Heliyon 9 (2023) e17949

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Risk assessment of microplastic pollution in an industrial region of Bangladesh

Mahir Tajwar [a], Mahmudul Hasan [b], Shamiha Shafinaz Shreya [b,*],
Mahfuzur Rahman [c], Nazmus Sakib [d], Md Yousuf Gazi [a]

[a] *Department of Geology, University of Dhaka, Dhaka, 1000, Bangladesh*
[b] *Department of Oceanography, University of Dhaka, Dhaka, 1000, Bangladesh*
[c] *Department of Oceanography, Noakhali Science and Technology University, Noakhali, 3814, Bangladesh*
[d] *Bangladesh Water Development Board, Dhaka, 1215, Bangladesh*

ARTICLE INFO

Keywords:
Microplastics
Industrial region
Terrestrial soil
Agricultural land
Narayanganj
Bangladesh

ABSTRACT

Despite the high potential for microplastics (MPs) pollution in Bangladesh, the presence of MPs in the industrial region has largely been unexplored in Bangladesh. So, this study was conducted to determine whether MP pollution is prevalent in the industrial soil of Bangladesh and the extent of its toxicity. To examine MPs, a total of 12 soil samples were collected from the industrial region of Narayanganj, and a stereoscopic microscope was used to visually identify the MPs. Prior to that the technique of density separation and sieving was applied to extract MPs from those 12 soil samples. Among the twelve investigated samples, a total of 151 MPs (Mean: 12.6 ± 7.9 particles kg^{-1}) were identified, which were mostly white and ranged in size from 0.5 to 1 mm. Different types of MPs according to their shapes such as fibers (60.3%), fragments (19.2%), films (10.6%), and foam (9.9%) have been detected. 7 MPs (Mean: 0.58 ± 0.79) have been found in 3 urban farmland sites, 15 MPs (Mean: 1.87 ± 1.81) in two near metropolitan areas, and 129 MPs (Mean: 4.6 ± 4.39) in 7 industrial locations. Five polymers were identified by μ-FTIR, among which Polyamide predominated, followed by Polypropylene. According to risk assessments, the region falls under hazard categories II and III, suggesting a moderate to high risk. This paper gives thorough information on the toxicity of MP in an industrial location; therefore, it may be useful in the development of effective methods to address environmental issues.

1. Introduction

Microplastics (MPs) have become a major concern among scientists around the world because of their ubiquitous presence in the aquatic and terrestrial environment which are posing a serious threat to the biodiversity and ecosystem [1]. MPs are plastic particles but smaller in size (1 μm–5 mm) and due to their strength and durability, may persist in the environment for hundreds to thousands of years [2–5]. MPs found in the environment are divided into two main classes i.e., primary microplastics and secondary microplastics [6]. Plastic particles that enter directly into the environment in sizes smaller than 5 mm are called primary MPs and their main sources are cosmetic products, clothing, facial cleaners, hand cleaners, toothpaste, exfoliation scrubs, drilling fluids, children's products, personal healthcare products, insect repellent, fishing, and aquaculture practices, etc [7–9]. Recycling of used plastics is also

---

* Corresponding author.
E-mail address: shreya@du.ac.bd (S.S. Shreya).

https://doi.org/10.1016/j.heliyon.2023.e17949
Received 5 April 2023; Received in revised form 1 July 2023; Accepted 3 July 2023

considered a vital source of MPs [10]. Secondary MPs do not enter the environment directly, rather they are derived from the degradation or breaking down of large plastic substances like plastic bags, plastic bottles, face masks, one-time cups, and plates. The degradation and breaking downs of larger plastics are mainly done by wave action, chemical weathering, UV radiation, and biological processes occurring in the natural environment [11–13]. Even sewage treatment plants where wastewater is treated can be a source of MPs for the aquatic environment [14–16]. So, the main reason for the ubiquities MPs in the surrounding environment is ascribed to the use of plastic products in daily life, and day by day the abundance of MPs is increasing as the use of plastic substances is also increasing [17,18]. Over 300 million tons of plastic products are currently produced yearly whereas this quantity was only 1.5 million tons in 1950 [7].

These rapidly increasing and improperly handled MPs ultimately end up in the plants and aquatic bodies via drains, surface runoff, the wind, or flooding. Aquatic organisms such as bivalves, mussels, zooplankton, shrimps, fishes, other invertebrates and vertebrates consume and uptake MPs as foods [19–22]. As a result, physical damage and health hazards, such as obstructing intestinal systems or gastrointestinal cuts, decreasing growth rate, blocked enzyme production, reproductive problems, pathological and oxidative stress are being observed in the aquatic species [23,24].

Worldwide plastic use was approximately 460 Mt in 2019 which might increase to 1231 Mt in 2060 [25]. Plastic production and consumption in 2019 were highest in North America, especially in the US where per capita consumption is 139 kg per year (without fiber and rubber polymers) and represents 19% of global plastics production [26]. The top ten countries in the world that produced the most plastic waste in 2016 are mentioned here with their values in million tons; United States (34.02) > India (26.33) > China (21.60) > Brazil (10.68) > Indonesia (9.13) > Russia (8.47) > Germany (6.68) > United Kingdom (6.47) > Mexico (5.90) > Japan (4.88) [27]. The accumulation of microplastics has primarily been attributed to anthropogenic activities on land, such as industrial manufacturing, agriculture, and municipal solid waste landfilling [28]. According to Browne et al. (2011), the majority of synthetic fibers discovered in aquatic environments originate from industrial sources.

In the context of Bangladesh, where plastic is one of the highest sources of export revenue, the use of plastics increased dramatically from 2.07 kg to 4.5 kg in just nine years (2005–2014), and the production of plastic related debris around 3000 tons per day [29,30]. The majority of these plastics are released into the environment without any kind of recycling which is polluting the aquatic environment of Bangladesh [22,31–38]. A higher amount of MPs was identified in the Cox's Bazar beach and St. Martin Island sediments [39–41], Moheskhali salt pans, brown shrimp, tiger shrimp, Bombay-duck, Goldstripe Sardinella, and in the intestine of our national fish, Hilsa shad (Tenualosa ilisha) from the northern Bay of Bengal [42–44]. Those represent a potential human exposure route through dietary uptake. As the extent of MPs is ubiquitous from the air we breathe to the food we eat, it is essential to know exactly the ecological and human health risks of MPs but it is a matter of regret that the assessment is still not done properly [45].

Narayangonj is one of the oldest industrial districts in the country and contributes significantly to the economic development of Bangladesh. Around 33% of the country's total textile mills and 55% of the country's total knitwear manufacturing are situated in this district [46]. The majority of the industries are located in the Sadar Upazila and day by day the industries are increasing in this area. In 2020, a considerable portion of the land (1538 acres) was converted into a built-up area which reduced the vegetation cover (15.85%) and water body (7.65%) of the study area [47]. To date, no studies have been conducted in this region to assess the MPs in the sediments and the ecological dangers they pose. The present study intends to investigate the abundance, distribution, and potential risks of MPs contamination in this industrial region. This study provides a first insight of microplastic pollution in the industrial region of Narayanganj and will be helpful to the municipal authority to manage plastic and microplastic pollution as well as to implement new regulations related to plastics and MPs.

2. Study area

The research area of Narayanganj lies in the central Bangladesh region of the broader Bengal Basin. The Basin covers a larger portion of Bangladesh and parts of West Bengal. The basin is defined by a thick sequence of sedimentary rocks, including sandstones, siltstones, and shales, deposited in various habitats, such as deltas, floodplains, and shallow marine environments [48]. The area includes the floodplains of major rivers like the Ganges, Brahmaputra, and Meghna, in addition to the rivers that flow into and out of them. The Shitalakshya, a major tributary of the Brahmaputra River that flows through the area of interest, is also an important source of sediment for the Bengal Basin. The river is known for transporting great amounts of sand and silt downstream [49].

Narayanganj, one of Bangladesh's oldest, most important, and busiest river ports, lies in the middle of the country. Due to its central location, the national and regional roads pass through Narayanganj. Massive industrialization is both the boon and the bane of this district. Population growth, rapid urbanization, etc. are the major factors causing environmental deterioration here [50].

Since the mid-19th century, the area has been commonly referred to as the Dundee of the East for its fascinating East-West fusion with world-class jute mills and textiles. By generating numerous employment opportunities in different industries, the city welcomed and housed tens of thousands of inhabitants and migrants from all over the country [51]. Being one of the most densely populated districts in Bangladesh, Narayanganj stands with a population of approximately 2.9 million people as of 2011 and a population density of 9444 inhabitants per square kilometer, which is significantly higher than the national average of 976 [52]. Being home to a variety of industries, including textiles, ceramics, pharmaceuticals, and food processing, Narayanganj generates a significant amount of waste that can potentially contaminate the environment [53].

