Assessment of microplastics as contaminants in a coal mining region

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ABSTRACT

Pollution generated by microplastics (MPs) has become an issue of global concern because of its severe effects on the general health of the ecosystem, especially the health of the terrestrial environment. There is a scarcity of data based on MP contamination research in Bangladesh that is currently available, and no work on MP contamination has previously been done in an industrial region of Bangladesh. As a result, this research was undertaken with the aim of determining whether or not MP contamination is present in the industrial area of the Barapukuria region in Bangladesh. The method of sieving and density separation was used in the process of extracting MPs from a total of 12 soil samples that were collected from the industrial area of Barapukuria. A stereomicroscope was utilized to accomplish the visual identification of the MPs. The concentration of MPs accounted for 1–15 items/100g (Mean: 6.75 ± 5.3) in the 12 sampled regions, mostly white in color and ranging in size from 0.5–1 mm. Fibers have been found to be the most prevalent among the detected MPs (fibers, foam, and fragments). 8-types of MPs (Mean: 0.32 ± 0.69) were detected in 5 rural farmland locations, 11 MPs (Mean: 1.1 ± 1.73) in 2 sub-urban farmland sites, 11 MPs (Mean: 2.2 ± 3.19) in 1 urban farmland site, 24 MPs (Mean: 2.4 ± 1.89) in 2 industrial locations, and 27 MPs (Mean: 2.7 ± 3.05) in 2 near metropolitan areas.

Based on the land use land cover analysis, higher contamination of MPs have been detected in the industrial and coal mine region of Barapukuria whereas relatively lower amount of MPs have been found in the rural and urban regions.

1. Introduction

Plastics are being used extensively in textile, construction, packaging, textile, agricultural, electronics manufacturing sectors, pharmaceutical, etc., since their mass production has been started during the early 20th century [1, 2]. Enormous plasticity, chemical stability, electrical insulation, and incredibly cheap and lightweight have boosted the global production of plastic materials steadily which is anticipated to be about 34 billion tons by 2050 [3]. Lower recycling propensity (only 9%), careless disposal, indiscriminate utilization, poor management, etc. are hitting the global annual plastic waste production to about 6.3 billion tons [4]. Once enter the environment, these wastes remain durable and find their way into freshwater systems, the oceans as well as in the terrestrial system [5]. In these habitats, plastics can create a deleterious threat to the biosphere by manipulating the functions of the prevailing ecosystem [6, 7, 8].

‘Microplastics’ refers to the very small pieces of plastic that are <5 mm in size, originating from various plastic materials such as polypropylene, polyethylene, polystyrene, etc. They are omnipresent both in all the spheres of the environment, water-insoluble, non-degradable (according to standardized tests), and create a serious threat to the existing biodiversity and ecosystem [9, 10]. Currently, MP pollution has been severely noticed in freshwater, marine, polar area, lands-every ecosystem of the earth [11, 12, 13, 14, 15]. However, the occurrence, characterization, fate, and effect of MPs in the terrestrial environment have got less attention from researchers compared to the aquatic

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environment which has created a gap of knowledge [15, 16, 17]. Since urban and industrial soils are loaded with discarded plastic materials more severely, more research priority should be given to them [18, 19].

Several studies suggested terrestrial environments as the most unique system that serves as a source of MP at the same time, their pathway of distribution towards the aquatic environments [15, 20, 21]. So far landfills have deposited about 79% of the total plastic garbage, hence the terrestrial soils have been noted as larger MPs sink in comparison to the oceans [15, 18, 22, 23]. Modern urban and industrial areas are the hotspots of plastic pollution because they involve kinds of activities highly such as packaging, construction, transportation, clothing, electronics, etc. which generate tons of plastic waste [24]. Once deposited on surface soil, smaller fragments are produced by disintegration and degradation processes of plastic materials [10, 17] which are termed secondary microplastics. Moreover, existing MPs, especially primary MPs, can also find their way into the terrestrial ecosystem directly [25]. On the other hand, MPs can absorb different organic pollutants [26] and can increase the bioavailability of heavy metals by acting as a catalyst in soil [27]. Therefore, smaller plastic materials can be transported through different elements of a terrestrial ecosystem by accumulation and uptake by soil biota [28].

