing Industry**	3381.1, 3330, 3257.5, 3171	O–H or N–H stretching (broad peaks), hydroxyl groups or amines	Polychloroprene
	1619.3	Aromatic C=C stretching	Polystyrene (PS)
	1420	CH_2 bending / aromatic C–C stretching	
	1005.8	Aromatic C–H in-plane bending / C–O stretching (ester)	
	774.02	C–H out-of-plane bending	
	661.04	C–H out-of-plane bend (aromatic ring)	
	425.3	C–Cl stretching	Polyvinyl Chloride (PVC)
2 (250m North) **The opposite of Bangladesh Chemical Complex**	1622.6	Aromatic C=C stretching	Polystyrene (PS)
	1426.8	CH_2 bending / Aromatic C–C stretching	
	1004	Aromatic C–H in-plane bending / C–O stretch (ester group)	
	775.26	C–H out-of-plane bending (para-substituted benzene ring)	
	692.61	C–Cl stretching	Polyvinyl Chloride (PVC)
	423.45	C–Cl stretching	
3 (250m South) **Chattogram Industries Ltd.**	1622.5	C=C stretching (aromatic or alkene)	Polystyrene (PS)
	1003.2	C–H in-plane bending or C–O stretching	
	692.54	C–Cl stretching	Polyvinyl Chloride (PVC)

The main FT-IR peaks found in soil samples are listed in Table 2 along with the functional groups to which they correspond. It recognizes various polymers, such as PS, PVC, and polychloroprene, and illustrates how polymer diversity varies by place. Higher polymer complexity is highlighted in the center of the table.

Table 3: Characterization of functional group and plastic type in plant roots

Sample	**Absorbance Peak (Wave Number) (cm-1)**	**Functional group**	**Type of microplastic**
1 (center) BSRM Steel Manufacturing Industry	3424,3333.6,3251.9	O–H (hydroxyl stretch, broad)	PET, Polyacrylamide
	1614.7	C=C stretching (aromatic or amide)	PET, Polyacrylamide
	1316.2	CH_2, CH_3 bending	Polyacrylamide
	1113.5,1034.5	C–O stretching (ester, ether, alcohol)	PET, Polyacrylamide
	877.83,780.54	C–H bending (aromatic, vinyl chloride)	PVC
	3078.9,2922.9,2850.8	C–H stretching (alkyl groups)	PS
2 (250m North) The opposite of the Bangladesh Chemical Complex	1406.5	CH_2, CH_3 bending	PS
	875.05,781.3,712.77, 617.9,562.23,400.37	C–H bending (aromatic, vinyl chloride) and C–Cl stretching vibration	PVC, PS
3 (250m South) Chattogram Industries Ltd.	3346.9	O–H (hydroxyl stretch, broad)	PET
	2939.8	C–H stretching (alkyl groups)	PS
	1608.2	C=C stretching (aromatic or amide)	PET, PS
	1317.3	CH_2, CH_3 bending	PS
	1028.4	C–O stretching (ester, ether, alcohol)	PET
	780.5,418.5	C–Cl stretching vibration	PVC

The absorbance peaks found in plant-root samples are listed in Table 3 along with the corresponding chemical groups. A greater variety of microplastics, including PET, polyacrylamide, PS, and PVC, are revealed, suggesting surface retention or plant uptake. According to this table, there are more different types of polymers in plant roots than in soil or the air.

Table 4: Characterization of functional group and plastic type in water

Sample no	Absorbance Peak (Wave Number) (cm-1)	Functional group	Type of microplastic
1 (center) **BSRM Steel Manufacturing Industry**	1636	C=C stretching (aromatic or amide)	PS
	411.71	C–Cl stretching vibration	PVC
2 (250m North) **The opposite of the Bangladesh Chemical Complex**	1635.3	C=C stretching (aromatic or amide)	PS
	407	C–Cl stretching vibration	PVC
3 (250m South) **Chattogram Industries Ltd.**	1635.2	C=C stretching (aromatic or amide)	PS
	404.67	C–Cl stretching vibration	PVC

FT-IR peaks detected in industrial water samples and the polymers associated with those peaks are shown in Table 4. PS and PVC are consistently detected in the water samples at all three locations, suggesting comparable patterns of contamination. This table illustrates the consistent and ongoing presence of microplastics in water impacted by effluent.