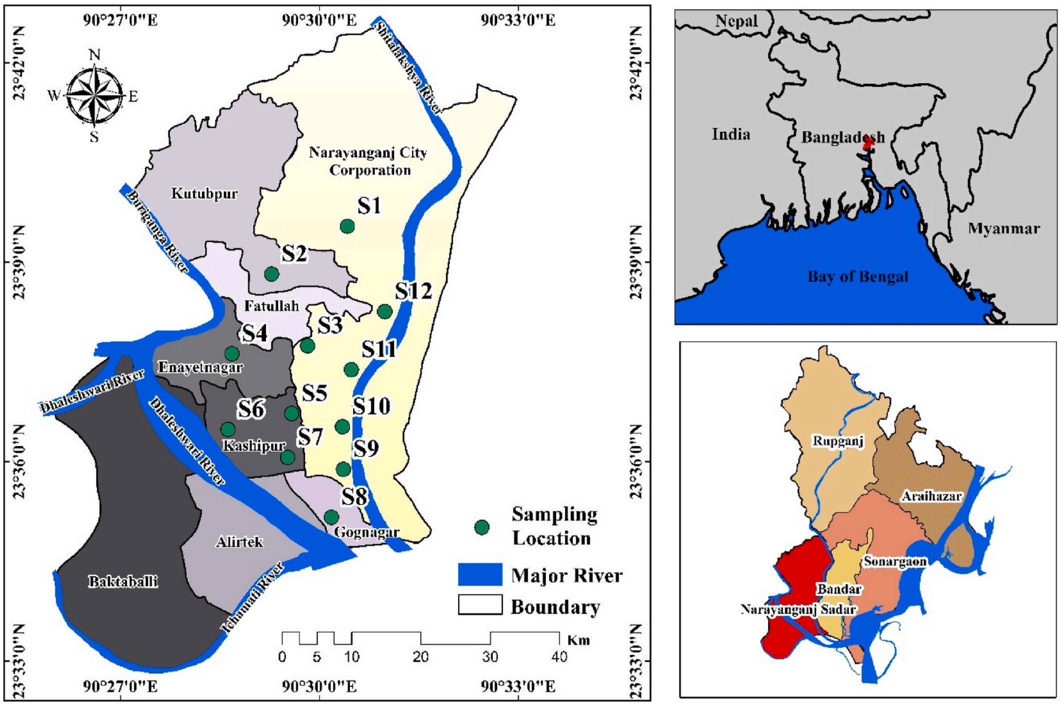

Fig. 1. Location map showing the sampling sites in Narayanganj, Bangladesh.

3. Methodology

3.1. Sample collection and preparation

Samples have been taken from 12 sites close to the acceesible industrial, urban, and suburban areas of the Narayanganj region (Fig. 1). Using a clean scraper made of stainless steel and auger, 12 samples of soil were taken from a depth of 2–3 m over an area of about 30 cm^2. Together, these samples added up to 2.2 kg of soil. The samples were mostly looked at with the naked eye to get rid of anything bigger than 10 mm. The soil samples were kept in a fresh, well-sealed aluminum foil box (3 mm thick) and then brought to the research lab [54,55].

3.2. Laboratory analysis

Samples were taken from the foil box and spread around the tray before drying at a temperature of 105° Celsius in an oven for 24 h. After drying the materials, a systematic extraction approach including sieving was used using a series of 8-inch Tyler Brass sieves with aperture widths of 5, 2.5, 1.25, and 0.625 mm, respectively. The samples were sieved for approximately 10 min and the collected grains were separated and the weight has been calculated [33].

Each sieved sample was placed in a 500 ml glass beaker, 100 ml of a 30% hydrogen peroxide solution was added, and the beakers had been warmed at 65° Celsius for a period of 24 h to facilitate the digestion of the organic materials [39]. The wet peroxide oxidation solution was transferred to a density separator [56] and permitted to settle overnight after 6 g of NaCl salt were added to every 20 mL of the sample (5 mM NaCl) [57]. After removing the solution from the density separator, it was filtered using a 5.0 m cellulose nitrate filter paper that was 47 mm in diameter [58].

3.3. Stereoscope analysis

A LEICA EZ4E stereo microscope was utilized for visual examination to detect the presence of microplastic in the obtained sample. The filter paper was put underneath the stereo microscope equipped with a 5-megapixel HD built-in digital camera, an 8x-35× zoom range (including 10× eyepieces), and a built-in light-emitting diode (LED) with 25,000 h of life [59]. Based on the identifying criteria reported by Cheung et al. (2016) [60], Hidalgo-Ruz et al. (2012), Catarino et al. (2018) [61], and Tajwar et al. (2022c), the microplastics were identified and separated. A 5 MP HD digital camera was used to acquire images of the discovered MPs. 0.3–0.5 mm, 0.5–1 mm, and 1–5 mm had been used to categorize the identified microplastic [62]. Also, the different hues of MP particles were identified and cataloged. Fiber, fragments, films, and foams were the categories used to categorize the several types of MPs [40,63].

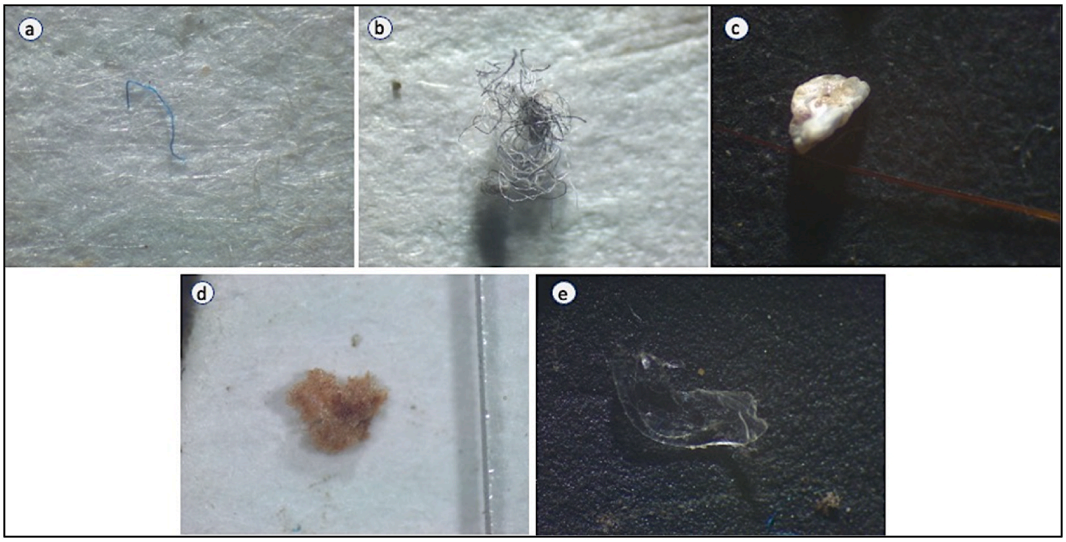

Fig. 2. Representative images of the identified microplastics in sample sediments under a stereoscopic microscope. (a, b = fiber; c = fragment; d = foam; e = film).

3.4. *FTIR-ATR analysis*

To determine the MP's molecular composition, ATR-FTIR spectroscopy was carried out using a device of Model: IRPrestige21; CAT No. 206-72010-36; Serial No. A2100450183. This was done so that the kind of polymer present in the found microplastic could be identified [64,65,66]. After loading the MPs into the FTIR, Infrared light was fired at the instrument to obtain the absorbance spectra of the samples. The polymer type was identified by looking for a specific absorbance band and cross-referencing its peaks against those in a database relating it to the standard degree of resemblance for detection, resemblance being close to 80% [67,68].

3.5. *Spatial analysis*

Microplastic abundance, subcategories of microplastic, and associated polymer types were mapped using ArcGIS (version 10.2).

3.6. *Quality control*

The soil samples had been wrapped in aluminum foil to avoid contamination from plastic. A cotton lab coat and nitrile gloves were used during sample handling. Before and after each step, the lab equipment used has been put through two distillation procedures to ensure its cleanliness. The Petri dishes were thoroughly cleaned and dried before use. Metal and glass instruments were used during the whole procedure. After isopropanol treatment, the ATR crystal was analyzed by ART FTIR [33,39].