Only a few research have existed that focused on MP-soil organism interaction and how it exerts a negative impact on the survival, growth, multiplication, and immunity of the soil organisms [6, 8, 10, 29]. Soil physical properties such as soil structures, porosity, water holding capacity, bulk density, aeration, etc. may be influenced by small-sized plastic materials [23]. In addition, different physico-chemical and biogeochemical properties of soil can be affected by MP pollution in various ways [30]. Changing of existing properties of soils eventually influences soil organisms which creates substantial adverse impacts on the functions and services of different elements of the polluted terrestrial ecosystem [31, 32, 33]. Furthermore, MP can produce some phytotoxic substances which adversely affect plant roots and soil faunas [18, 31]. Organic matter depletion as a consequence of MP accumulation in soil and sorption of toxic heavy metals with smaller plastic materials has been reported [27]. Excessive use of single-use plastics along with improper management of landfills without facilities of the waste separation system has been found as the primary and secondary sources of MP pollution in the terrestrial and marine environment of Bangladesh [34, 35, 36]. Several studies have shown that mega-plastics are harmful to the environment in this area. But Bangladesh still hasn’t done enough research on a large scale to figure out what MP pollution is and how it affects the land and water ecosystems [37, 38].

Since 2005, the Barapukuria Coal Mine has been the only working coal mine producing around one million metric tons of coal annually [39]. A coal-fired power plant was started in 2006 which is fed by the coal from the adjacent Barapukuria Coal Mine [40]. A busy urban area has been developed surrounding the mining and power plant area mostly resided by miners, engineers, officials, laborers, vendors, and local people. As a consequence, piles of plastic waste are being generated and
improper management of these wastes is posing threat to the surrounding biosphere of Barapukuria [100]. A number of studies have been conducted on the presence of MPs and the extent to which they are distributed across the coastal sediments of the South Asian region [41, 42, 43, 44, 45, 46, 47, 48, 49]. Recent research has shown that microplastic particles (MPs) can be found in aquatic fish and shrimp samples taken from the northern part of the Bay of Bengal [50, 51, 52, 53, 54], and investigations have been conducted to determine the extent to which the coastal region of Bangladesh is contaminated with MPs [13, 55, 56, 57, 58, 101]. Even though few studies on MP abundance has been done in agricultural and urban sites in Bangladesh [59, 60], to this day, there has been no research carried out in a coal mine region. Thus, the current study is the first attempt to provide a comprehensive analysis of the extent, sources, and characteristics of MPs in the industrial coal mine area of Barapukuria, Bangladesh.

2. Study area

Bearing the single actively producing coal mine in Bangladesh, the survey area Barapukuria is situated in the Parbatipur Upazilla of Dinajpur District, Rangpur Division, lying in the Bengal Basin’s northwestern region. The coordinates are latitude 25° 32’ 17” N to 25° 31’ 34.32” N and longitude 88° 56’ 31” E to 88° 58’ 05” E [40]. The area is 240 km northwest of Dhaka, the capital city of Bangladesh, and 25 km south of Saidpur, the nearest regional airport. The Dinajpur district has a flat surface topography. The average elevation is approximately 30–32 m above mean sea level [61]. The study area is part of the Gondwana basin, a plain land residuum underlying a series of sedimentary rocks of Pleistocene to Permian on the basement complex of the Precambrian age [62, 102]. The site’s climate is very sunny and humid all year, with noticeable seasonal variations in rainfall [63].

According to the Bangladesh population census report in 2011, on average 924 people/km² reside in the investigation area. People in the area are used to a rural lifestyle based on agricultural activity [64]. The Barapukuria coal mine is the largest project at present, nearby to the investigated site. The land around BCM is also primarily agricultural, with three varieties of paddy being the main crop [65]. In close proximity to this location, three rivers—the Jamuna, Ghimai, and Khorkhori—as well as a number of drainage channels intersect [66]. These streams have traditionally served as a source of local irrigation due to the rainfall-runoff process that primarily creates them [67] where approximately 1500 m³/hr is the drain’s discharge rate [61]. A common channel carries the wastewater from an industrial site of Barapukuriya, the Barapukuriya Coal Mine (BCM), and the thermal power plant that is situated on opposite sides of the BCM boundary. This coal-extracted drain water is frequently used for irrigation, especially during the dry season (winter), when the Ghimai river becomes dry and the river Khorkhori has a water shortage [68]. However, there is a low concentration of pollutants since the waste from the coal inrush distributes across a large region with a stream of drainage water during the monsoon, when the flow of the rivers increases.