The characterization of functional groups and plastic types found in air dust, soil, plant roots, and water samples taken from an industrial area in Chattogram is shown collectively in Tables 1 through 4. Polystyrene (PS) and polyvinyl chloride (PVC) were consistently found in all environmental components and sampling locations, according to the FT-IR spectral analysis, suggesting widespread microplastic contamination. Additionally, soil samples at the central location contained specific polymers like polychloroprene, while plant roots contained polyethylene terephthalate (PET) and polyacrylamide, demonstrating the variety of polymer types in various media. Plant roots containing PET and polyacrylamide demonstrate the possible dangers of microplastic entering the food chain. PS and PVC dominated the uniform patterns found in the water samples, indicating ongoing industrial discharge. Overall, the combined data from Tables 1 to 4 reveal that PS and PVC are the dominant pollutant. These findings collectively confirm that industrial activities are the primary source of microplastic contamination, leading to the distribution of persistent plastic particles throughout air, soil, plants, and water in the surrounding environment.

5. CONCLUSIONS

This study investigated the presence and spatial distribution of microplastics (MPs) in air dust, soil, water, and plant roots within an industrial zone of Chattogram, Bangladesh, using Fourier Transform Infrared (FT-IR) spectroscopy. The results clearly confirm that microplastic contamination is pervasive across all investigated environmental compartments in the study area. Polystyrene (PS) and polyvinyl chloride (PVC) were consistently detected in all sample types and at all sampling locations, indicating continuous and widespread emissions associated with industrial activities. In addition, polyethylene terephthalate (PET), polyacrylamide, and polychloroprene were identified in specific environmental matrices, particularly in plant roots and central soil samples, reflecting localized industrial influences and material-specific behavior in the environment. The dominance of PS and PVC observed in this study aligns with findings reported in previous studies conducted in industrial, urban, and effluent-impacted environments both in Bangladesh and globally, confirming that these polymers are among the most persistent and widely distributed forms of microplastics. The greater polymer diversity observed at the central sampling location highlights the influence of intensive industrial operations on microplastic composition and spatial variability. Moreover, the uniform detection of PS and PVC in water samples across all locations suggests ongoing industrial discharge and inadequate containment of plastic waste within the drainage system. Notably, the identification of PET, polyacrylamide, PS, and PVC in plant root samples provides field-based evidence of microplastic interaction with terrestrial vegetation in an industrial setting. This finding supports emerging concerns regarding the potential transfer of microplastics from contaminated soils into biological systems and, ultimately, the food chain. Compared to aquatic and atmospheric compartments, plant-associated microplastics remain insufficiently studied, and the present work contributes valuable data to this growing research area.

Overall, the study demonstrates that industrial activities are a primary driver of microplastic contamination in the investigated area, resulting in the accumulation and dispersion of persistent plastic polymers across air, soil, water, and biotic components. While the present work was limited to qualitative identification due to instrumental constraints, the findings provide a strong baseline for future investigations. Further research incorporating quantitative analysis, particle size and shape characterization, seasonal variability, and expanded spatial coverage is essential to fully assess environmental and human health risks. Strengthening industrial waste management practices and implementing regular monitoring programs are crucial steps toward mitigating microplastic pollution in rapidly industrializing regions such as Chattogram.

DECLARATION OF USE OF AI:

The authors would like to state that AI tools like ChatGPT, DeepSeek, and Perplexity were used as in a certain manner as supporting tools. At different stages of preparing the manuscript, these tools were used predominantly for text generation to better describe the ideas, clarifying explanations of the outcomes and for describing results. So in short, AI was used for wording, clarity and organizing sentence structures. But the fundamental ideas, explanations and procedures of the work was solely created by the author's understanding and judgment. AI didn’t influence any technical judgment in this paper. Moreover, any suggestions about the write-up generated by AI were carefully checked and adjusted so they matched what the authors intended to describe within academic practice. All the responsibility for the content’s integrity rests with the authors, and they acknowledge the supporting role of AI in shaping the write-up of the respective manuscript.

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