3.7. *Risk assessment*

In this research, the Hkanson technique [69] was used to assess the hazards of microplastics. Many risk variables, including the potential ecological risk factor (PRF), the potential ecological risk index (PRI), the microplastic concentration factor (MCF), and the toxicity response factor (TRF), had been examined using this technique. Other previous research has also used the same methodology [70–73].

$$\mathrm{PRF} = \mathrm{Cs}/\mathrm{Cb} \tag{1}$$

PRF- potential ecological risk factor; Cs-concentration of sample; Cb-background concentration (least concentration in the study)

$$\mathrm{PLI} = \sqrt{\mathrm{PRF}} \tag{2}$$

PLI- pollution load index

$$\mathrm{PRI} = \sum [(\mathrm{Pi} / \mathrm{Cs}) * \mathrm{S}] \tag{3}$$

PRI- potential ecological risk index; 'Pi' - number of specific polymer types collected at each sampling location; 'S' - hazard scores of polymers of MPs obtained from Lithner et al. (2011) [74].

$$\mathrm{PHI} = \Sigma \mathrm{Pn} \times \mathrm{S} \tag{4}$$

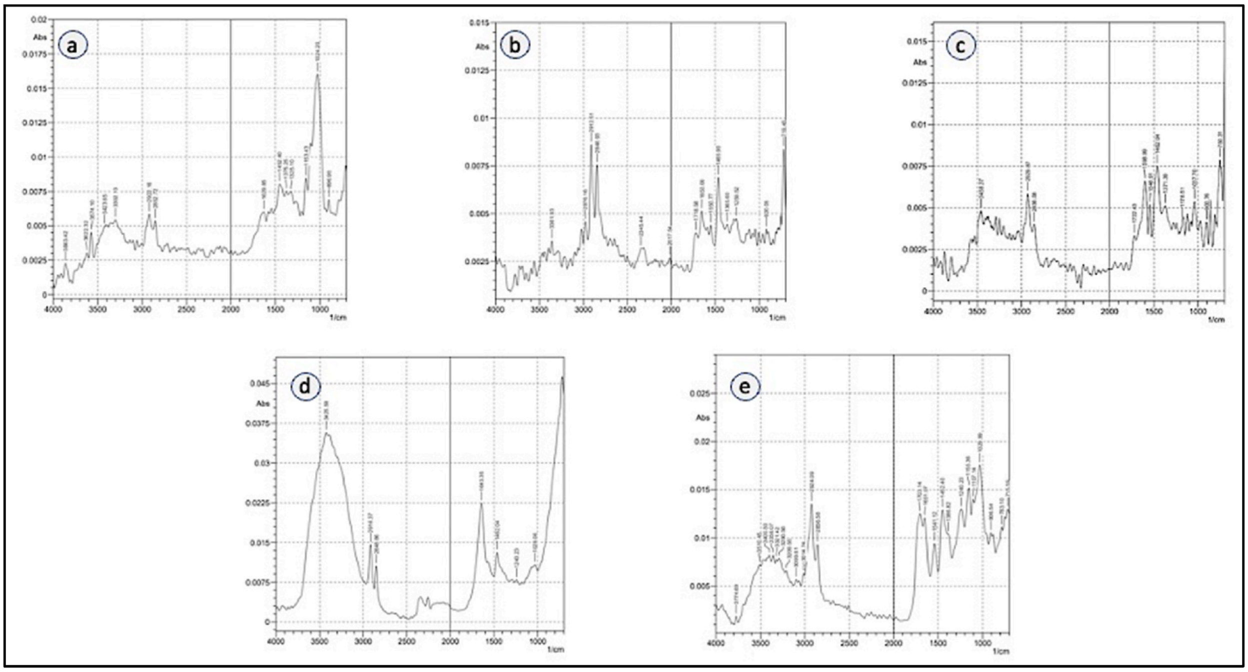

Fig. 3. The illustration represents the FTIR spectrum of microplastics used for identifying polymer composition. (a = Polyamide; b = Polyethylene; c = Polyethylene terephthalate; d = Polypropylene; e = Polyurethane).

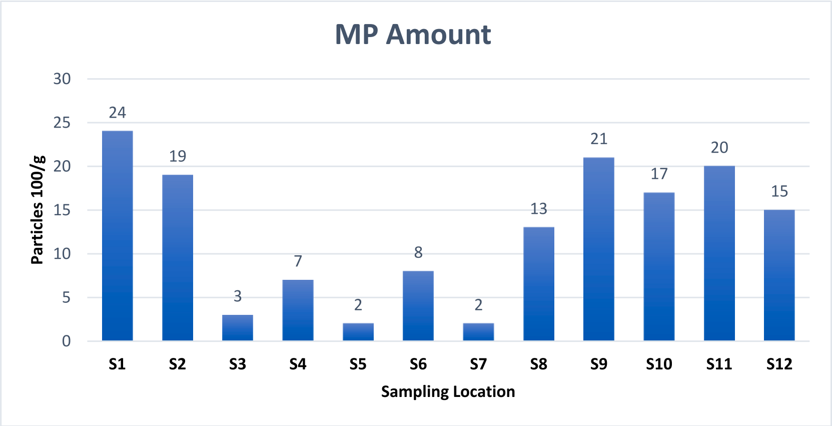

Fig. 4. The spatial abundance of microplastics in the study area.

PHI- Polymer Hazard Index; Pn –specific polymer percentage. PHI was determined using the technique given by Ranjani et al. (2021) using polymer scores supplied by Lithner et al. (2011) [74].

4. Results and discussion

4.1. Stereoscopic identification of potential microplastics

With the aid of a stereomicroscope, microplastics (MPs) were found in soil samples from an industrial area in Bangladesh. A total of 151 microplastic particles were detected across 12 separate sampling locations spread among industrial areas, near the metropolitan city areas, and urban lands. According to the results of the study, it is observed that the soil samples contain microplastics in various shapes, colors, and sizes.

Identified MPs are categorized into four types according to their shape: fiber (Fig. 2 a,b), fragment (Fig. 2c), foam (Fig. 2d), and film (Fig. 2e). In every sampling site, fibers were found to be the most prevalent shape. Among a total of 151 identified MPs, 91 fibers were counted, representing about 60% of the total MPs. Fragments were the second most dominant type. With 29 particles, it accounts for

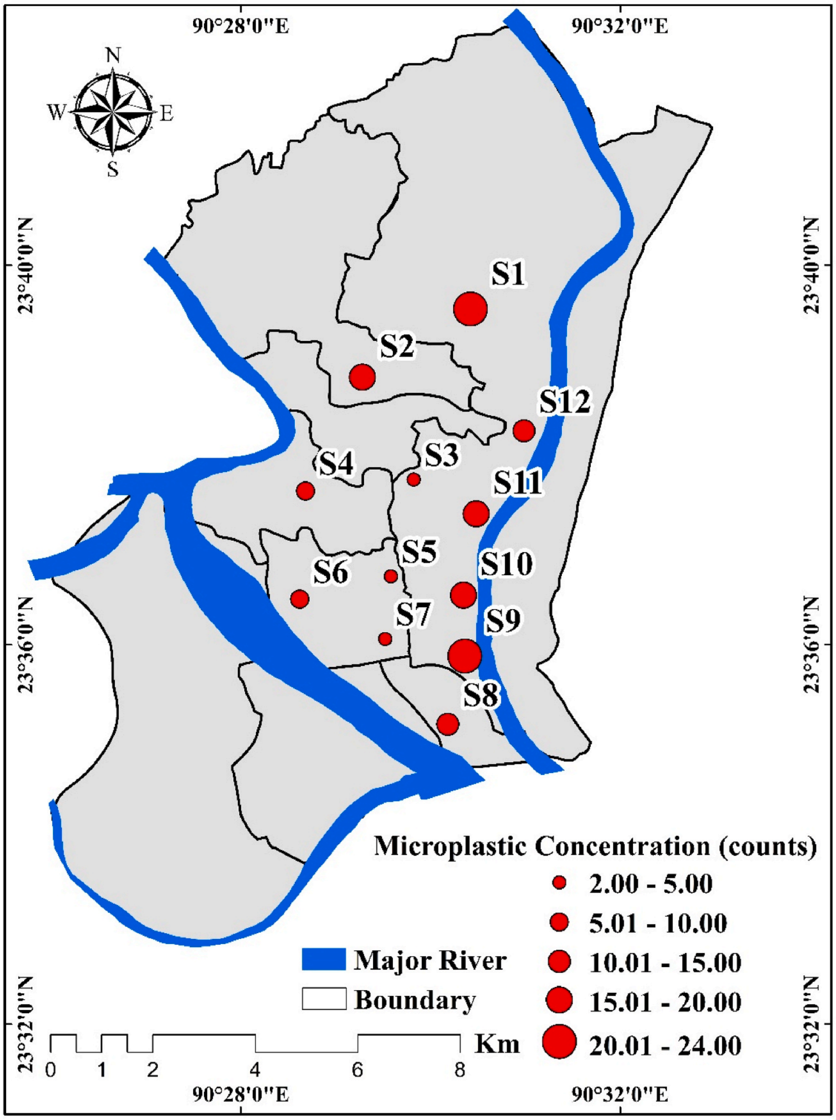

Fig. 5. The spatial concentration of the identified microplastics in the sampled locations.