3. Methodology

3.1. Sample collection and preparation

Surface soil samples were collected during the fieldwork conducted in the month of December 2021. Samples have been collected from 12 locations (Figure 1) that covered the industrial area of the Barapukuria coal mine and its surrounding, rural, urban, suburban, and farmlands. An overview of the locations where samples have been collected from has been shown in Figure 1. An amount of 12 soil samples have been extracted using a clean stainless-steel scrapper from a depth of 2 m from an area of about 30 cm² which cumulated to a bulk sample of 2.2 kg of soil [55]. The samples were primarily analyzed using the unaided eye to discard the materials larger than 10 mm in size. The soil samples had

Figure 2. Under a stereoscopic microscope, the figure depicts the identified microplastics in the investigated soil samples. Particles were classified into four types: (a) fiber; (b) foam; (c) film; and (d) fragment.
been kept in a well-sealed, fresh foil box made of aluminum (thickness 3 mm) and brought to the research laboratory.

3.2. Laboratory analysis

Specimens were removed from the foil box and scattered across the plate before being dried in an oven at 105 degrees celsius for a period of 24 h. After the samples were dried, a systematic extraction technique involving sieving was carried out using a succession of 8-inch Tyler Brass sieves with aperture diameters of 5, 2.5, 1.25, and 0.625 mm correspondingly [56]. After sieving for around 10–12 min, the weight of the collected grains has been quantified and displayed in relation to each mesh number [55]. To digest the organic matter, the sieved sample was put inside a glass beaker with a capacity of 100 ml of hydrogen peroxide solution with a concentration of 30 percent was added to each sample, and the beakers were heated at 65 degrees celsius for 24 h [13]. In order to increase the density of the aqueous solution, 6 g of NaCl salt had been added to every 20 mL of the sample (5 mM NaCl) [69], and the wet peroxide oxidation solution had been moved to a density separator [70] and left to settle for the night. Using a cellulose nitrate filter paper of 5.0 μm and 47 mm in diameter, the solution was filtered from the density separator [71].

For visual analysis, a stereo microscope (LEICA EZ4E) has been used to observe the presence of MPs in the collected sample. The filter paper was placed under the stereo microscope equipped with a built-in digital camera with a resolution of 5 megapixels HD, a zoom range of 8x-35x (including 10x eyepieces), and a built-in light-emitting diode with 25,000 h (LED) [72]. The MPs were detected and sorted out based on the identifying characteristics as described by some researchers [56,72,73]. A 5MP HD digital camera was used to capture the pictures of the MPs that were found. The detected MP was grouped into three size classes: 0.3–0.5 mm, 0.5–1 mm, and 1–5 mm [29]. In addition to that, the various colors of MP particles were distinguished and cataloged. Fiber, fragments, films, microbeads, and foams were the categories that were used to classify the many forms of MPs [74].

The ATR-FTIR spectroscopy was performed with the equipment of Model: IRPrestige21; CAT No.: 206–72010-36; Serial No.: A2100450183 in order to identify the chemical structure of the MP. This was done in order to analyze the discovered MP and determine the presence of the kind of polymer that was there [75, 76, 77]. After the MPs had been loaded into the FTIR, it was subjected to bombardment with Infrared radiation in order to acquire the sample spectra based on the extent of absorbance. After the sample spectrum was obtained, the polymer was identified by determining the presence of the obtained absorbance band and then correlating the band's peaks with the information included in the spectral database [78]. The standard degree of resemblance for detection was decided at 80% as observed by some researcher [79].

Figure 3. The figure represents the spatial distribution of fiber, film, fragment, and foam in a pie chart depicting the amount of each of the types of MP in the sampled sites.
Geospatial software, ArcGIS (version 10.2), has been used to delineate the spatial distribution of MP abundance, individual categories of MP, and types of the related polymer and to correlate them to land use land cover analysis.