19% of the overall quantity. Films and foam were counted in similar quantities (16 and 15 respectively), making up roughly 10% of the total amount of MPs. So, in brief, the distinct morphologies in the soil samples of the study area were detected in the following order: fiber > fragment > film > foam.

This result is consistent with some other research conducted in Bangladesh where the types of identified MPs included fiber, fragment, film, and foam. Among these four types of particles, fiber was found by Tajwar et al. (2022b) to be the most prevalent in urban land areas, industrial areas, and near metropolitan city areas. One study on farmland soil in central Bangladesh found that the fragment type was higher [75]. If we also compare this result to the coastal regions of Bangladesh, we find that in three research [29,41,55] fiber was discovered to be the abundant type of MPs, while in another two studies, fragment type is discovered to be higher [39,76]. Fibers are also the most common particle in the rest of the world, with more than 70% of discovered MPs being fibrous in various locations [77,78]. The use of synthetic textiles in garments may have contributed to this larger percentage of fibers [64,79,80].

The majority of the MPs calculated in this study (63%) were 0.5–1 mm in size, followed by 1–1.5 mm (25%) and <0.5 mm (12%).

The recorded MPs (59%) were found to be colored, while the remaining (41%) were fairly transparent. At Changjiang Estuary, China, Peng et al. (2017) [81] found MPs were white (52%), red (15%), black (18%), and others (15%), which is consistent with Tajwar et al. (2022c) and [39]. Nevertheless, shape, size, and color variations may be attributable to the source type of MPs in different places.

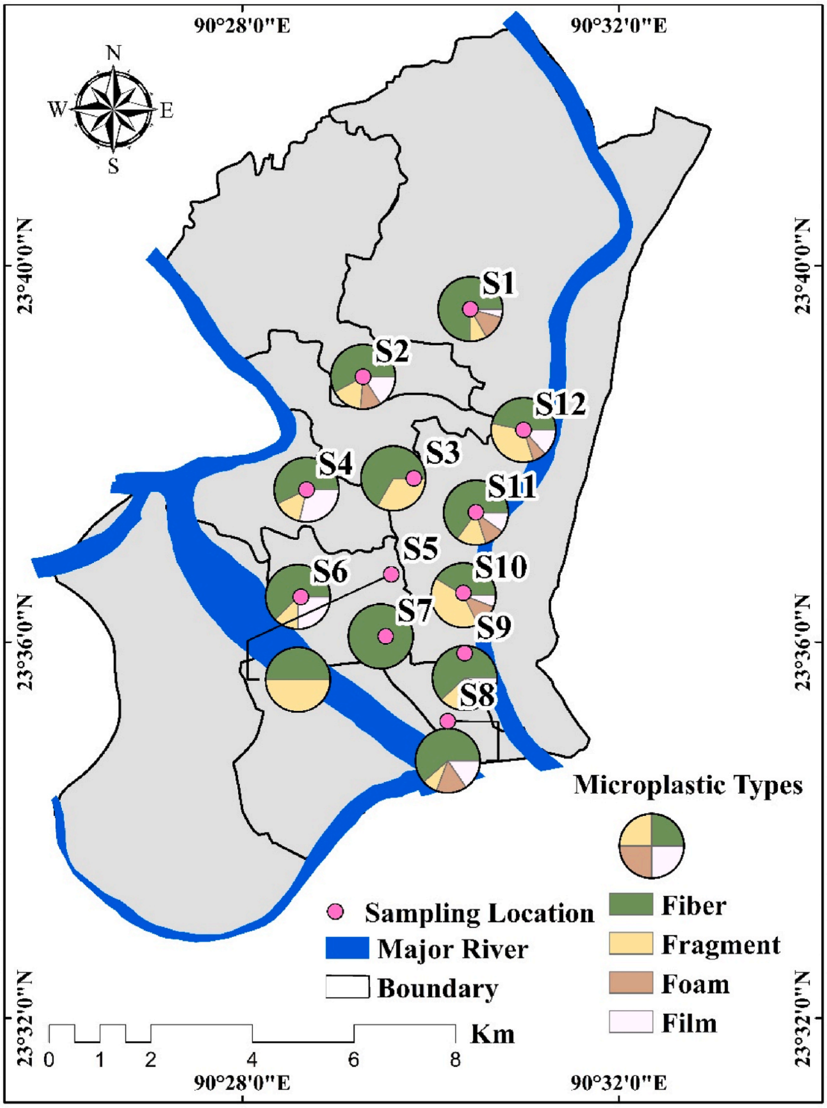

Fig. 6. The spatial distribution of fibers, fragments, films, and foams in a pie chart delineating the quantity of the types of microplastic in the sampled locations.

4.2. ATR-FTIR analysis of potential MPs

The polymer composition of the detected MPs was analyzed and tallied using the ATR-FTIR method by evaluating the individual transmittance and absorbance bands of the soil samples.

In this study, 5 types of diverse polymers were identified by FTIR (Fig. 3), including Polyamide, Polyethylene, Polyethylene terephthalate, Polypropylene, and Polyurethane .

From the result, it is observed that Polyamide had been the most dominant type of polymer (60%). The second most abundant polymer was polypropylene covering 14% of the total detected polymers. The third most found one belonged to Polyethylene (10.6%) followed by Polyurethane (10%). Polyethylene terephthalate accounted for nearly 5%.

Additionally, the findings revealed that the majority of fibrous microplastics were formed of Polyamide. Further, Polypropylene and Polyethylene Terephthalate made up the fragmented microplastics. Foam consisted of Polyurethane and film was found to be composed of polyethylene.

Polyamides are frequently used in textiles, the automobile sector, cooking utensils, and sportswear due to their high durability and strength. Another found polymer Polyethylene is used to make shopping bags, trash bags, food wraps, plastic films, and many other products [57]. Yogurt containers, straws, wrapping films, diapers, and specialty bags all are made with polypropylene polymers [31]. Manufacturing shopping bags, water bottles, containers, clothing, building materials, and other items use polyethylene terephthalate. So, these sources may be relevant while tracing back to the origin of the polymers as the samples were collected from the industrial

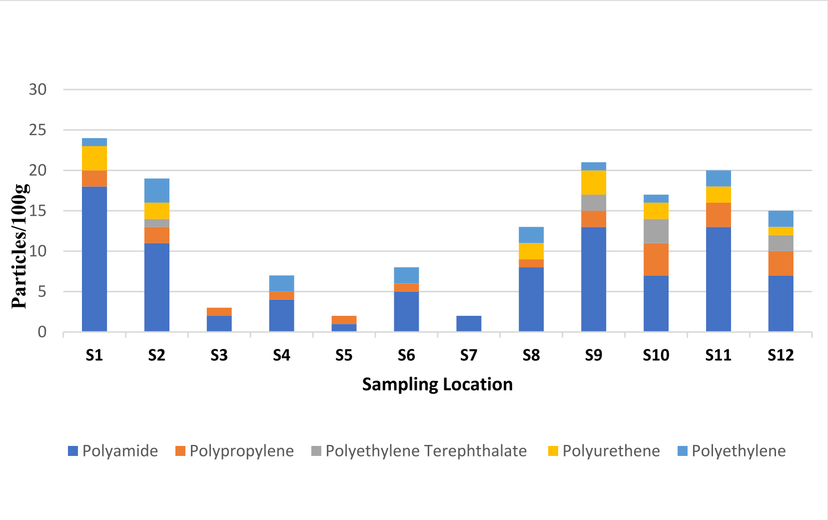

Fig. 7. The abundance and distribution of polymer types in the study area.

region, near the metropolitan city and urban lands.

4.3. Spatial distribution of MPs

From the analyses, it is found that each of the 12 locations of the study area had a different level of microplastic contamination and it is distinguishable by the land use of the study area. To calculate the number of MP particles, 100 gm of soil sample was examined from each sampling site. From the result and from Fig. 4, it is observed that MPs are in higher numbers in S1, S2, S8, S9, S10, S11, and S12 sites which are industrial regions and have the highest number in S1 (24). A total of 129 particles are found in these industrial areas which cover 85% of the total detected MPs in the entire study area. Compared to this, MPs were found in a lower amount in the other sampling sites. Two sampling sites from near metropolitan city areas S4 and S6 had 7 and 8 i.e., a total of 15 particles. And the other three sampling sites from urban lands S3, S5, and S7 had a total of 7 particles.