3.3. Quality control

In order to prevent any potential contamination from plastic, the soil samples had been stored in aluminum foil. During the time when the
samples were being handled, cotton lab coats and nitrile gloves were worn. All of the laboratory equipment that was utilized had been cleansed and thoroughly rinsed that had been through two distillation processes before and after each procedure. Before being used, the Petri dishes were given numerous washings and then were dried off. Throughout the entirety of the process, tools made of metal and glass were utilized. The ATR-crystal had been treated with isopropanol prior to the ART FTIR analysis being performed on it.
Figure 8. The figure shows the regional occurrence and distribution of microplastics in the sampled soil near Barapukuria Coal Mine.

Figure 9. The figure shows the spatial occurrence and distribution of the identified MPs in the sampled locations of Barapukuria. The circular red symbol on the map represents the level of concentration.
4. Results and discussion

4.1. Identification of microplastics using stereomicroscope

In the present study, microplastics (MPs) were identified using a stereomicroscope in several locations near the urban area of an industrial region at the Barapukuria coal mine. The samples were collected from 12 different locations, including farmland, residential areas, and industrial areas, containing a total of 81 MPs. According to the findings, MPs persist in soil samples in a variety of shapes, sizes, and colors.

MPs were classified into four types based on their shape: fibers, films, foams, and fragments (Figure 2). Fibers were encountered to be the most abundant shape on the majority of the sampling sites. Fibers were measured 45 times out of 81 detected MPs, accounting for more than half of all MPs. Following that, films were the second most abundant in the sampling locations, accounting for 28% of total MPs with 23 particles. A significant number of fragments and foam were also discovered (9 and 4 respectively). So, in the soil samples from the study area, the distinct shapes were identified in the following order: fiber > film > fragment > foam (Figure 3).

According to color classification, 55% were identified as colored, while the remaining 45% in this study were comparatively transparent. In terms of area, soil samples were collected from five different farmland near Barapukuria industrial/coal mine area, each exhibiting a different amount of concentration and shape of MPs.

Among the sampling sites in rural farmland, five (5) locations were in rural farmland of which MPs were found in four (4) samples and counted 8 in the total amount of MP within 500gm of Dry Weight (DW) soil. According to shape classification, 7 fiber types and 1 film type of MP were identified. Of the detected MPs, 35% have been found to be white, 35% red, 15% transparent, and 15% black. Two sites were selected from suburban farmland and from those 11 MP were found (200 g⁻¹). Among those, fiber types were counted 8 in amount, and film type was measured 3 in amount. 25% of the MPs are white, 25% transparent, 20% red, 20% black, and 10% have been observed to be blue. Eleven (11) MPs were found from only one sampling site of urban farmland. Based on types, those were fiber (7) and film (4) within 100gm of soil sample. Out of these MPs, 35% are transparent, 25% black, 20% red, and 20% have been detected to be white. In the stereomicroscopic analysis of 2 samples that were collected from near metropolitan city area, a total of 27 MPs were found within 200 gm Dry Weight (DW) soil. According to their shape classification, 14 MP were found as fiber, 9 were film, 2 were foam, and 2 were fragment type. Among the identified MPs, 25% have been observed to be transparent, 20% white, 15% red, 15% black, 15% brown, and 10% blue. Among two sampling sites near the coal mine region of Barapukuria, 24 MPs (200g⁻¹) were identified. From the identified ones, fiber was found 9 in amount. After that fragment type was found in a higher amount here (7). Film type was found 6 in amount and foam was found 2 in amount. Among them 30% is red, 20% transparent, 20% white, 20% black, and 10% is brown. Thus, MPs were found higher in the urban, metropolitan city region, and near industrial areas than the rural farmland which is congruent with the analysis of central farmlands in Bangladesh [59].

In the case of shape analysis, it is seen that microfibers are also the most prevalent particle throughout the rest of the world, where more