Based on the type of MPs, Fig. 5 depicts the spatial abudance of MPs. The result revealed that fibre was highly abundant in S1 (18), S2 (11), S9 (13) and S1 (13) areas and least abundant in S5 (1). Fragment was found in the highest number in S10 (7). The other sampling sites had fragments of less than 5. Foam and film were found to be more or less similar in number (0–3) in all the sampling sites (see Fig. 6).

The distribution and spatial abundance of MPs are closely correlated with the surrounding industrial and human activities. Assessing the presence of MP particles in soils under various land uses, we discovered conclusive evidence of microplastic contamination in industrial regions in higher amounts and in urban lands and near metropolitan city areas in lesser amounts. The findings from the current study can be compared with some previous studies for similar land uses. In a coal mine region of Bangladesh, a total of 24 MPs had been found from two sampling sites and 27 MPs had been found from two near metropolitan cities which is comparatively lesser in amount than the present study [33]. In terms of global context, the present study can be better compared with a textile industrial area in Shaoxing city, China where an abundance of MPs varied from 16.7 to 1323.3 items/kg (DW) in the sediment sample which is much higher than the present research findings [82]. Again, another study in Sydney, Australia it is observed that MPs were found to be of the amount 2400 mg/kg on average with a range of 300 mg/kg to 67500 mg/kg which also indicates higher contamination than the present study [83].

As the present study area is home to several textiles and industries, it is assumed that this MPs contamination was induced by the production and trading operations of textile industries. Also, poor waste disposal systems from industrial operations influence the abundance of MP in larger amounts in the industrial region followed by metropolitan city areas and urban lands. To effectively reduce local MP pollution, it is recommended that strict regulations should be implemented in the future [82].

4.4. Spatial distribution of identified polymer types

The spatial distribution and abundance of the identified polymers – Polyamide, Polypropylene, Polyethylene Terephthalate, Polyurethane, and Polyethylene are shown in a bar diagram displaying the amount of detected polymer throughout the study area (Fig. 7) (see Fig. 8).

From Fig. 7, it can be clearly observed that polyamide was found to be the most abundant polymer in all the sampling locations and among those, S1 contained the highest polyamide (18) followed by S9 (13), S11 (13), S2(11), S8 (8), S6 (5), S10 (7), S12 (7), S4 (4), S3 (2), S7 (2), and S5 (1). Polypropylene was found highest in S10 (4). At S11 and S12 the amount of polypropylene was 3. Other than these, all other sampling sites had 1 or 2 polypropylenes with no amount in S7. Polyethylene Terephthalate had been found in only 4

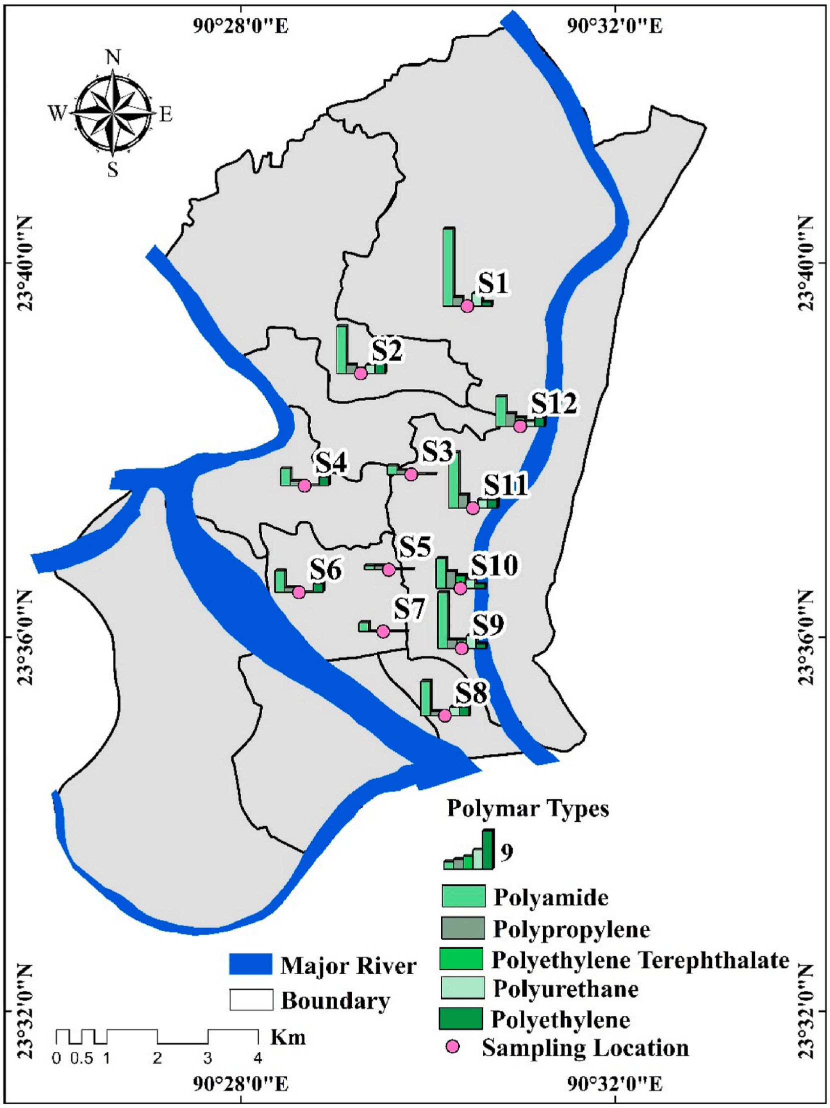

Fig. 8. The polymer concentration in of the sampled locations.

locations among 12 sampling locations. And among those 4 locations, S10 contained the highest amount (3). Polyurethane was found in 7 samples having 1 to 3 in amount. Polyethylene was found in 9 sampling locations except for the three locations which are urban lands. It also ranged between 1 and 3 in the individual samples.

4.5. Risk assessment of MP pollution

PLI, PRI, PHI, and CF (Fig. 9) have been used to evaluate the risk of microplastic contamination in the study area. Based on the calculated outcomes and scores, the level of risk has been discussed for each factor. From the results, it was found that the PLI (Eqn. (2)) values ranged from 1.00 to 3.46 in the entire study area, which can be put under the low-risk category (I). PRI (Eqn. 3) values (ranging from 150 to 600) revealed medium risk (II) in S1, S8, S9, and S10 sites, which are in industrial regions, while all other sampling sites were classified as low-risk (I) as the PRI values were below 150. In the industrial regions of the study area (S1, S2, S8, S9, S10, S11, and S12), PHI (Eqn. (4)) values have been found to be higher than 1000, which is classified as 'danger' (category IV). MPs from areas near metropolitan cities (S3, S5, and S7) with a PHI value of 100–1000 fall into the high-risk category (III). The other two urban lands sampling sites (S4 and S6) showed PHI values of less than 100, belonging to the medium-risk category (II). However, by stations, CF has been measured the highest in industrial areas, e.g., S1 (12), S2 (9.5), S8 (6.5), S9 (10.5), S10 (8.5), S11 (10), and S12 (7.5). After industrial regions, near metropolitan areas showed a bit higher CF value (3.5 and 4). Urban land areas showed lower CF values (1.5 and 1). So, observing all the values of each risk assessment factor clearly, it can be said that the risk is much higher in the industrial regions, followed by metropolitan city areas and urban lands.