![Figure 10. The figure shows the distribution of polymer types in the sampled soil near Barapukuria.](image-url)

| Country          | Location       | Sample Type                  | MP Abundance | Reference |
|------------------|----------------|------------------------------|--------------|-----------|
| Bangladesh       | Barapukuriya   | Industrial & Agricultural soils | 1-15 items/100g | This study |
|                  | Dhaka          | Agricultural Farmland        | 0-1.34 items/kg | [59]      |
| China            | Shanghai       | Vegetable Farmland           | 70 items/kg   | [88]      |
|                  | Nanjing & Wuxi | Agricultural land soil       | 855 items/kg  |           |
|                  | Wuhan          | Vegetable plots soil         | 1.6*105 items/kg | [89]     |
|                  | Hangzhou       | Agricultural soils           | 503.3 items/kg | [90]      |
|                  | Shaanxi        | Agricultural soils           | 2420 items/kg | [91]      |
|                  | Xinning        | Agricultural soils           | 308 ± 138.1 items/kg |      |
| Korea            | Yeoju City     | Agricultural soils           | 664 items/kg  | [92]      |
| Pakistan         | Lahore         | Agricultural soil            | 3712 ± 2156 items/kg | [94]     |
|                  | Topsoil        | Agricultural soil            | 4483 ± 2315 items/kg |           |
| Germany          | Southeast Germany | Agricultural Farmland     | 0.34 ± 0.36 items/kg | [95]     |
| Spain            | Eastside       | Agricultural soil            | 930 ± 740 items/kg | [96]     |
| Chile            | Mellipill      | Agricultural soil            | 184-306 pieces/kg | [97]     |
|                  |                | Farmland Soil                | 2010 items/kg | [98]      |
| Argentina        |                |                              | 30 ± 19 kg/ha | [99]      |
than 70% of MPs were found to be fibrous in various places [80, 81]. If we look at Bangladesh’s perspective, it is found from one study in central Bangladesh’s farmland soil that the fragment type of MP is higher [59]. However, in beach sediments of Bangladesh, fiber was found to be the dominant type of MPs in three studies [55, 56, 69] and in another two studies, fragment type is found to be higher [13, 58].

The majority of the MPs calculated in this study were between the sizes of 0.5 and 1 mm (59%), followed by 1–1.5 mm (26%), and 0.5 mm (15%). This outcome is consistent with the trends mentioned by some researchers [82–84]. These results, however, differed from those of other studies [29, 53, 85, 86], which primarily found MPs larger than 1 mm, particularly in comparison with central farmland soils of Bangladesh. MPs were found between 1-5 mm in central farmlands of Bangladesh [59] which is higher than the MPs found in the Barapukuria region. However, the variation in shape, size, and color might be due to the source type of MPs in different areas.

4.2. Identification of polymer types by ATR-FTIR

To determine the polymer types, the identified MPs were reexamined using FTIR spectroscopy. Based on the identification of polymer types, they are categorized into eight groups: Rayon, Nylon, Polyethylene (PE), Polypropylene-Polyethylene (PP + PE), Polyurethane (PU), Epoxy, Polystyrene (PS), and Alkyd.

Rayon had the highest percentage of polymers containing 33 particles, accounting for 41% of all the polymers that were identified in the study area, and Polyethylene had the second-highest percentage of polymers in the MPs that were found, according to FTIR results. Polyethylene accounted for nearly 21% of all polymers. Nylon was observed to be the third most abundant polymer type, with 12 particles per 100 g (15%). Polypropylene-Polyethylene copolymer accounted for 7.4%. Polystyrene represented 6.2% of the total polymer. Alkyd and Polyurethane were found to be almost 5% and 3.7% respectively. Apart from these, Epoxy was found in a small percentage (1.2%) of the total sample (Figures 4, 5, 6, and 7).

Furthermore, the findings revealed that the majority of fibrous MPs were made of Rayon and Nylon. The fragmented MPs were made of polystyrene and alkyd. Copolymers of polypropylene-polyethylene and Polyethylene polymer made up the films. Besides this, Polyurethane and Epoxy were identified as the foams.

The study’s findings are consistent with previous research on Bangladesh’s coastal areas [13, 55, 56, 58, 69]. According to the findings, Rayon and Polyethylene are two of the most abundant polymers in the soil samples. Several studies can be used to infer the sources of the various types of polymers. Trash bags, food wraps, shopping bags, plastic film, and other products are made from high and low-density polyethylene [87]. Polypropylene polymers are used in the manufacture of yogurt containers, diapers, straws, wrapping films, butter tubs, and specialty bags [87]. Plastic materials used for packaging could be
potential sources of copolymer PP and PE. PS polymers are used as a raw material in consumer plastics and have the potential to pollute water bodies [78]. Polystyrene is used to make hot beverage cups, thermally insulated take-home boxes, food containers, such as trays for carrying meat and eggs, and insulating materials [87]. Alkyd and epoxy resins are widely used in the manufacture of paints, coatings, adhesives, and a wide range of other construction-related products. As a result, these two polymers’ origins can be traced back to these items.