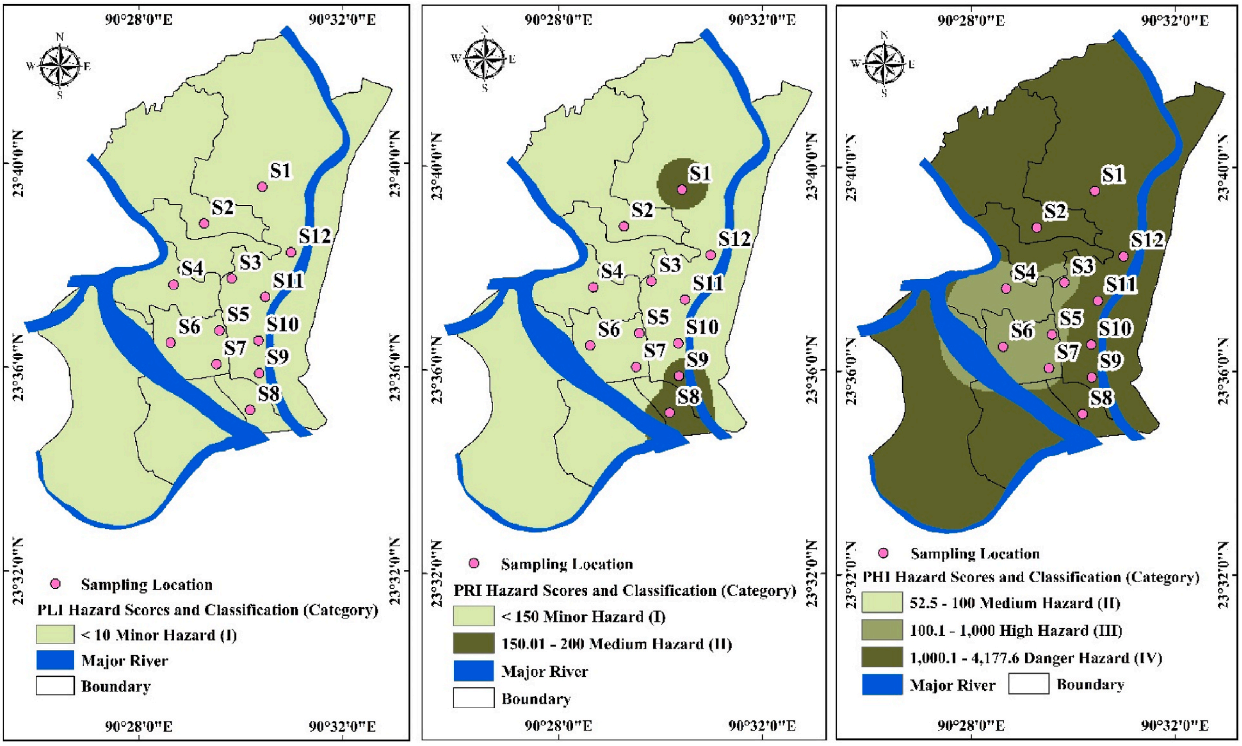

Fig. 9. Spatial distribution maps of risk evaluation indices in the study area.

Due to the fact that many terrestrial and marine organisms consume MPs, these have an effect on soil animals and soil microbiota [84,85]. MPs taken up by plants may transfer to humans via the food chain, posing serious dangers to human health and biota [72]. Therefore, studies on the ecological risk of MPs contamination are very significant.

A few studies have been found that conducted risk assessments in marine environments [32,84,86]. However, no such prior study has been found on the ecological risk assessment of microplastics in any industrial region. Hence, our research findings provided preliminary information on MPs pollution in the study area and quantitative estimates of the level of ecological risk, which would help future research in this field.

5. Conclusion

This research was undertaken to determine whether MPs are present or not and if present, with the aim of identifying the presence of MPs and determining its level of toxicity in the industrial area of the Narayanganj region in Bangladesh. This study presents both qualitative and quantitative data on the prevalence of plastic pollution in three distinct categories of environments. The most abundant kind of microplastic was found to be fibers, which made up of 60% of the total, followed by fragments, which made up 19% of the total. Narayanganj is a region with high anthropogenic influences such as industrial, and domestic activities, which contribute to the presence of microplastics. Thus, the current study attempted to figure out the potential ecological risks of microplastics in this region. The PHI, PLI, and PRI scores place the region in the category of moderate to high-risk zone. The hazard scores are directly proportional to the polymer composition and abundance of microplastics. A higher number of high-hazard polymers, such as Polyamide and Polyurethane have contributed to this elevated danger. This work increased our understanding of the pollution and toxicity of MPs in an industrial region of Bangladesh and provided an impulsion for further research to identify the source and consequences of MPs in an industrial setting. In addition to providing a worldwide context for the level of microplastic toxicity in an industrial location, the study will also assist in providing a global perspective on the issue.

Author contribution statement

Mahir Tajwar: Contributed reagents, materials analysis toos or data, Performed the experiment, Wrote the paper.
Mahmudul Hasan: Analyzed and interpreted the data, Wrote the paper.
Shamiha Shafinaz Shreya: Conceived and designed the experiments, Wrote the paper.
Mahfuzur Rahman: Analyzed and Interpreted the data, Wrote the paper.
Md. Yousuf Gazi: Conceived and designed the experiments, Wrote the paper.
Nazmus Sakib: Analyzed and interpreted the data, Wrote the paper.

Data availability statement

Data included in article/supp. material/referenced in article.

Additional information

No additional information is available for this paper.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not Applicable.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

The authors are grateful to the Centre for Advanced Research in Sciences (CARS), the University of Dhaka, and the Department of Oceanography, University of Dhaka for allowing laboratory analyses of the soil samples.

References

[1] T. Islam, Y. Li, M.M. Rob, H. Cheng, Microplastic pollution in Bangladesh: research and management needs, Environ. Pollut. (2022), 119697.
[2] C.M. Boerger, G.L. Lattin, S.L. Moore, C.J. Moore, Plastic ingestion by planktivorous fishes in the North pacific central gyre, Mar. Pollut. Bull. 60 (2010) 2275–2278.
[3] M. Cole, P. Lindeque, C. Halsband, T.S. Galloway, Microplastics as contaminants in the marine environment: a review, Mar. Pollut. Bull. 62 (2011) 2588–2597.
[4] S. Rist, B.C. Almroth, N.B. Hartmann, T.M. Karlsson, A critical perspective on early communications concerning human health aspects of microplastics, Sci. Total Environ. 626 (2018) 720–726.
[5] M.A.M. Siddique, M. Rahman, S.M.A. Rahman, M.R. Hassan, Z. Fardous, M.A.Z. Chowdhury, M.B. Hossain, Assessment of heavy metal contamination in the surficial sediments from the lower Meghna River estuary, Noakhali coast, Bangladesh, Int. J. Sediment Res. 36 (2021) 384–391.
[6] H.S. Auta, C.U. Emenike, S.H. Fauziah, Distribution and importance of microplastics in the marine environment: a review of the sources, fate, effects, and potential solutions, Environ. Int. 102 (2017) 165–176.
[7] J. Boucher, D. Friot, Primary Microplastics in the Oceans: a Global Evaluation of Sources, Iucn Gland, Switzerland, 2017.
[8] S. Chatterjee, S. Sharma, Microplastics in our oceans and marine health, F. Actions Sci. Reports, J. F. Actions. (2019) 54–61.
[9] G. Kibria, D. Nugegoda, G. Rose, A.K.Y. Haroon, Climate change impacts on pollutants mobilization and interactive effects of climate change and pollutants on toxicity and bioaccumulation of pollutants in estuarine and marine biota and linkage to seafood security, Mar. Pollut. Bull. 167 (2021), 112364.
[10] G. Suzuki, N. Uchida, K. Tanaka, H. Matsukami, T. Kunisue, S. Takahashi, P.H. Viet, H. Kuramochi, M. Osako, Mechanical recycling of plastic waste as a point source of microplastic pollution, Environ. Pollut. 303 (2022), 119114.
[11] J.L. Conkle, C.D. Báez Del Valle, J.W. Turner, Are we underestimating microplastic contamination in aquatic environments? Environ. Manage. 61 (2018) 1–8.
[12] J. Yuan, J. Ma, Y. Sun, T. Zhou, Y. Zhao, F. Yu, Microbial degradation and other environmental aspects of microplastics/plastics, Sci. Total Environ. 715 (2020), 136968.
[13] S.T.L. Sait, L. Sørensen, S. Kubowicz, K. Vike-Jonas, S. V Gonzalez, A.G. Asimakopoulos, A.M. Booth, Microplastic fibres from synthetic textiles: environmental degradation and additive chemical content, Environ. Pollut. 268 (2021), 115745.
[14] S.A. Carr, J. Liu, A.G. Tesoro, Transport and fate of microplastic particles in wastewater treatment plants, Water Res. 91 (2016) 174–182.
[15] M.M. Haque, F.Y. Nupur, F. Parvin, S.M. Tareq, Occurrence and characteristics of microplastic in different types of industrial wastewater and sludge: a potential threat of emerging pollutants to the freshwater of Bangladesh, J. Hazard. Mater. Adv. 8 (2022), 100166.
[16] V.Z. Sönmez, C. Akarsu, N. Sivri, Impact of coastal wastewater treatment plants on microplastic pollution in surface seawater and ecological risk assessment, Environ. Pollut. 318 (2023), 120922.
[17] C. Alomar, F. Estarellas, S. Deudero, Microplastics in the Mediterranean Sea: deposition in coastal shallow sediments, spatial variation and preferential grain size, Mar. Environ. Res. 115 (2016) 1–10.
[18] M. Tajwar, S.S. Shreya, M.Y. Gazi, M.B. Hossain, Abundance and distribution of MPs and NPs in soil: a global scenario, in: Micro Nanoplastics Soil Threat. To Plant-Based Food, Springer, 2023, pp. 35–57.
[19] K. Schmid, K.O. Winemiller, D. Chelazzi, A. Cincinelli, L. Dei, T. Giarrizzo, First evidence of microplastic ingestion by fishes from the Amazon River estuary, Mar. Pollut. Bull. 133 (2018) 814–821.
[20] X. Sun, Q. Li, M. Zhu, J. Liang, S. Zheng, Y. Zhao, Ingestion of microplastics by natural zooplankton groups in the northern South China Sea, Mar. Pollut. Bull. 115 (2017) 217–224.
[21] A. Naji, M. Nuri, A.D. Vethaak, Microplastics contamination in molluscs from the northern part of the Persian Gulf, Environ. Pollut. 235 (2018) 113–120.
[22] R. Kumar, R. Sinha, M.R.J. Rakib, S. Padha, N. Ivy, S. Bhattacharya, A. Dhar, P. Sharma, Microplastics pollution load in sundarban delta of bay of bengal, J. Hazard. Mater. Adv. (2022), 100099.
[23] K. Kor, A. Mehdinia, Neustonic microplastic pollution in the Persian Gulf, Mar. Pollut. Bull. 150 (2020), 110665.
[24] R. Sutton, S.A. Mason, S.K. Stanek, E. Willis-Norton, I.F. Wren, C. Box, Microplastic contamination in the san francisco bay, California, USA, Mar. Pollut. Bull. 109 (2016) 230–235.
[25] O. for E.C. and Development, Global Plastics Outlook, Policy Scenarios to 2060, OECD Publishing, 2022.
[26] M.C. Heller, M.H. Mazor, G.A. Keoleian, Plastics in the US: toward a material flow characterization of production, markets and end of life, Environ. Res. Lett. 15 (2020), 94034.