4.3. Occurrence and distribution of microplastics

From the study, it is found that each of the 12 locations that were sampled had a different level of MP contamination. To calculate the total amount of MPs, 100gm of soil sample was analyzed from each chosen location. From Figure 8, it can be observed that the highest concentration of MP was found in the S9 sample (15) which is collected from near metropolitan city farmland. In another sample location near metropolitan city farmland S4, 12 MPs were found. In S6 and S2, the number of MPs was also found in higher amounts (15 and 11 respectively). These two sample locations are near the industrial area. In location S11, 11 MP was found which is also relatively higher and it is urban farmland. In S10 and S8 MPs were found 7 and 4 in number. Compared to these locations, MPs were found to be lower in S12, S7, S1, S3, and S5 (3, 2, 2, 1, and 0 respectively) collected from rural farmland areas (Figure 9).

Based on their type, Figure 10 depicts the distribution of MPs. The results revealed that microfiber was highly abundant in the S4, S11, S6, and S9 regions (27 particles out of 45), whereas it was least abundant in the S3, S1, and S12 regions, with 1–2 microfiber particles identified from the sampled soils. In the case of microfilm, it was discovered that S9 had the most (7), while S8 and S12 had the least (each with 1) and no microfilm was found at S1, S5, and S7. Micro fragment was found in the highest amount at sample location S2 (4). Another two sample locations S3 and S9 contained 3 and 1 micro fragments respectively. In other sample locations, fragments were absent. The foam was found at S2, S4, S6, and S8, each containing 1 micro foam. However, no MPs were found in sample location S5.

It might be assumed that poor waste disposal management and industrialization contribute to the abundance of MP in higher amounts near the metropolitan city region, and urban and industrial areas. However, MPs have been found in a lower amount in the rural farmland areas.

If we consider the total concentration amount of MPs in a unit sample, it is observed that MPs are more abundant in the samples of beach sediment in Bangladesh than in agricultural soils. Based on the studies done at Cox’s Bazar, MP abundance ranged from 200 to 378.8 items/kg in 24 surficial sediment samples [69]. In other two studies [55,56], it is found that the abundance of MPs was 2–49 grain per 100 in Saint Martin Island and 5–111 grain 100 in Cox’s Bazar, Bangladesh.

However, in the present study 81 MPs was found from 12 sampled location (a total 1.2 kg DW soil sample) in the agricultural soil of the Barapukuria region. Compared to this result another study on agricultural lands showed that 22 MPs were found from 32 samples in four different agricultural farmlands in the northern part of Dhaka, Bangladesh [59]. In

Figure 12. Land use land cover (LULC) along with the concentration of MPs in the study area.
terms of global context, Table 1 shows a comparison between the quantity of MP found in the present study and other pertinent studies.

4.4. Abundance and distribution of polymer

Through the assessment of the distinctive absorbance bands of the 12 sampled locations close to the farmlands of the Barapukuria Power Plant, the abundance and distribution of polymer in the identified MPs were evaluated and counted using the ATR-FTIR method. The distribution of polymer types varied in different farmlands.

In case of Rural Farmland among the identified polymer types in the sampled location of Barapukuria, only Rayon and Polyethylene were found in rural farmland (S1, S3, S5, S7, and S12). Rayon was found 7 in amount and Polyethylene accounted for 1 in number. In the two sites of suburban farmland (S8 and S10), Rayon, Nylon, and Polyethylene were found in a total of 11 in an amount where rayon constitutes around 54.5%, Nylon was counted for 18%, and Polyethylene was about 27%. In one sampling site of urban farmland (S11), Rayon counted for 5, Nylon counted for 2, Polyethylene counted for 3 and the copolymer of Polypropylene-Polyethylene counted for 1. So, in comparison with the other types of MPs, in urban farmland rayon was also found higher percentage (about 45%). Near the metropolitan city, samples were collected from two sites (S4 and S9) where rayon was found in the highest amount (9) among all other polymer types. Polyethylene was counted as the second highest (7) and Nylon was counted for 5. The copolymer of Polypropylene-Polyethylene, Polyurethane, and Poly-styrene these three types were counted 2 each. All eight types of identified polymers from the study area were found near the coal mine region (S2 and S6). In the case of concentration amount, Rayon counted for 6, Alkyd counted for 4, while Nylon, Polyethylene, Poly-styrene, and copolymer Polypropylene-Polyethylene all these four types were counted 3 each. And Polyurethane and Epoxy each counted 1 in amount.