[27] H. Ritchie, M. Roser, Plastic Pollution, Our World Data, 2018.

[28] G. Vandermeersch, L. Van Cauwenberghe, C.R. Janssen, A. Marques, K. Granby, G. Fait, M.J.J. Kotterman, J. Diogène, K. Bekaert, J. Robbens, A critical view on microplastic quantification in aquatic organisms, Environ. Res. 143 (2015) 46–55.

[29] M.B. Hossain, P. Banik, A.-A.U. Nur, T. Rahman, Abundance and characteristics of microplastics in sediments from the world's longest natural beach, Cox's Bazar, Bangladesh, Mar. Pollut. Bull. 163 (2021), 111956.

[30] M. Mourshed, M.H. Masud, F. Rashid, M.U.H. Joardder, Towards the effective plastic waste management in Bangladesh: a review, Environ. Sci. Pollut. Res. 24 (2017) 27021–27046.

[31] M.S. Hossain, M.B. Hossain, M.R.J. Rakib, Y.N. Jolly, M.A. Ullah, M. Elliott, Ecological and human health risk evaluation using pollution indices: a case study of the largest mangrove ecosystem of Bangladesh, Reg. Stud. Mar. Sci. 47 (2021), 101913.

[32] M.R.J. Rakib, A. Ertaş, T.R. Walker, M.J. Rule, M.U. Khandaker, A.M. Idris, Macro marine litter survey of sandy beaches along the Cox's Bazar Coast of Bay of Bengal, Bangladesh: land-based sources of solid litter pollution, Mar. Pollut. Bull. 174 (2022), 113246.

[33] M. Tajwar, S.S. Shreya, M. Hasan, M.B. Hossain, M.Y. Gazi, N. Sakib, Assessment of microplastics as contaminants in a coal mining region, Heliyon 8 (2022), e11666.

[34] Z.A. Pushan, E. Rahman, N. Islam, N. Aich, A critical review of the emerging research on the detection and assessment of microplastics pollution in the coastal, marine, and urban Bangladesh, Front. Environ. Sci. Eng. 16 (2022) 1–14.

[35] M.J. Hossain, S. AftabUddin, F. Akhter, N. Nusrat, A. Rahaman, M.N.A. Sikder, M.M. Monwar, M.S.N. Chowdhury, S. Jiang, H. Shi, Surface water, sediment, and biota: the first multi-compartment analysis of microplastics in the Karnafully river, Bangladesh, Mar. Pollut. Bull. 180 (2022), 113820.

[36] S. Al Nahian, M.R.J. Rakib, S.M.B. Haider, R. Kumar, M. Mohsen, P. Sharma, M.U. Khandaker, Occurrence, spatial distribution, and risk assessment of microplastics in surface water and sediments of Saint Martin Island in the Bay of Bengal, Mar. Pollut. Bull. 179 (2022), 113720.

[37] S. Sarker, A.N.M.S. Huda, M.N.H. Niloy, G.W. Chowdhury, Trophic transfer of microplastics in the aquatic ecosystem of Sundarbans mangrove forest, Bangladesh, Sci. Total Environ. (2022), 155896.

[38] A. Ashrafy, A.A. Liza, M.N. Islam, M.M. Billah, S.T. Arafat, M.M. Rahman, S.M. Rahman, Microplastics pollution: a brief review of its source and abundance in different aquatic ecosystems, J. Hazard. Mater. Adv. (2022), 100215.

[39] M. Rakib, R. Jahan, S. Al Nahian, M.B. Alfonso, M.U. Khandaker, C.E. Enyoh, F.S. Hamid, A. Alsubaie, A.S.A. Almalki, D.A. Bradley, Microplastics pollution in salt pans from the Maheshkhali Channel, Bangladesh, Sci. Rep. 11 (2021) 1–10.

[40] M. Tajwar, S. Saha, S. Saha, M. Gazi, M. Gazi, Identification and spatial distribution of microplastics in the coastal regions of cox's bazar, Bangladesh, in: Geol. Soc. Am. Abstr. With Programs. Southeast. Sect, . Annu. Meet. Geol. Soc. Am., 2021, 10.1130/Abs/2021se-362277.

[41] M. Tajwar, S.S. Shreya, M.Y. Gazi, M. Hasan, S.K. Saha, Microplastic contamination in the sediments of the Saint Martin's Island, Bangladesh, Reg. Stud. Mar. Sci. 53 (2022), 102401.

[42] M.S. Hossain, F. Sobhan, M.N. Uddin, S.M. Sharifuzzaman, S.R. Chowdhury, S. Sarker, M.S.N. Chowdhury, Microplastics in fishes from the northern bay of bengal, Sci. Total Environ. 690 (2019) 821–830.

[43] M.S. Hossain, M.S. Rahman, M.N. Uddin, S.M. Sharifuzzaman, S.R. Chowdhury, S. Sarker, M.S.N. Chowdhury, Microplastic contamination in penaeid shrimp from the northern bay of bengal, Chemosphere 238 (2020), 124688.

[44] M.A.M. Siddique, A. Uddin, S.M.A. Rahman, M. Rahman, M.S. Islam, G. Kibria, Microplastics in an anadromous national fish, Hilsa shad Tenualosa ilisha from the Bay of Bengal, Bangladesh, Mar. Pollut. Bull. 174 (2022), 113236.

[45] A.A. Koelmans, P.E. Redondo-Hasselerharm, N.H.M. Nor, V.N. de Ruijter, S.M. Mintenig, M. Kooi, Risk assessment of microplastic particles, Nat. Rev. Mater. 7 (2022) 138–152.

[46] A. Ahmed, S.M. Tareq, Textile Industries in Bangladesh: A Rising Environmental Degradation Down the Drains. Bangladesh Textile Today, 2008.

[47] M.A. Rahman, K.S. Islam, S.I. Siam, S. Islam, SPATIOTEMPORAL CHANGE OF LAND USE LAND COVER: A CASE STUDY OF NARAYANGANJ SADAR UPAZILA, BANGLADESH, Khulna Univ. Stud., 2022, pp. 233–243.

[48] M.A. Hoque, W.G. Burgess, M. Shamsudduha, K.M. Ahmed, Delineating low-arsenic groundwater environments in the bengal aquifer system, Bangladesh, Appl. Geochem. 26 (2011) 614–623.

[49] S.L. Goodbred Jr., S.A. Kuehl, Floodplain processes in the Bengal Basin and the storage of Ganges–Brahmaputra river sediment: an accretion study using 137Cs and 210Pb geochronology, Sediment. Geol. 121 (1998) 239–258.

[50] M.G. Mortoja, T. Yigitcanlar, How does peri-urbanization trigger climate change vulnerabilities? An investigation of the dhaka megacity in Bangladesh, Rem. Sens. 12 (2020) 3938.

[51] A.H.M. Noman, M.A. Mia, H. Banna, M.S. Rana, A.S.A.F. Alam, C.S. Gee, C.R. Isa, A.C. Er, City profile: Narayanganj, Bangladesh, Cities 59 (2016) 8–19.

[52] Bangladesh Bureau of Statistics, District statistics Narayanganj 2011, statistics and information Division,Ministry of planning, government of people republic of Bangladesh, Available at: http://203.112.218.65:8008/WebTestApplication/userfiles/Image/District%20Statistics/Narayanganj.pdf, 2013. (Accessed 26 March 2023). Retrieved.

[53] A. Ahmed, M.A. Quader, Environmental aspects of solid waste management: a case study of Narayanganj city, ASA Univ. Rev. 5 (2011) 133–143.

[54] S. Afrin, M.K. Uddin, M.M. Rahman, Microplastics contamination in the soil from urban landfill site, dhaka, Bangladesh, Heliyon 6 (2020), e05572.

[55] M. Tajwar, M. Yousuf Gazi, S.K. Saha, Characterization and spatial abundance of microplastics in the coastal regions of Cox's Bazar, Bangladesh: an integration of field, laboratory, and GIS techniques, Soil Sediment Contam, Int. J. 31 (2022) 57–80.

[56] R.L. Coppock, M. Cole, P.K. Lindeque, A.M. Queirós, T.S. Galloway, A small-scale, portable method for extracting microplastics from marine sediments, Environ. Pollut. 230 (2017) 829–837.

[57] S. Hossain, M.A. Rahman, M.A. Chowdhury, S.K. Mohonta, Plastic pollution in Bangladesh: a review on current status emphasizing the impacts on environment and public health, Environ. Eng. Res. 26 (2021).

[58] J.C. Prata, J.P. da Costa, A.C. Duarte, T. Rocha-Santos, Methods for sampling and detection of microplastics in water and sediment: a critical review, TrAC Trends Anal. Chem. 110 (2019) 150–159.

[59] V. Hidalgo-Ruz, L. Gutow, R.C. Thompson, M. Thiel, Microplastics in the marine environment: a review of the methods used for identification and quantification, Environ. Sci. Technol. 46 (2012) 3060–3075.

[60] P.K. Cheung, L.T.O. Cheung, L. Fok, Seasonal variation in the abundance of marine plastic debris in the estuary of a subtropical macro-scale drainage basin in South China, Sci. Total Environ. 562 (2016) 658–665.

[61] A.I. Catarino, V. Macchia, W.G. Sanderson, R.C. Thompson, T.B. Henry, Low levels of microplastics (MP) in wild mussels indicate that MP ingestion by humans is minimal compared to exposure via household fibres fallout during a meal, Environ. Pollut. 237 (2018) 675–684.

[62] K. Zhang, J. Su, X. Xiong, X. Wu, C. Wu, J. Liu, Microplastic pollution of lakeshore sediments from remote lakes in Tibet plateau, China, Environ. Pollut. 219 (2016) 450–455.

[63] J.P.G.L. Frias, R. Nash, Microplastics: finding a consensus on the definition, Mar. Pollut. Bull. 138 (2019) 145–147.

[64] M.A. Browne, P. Crump, S.J. Niven, E. Teuten, A. Tonkin, T. Galloway, R. Thompson, Accumulation of microplastic on shorelines woldwide: sources and sinks, Environ. Sci. Technol. 45 (2011) 9175–9179.

[65] S. Primpke, C. Lorenz, R. Rascher-Friesenhausen, G. Gerdts, An automated approach for microplastics analysis using focal plane array (FPA) FTIR microscopy and image analysis, Anal. Methods 9 (2017) 1499–1511.

[66] Y.K. Song, S.H. Hong, M. Jang, G.M. Han, M. Rani, J. Lee, W.J. Shim, A comparison of microscopic and spectroscopic identification methods for analysis of microplastics in environmental samples, Mar. Pollut. Bull. 93 (2015) 202–209.

[67] R. Li, L. Zhang, B. Xue, Y. Wang, Abundance and characteristics of microplastics in the mangrove sediment of the semi-enclosed Maowei Sea of the south China sea: new implications for location, rhizosphere, and sediment compositions, Environ. Pollut. 244 (2019) 685–692.

[68] C. Edo, M. Tamayo-Belda, S. Martínez-Campos, K. Martín-Betancor, M. González-Pleiter, G. Pulido-Reyes, C. García-Ruiz, F. Zapata, F. Leganés, F. Fernández-Piñas, Occurrence and identification of microplastics along a beach in the biosphere reserve of lanzarote, Mar. Pollut. Bull. 143 (2019) 220–227.

[69] L. Hakanson, An ecological risk index for aquatic pollution control. A sedimentological approach, Water Res. 14 (1980) 975–1001.

[70] G. Peng, P. Xu, B. Zhu, M. Bai, D. Li, Microplastics in freshwater river sediments in Shanghai, China: a case study of risk assessment in mega-cities, Environ. Pollut. 234 (2018) 448–456.

[71] R. Li, L. Yu, M. Chai, H. Wu, X. Zhu, The distribution, characteristics and ecological risks of microplastics in the mangroves of Southern China, Sci. Total Environ. 708 (2020), 135025.

[72] Z. Pan, Q. Liu, R. Jiang, W. Li, X. Sun, H. Lin, S. Jiang, H. Huang, Microplastic pollution and ecological risk assessment in an estuarine environment: the Dongshan Bay of China, Chemosphere 262 (2021), 127876.

[73] P. Prarat, P. Hongsawat, Microplastic pollution in surface seawater and beach sand from the shore of Rayong province, Thailand: distribution, characterization, and ecological risk assessment, Mar. Pollut. Bull. 174 (2022), 113200.

[74] D. Lithner, Å. Larsson, G. Dave, Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition, Sci. Total Environ. 409 (2011) 3309–3324.

[75] M.M. Himu, S. Afrin, M.A. Akbor, M.A.B. Siddique, M.K. Uddin, M.M. Rahman, Assessment of microplastics contamination on agricultural farmlands in central Bangladesh, Case Stud. Chem. Environ. Eng. 5 (2022), 100195.

[76] S.M.A. Rahman, G.S. Robin, M. Momotaj, J. Uddin, M.A.M. Siddique, Occurrence and spatial distribution of microplastics in beach sediments of Cox's Bazar, Bangladesh, Mar. Pollut. Bull. 160 (2020), 111587.

[77] A. Blašković, P. Fastelli, H. Čižmek, C. Guerranti, M. Renzi, Plastic litter in sediments from the Croatian marine protected area of the natural park of Telaščica bay (Adriatic Sea), Mar. Pollut. Bull. 114 (2017) 583–586.

[78] N. Sathish, K.I. Jeyasanta, J. Patterson, Abundance, characteristics and surface degradation features of microplastics in beach sediments of five coastal areas in Tamil Nadu, India, Mar. Pollut. Bull. 142 (2019) 112–118.

[79] E. Hernandez, B. Nowack, D.M. Mitrano, Polyester textiles as a source of microplastics from households: a mechanistic study to understand microfiber release during washing, Environ. Sci. Technol. 51 (2017) 7036–7046.

[80] I.E. Napper, R.C. Thompson, Release of synthetic microplastic plastic fibres from domestic washing machines: effects of fabric type and washing conditions, Mar. Pollut. Bull. 112 (2016) 39–45.

[81] G. Peng, B. Zhu, D. Yang, L. Su, H. Shi, D. Li, Microplastics in sediments of the changjiang estuary, China, Environ. Pollut. 225 (2017) 283–290.

[82] H. Deng, R. Wei, W. Luo, L. Hu, B. Li, H. Shi, Microplastic pollution in water and sediment in a textile industrial area, Environ. Pollut. 258 (2020), 113658.

[83] S. Fuller, A. Gautam, A procedure for measuring microplastics using pressurized fluid extraction, Environ. Sci. Technol. 50 (2016) 5774–5780.

[84] M. Ranjani, S. Veerasingam, R. Venkatachalapathy, M. Mugilarasan, A. Bagaev, V. Mukhanov, P. Vethamony, Assessment of potential ecological risk of microplastics in the coastal sediments of India: a meta-analysis, Mar. Pollut. Bull. 163 (2021), 111969.

[85] D. He, Y. Luo, S. Lu, M. Liu, Y. Song, L. Lei, Microplastics in soils: analytical methods, pollution characteristics and ecological risks, TrAC Trends Anal. Chem. 109 (2018) 163–172.

[86] M. Ranjani, S. Veerasingam, R. Venkatachalapathy, T.P.S. Jinoj, L. Guganathan, M. Mugilarasan, P. Vethamony, Seasonal variation, polymer hazard risk and controlling factors of microplastics in beach sediments along the southeast coast of India, Environ. Pollut. 305 (2022), 119315.