The spatial abundance and distribution of Rayon, Nylon, Polyethylene, Polypropylene-Polyethylene, Polyurethane, Epoxy, Polystyrene, and Alkyd in the Barapukuria Power Plant area where samples were collected are shown in a bar diagram representing the amount of each polymer there (Figure 11).

4.5. Correlation between LULC and MPs

By generating a land use and land cover map, the amount of MP in the study area has been correlated with land use. MP concentration has been represented with the red color rounded symbol on this map (Figure 12). Additionally, the light green color depicts agricultural land, which is the main area of research, pink color represents the settlement area, green color indicates the vegetation and blue denotes the water body. Clearly, it is observed that near the pink color regions where there are settlements, MP concentration is higher. Precisely, S2 and S6 are showing a higher concentration which is near the industrial area of the coal mine. S4 and S9 are also showing a higher count of MPs which is near the metropolitan city region. The urban farmland (S11) also delineates a higher percentage of MPs. However, compared to those areas, rural farmland (S1, S3, S5, S7, and S12) show a lower concentration.

So, it might be reasonable to conclude that the accumulation and variation in MP concentrations are associated with improper waste disposal near the coal mine industry, metropolitan city region, and urban farmland areas where there are settlements.

5. Limitations

Since this is the first study ever done on MP pollution in a coal mine area, there have been some problems that need to be fixed so that future studies can be done properly. Here are some of these restrictions: There isn’t enough information about terrestrial MP pollution. There isn’t an established set of standard for collection of samples to evaluate the extent of MP pollution. There is no proper plastic management scheme in a mining area of the country.

6. Conclusions

Plastics and the products of their breakdown, known as microplastics (MPs), can be found almost anywhere in the natural world. It is possible that industrial soils are the most polluted soils due to this form of pollution. The amount of evidence available regarding human exposure to MPs originating from urban and industrial soils is extremely limited. As a result, this research was undertaken with the aim of determining whether or not MP contamination is present in the industrial area of the Barapukuria region in Bangladesh. This study presents both qualitative and quantitative data on the prevalence of plastic pollution in five distinct categories of environments. Each of the five locations yielded positive results in the search for MPs. About 81 MPs (Mean: 6.75 ± 5.3) with 4 distinct forms were detected from the 12 sample locations. The average occurrence of MPs detected in rural, suburban, urban, coal mine industry locations, and near the metropolitan area are 0.32 ± 0.69; 1.1 ± 1.73; 2.2 ± 3.19; 2.4 ± 1.89, and 2.7 ± 3.05 MPs, respectively. The most abundant kind of MP was found to be fibers, which made up fifty percent of the total, followed by films, which made up twenty-six percent of the total. The majority of the detected MPs were detected to be colored, accounting for 59% of the total, which is an indication of a land-oriented origin. In terms of polymer types, Rayon (41%), Polyethylene (21%) and Nylon (15%) are the abundant polymer types among the identified ones. According to the land use and land cover mapping, when compared to rural farmland, which is less contaminated with MP particles, metropolitan city areas and coal mine industry regions have a higher concentration of MP particles. The levels of contamination in the urban and suburban areas are rather moderate. The research offers a fresh perspective on the prevalence of MPs and the rate at which they are accumulating in the industrial zone of Bangladesh. Therefore, it is necessary to conduct additional studies in order to comprehend the fate of MPs in the environment and the ecological problems concerns that they cause. Furthermore, it is essential to take the proper measures in order to reduce pollution caused by MPs in terrestrial ecosystems.

Declarations

Author contribution statement

Mahir Tajwar: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data.
Shamiha Shafinaz Shreya, Mamudul Hasan, Bayazid Hossain, Md. Yousuf Gazi, and Nazmus Sakib: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Declaration of interest’s statement

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