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Identification and characterization of microplastics in surface water sources at Rajshahi City

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Abstract

Microplastics (MPs) in recent decades have been highlighted as a major concern since they have penetrated our food chain. Various tourist attractions generate a huge plastic waste, causing plastic pollution in Rajshahi City. Thus, the present investigation aims to detect and characterize MPs in surface water and their impacts on water quality parameters. The experimental setup consists of ATR-FTIR spectroscopy to identify, quantify and classify MPs from water bodies collected from the study site (T-Badh) in Rajshahi City. The majority of plastics in the sample were identified as polyethylene and polyesters through the FTIR technique. The study depicts MPs in various sizes ranging from 165µm – 4.25 mm. The abundance was 12–18 (mean = 15) particles/m^3 in surface water. The shapes of the particles are mostly fragments and fibers. The Canonical-Correlation Analysis (CCA) shows the correlation between MPs concentrations and physicochemical water parameters. The study implies that concerns have been raised about the potential impacts of MPs' presence in Rajshahi City on human health.

Keywords: *Microplastics; Surface water; FTIR; Water quality; Canonical-Correlation Analysis.*

1 Introduction

Microplastics (MPs) are manmade organic polymers by polymerizing monomers obtained from oil or gas (Derraik et al, 2002; Rios et al., 2007; Thompson et al., 2009). There are a variety of polymers that are commonly used today, such as Polyethylene, Polypropylene, Polyethylene terephthalate, Polyvinyl chloride, Polylactic acid, Polystyrene, Polycarbonate, Acrylic and Polyesters. MPs are lightweight, strong, inert, durable, and corrosion resistive. MPs with sizes ranging from 1 µm to 5 mm may be created from plastic trash through weathering, abrasion, mechanical breakdown, photolysis, and the presence of microorganisms (Wu et al., 2018). MPs are frequently discovered in marine species, raising concerns among scientists as they become a threat to the biota (Fendall and Sewell, 2009; Thompson et al., 2004; Barnes et al., 2009). The globe produced about 6300 million metric tons of primary and secondary plastics. About 600 metric tons (9%) of plastics were recycled, and 800 metric tons (12%) were burned. Only 10% of the plastics were recycled more than once. Up to 60% of all plastics that have been produced, which is around 4900 metric tons, have been thrown away and are now accumulating in dumps and the ecosystem since 2015 (Geyer et al., 2017). Studies have shown that MP exposure in freshwater can lead to negative consequences such as death, neurotoxicity, and damage. Additionally, it can cause oxidative stress and a decrease in the fitness levels of both individuals and communities (Bhattacharya et al., 2014; Au et al., 2015; Lagarde et al., 2016). Numerous detrimental effects, such as immobility, death, eating inhibition, poor reproductive fitness, etc. have been linked to the use of MPs (Rehse et al., 2016; Besseling et al., 2014; Nasser and Lynch, 2015; Jemec et al., 2016; Frydkjær et al., 2017; Ogonowski et al., 2016).

While the concentration of MPs in coastal environments has received significant attention, the presence of MPs in inland waterways like rivers, canals, ponds, etc. has become more significant day by day. The data and information on MPs in water bodies in Rajshahi City are mostly unknown. As a result, it's critical to determine the MPs concentration in Rajshahi's City (T-Badh). The primary goals of this study are to identify, quantify, and categorize MPs based on their shape and size in the Padma River (T-Badh) in Rajshahi City. Additionally, the study aims to investigate the impact of these MPs on water quality parameters.

2 Methodology

2.1 Study Area

In this study, the sample was collected from T-Badh which is located at coordinates (24°21'40.4"N, 88°34'14.5"E) and one of the most popular tourist spots in Rajshahi City. Around 2000 visitors visit this beautiful place every day. People throw plastic waste in the riverside or directly into the river. Then, the plastic wastes mix with storm water and deposit in the river.

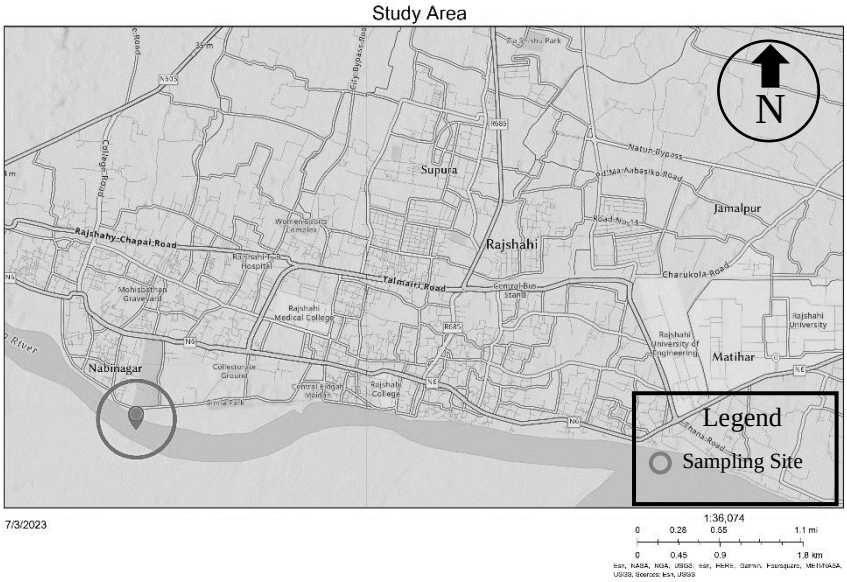

Figure 1. The location of the sampling area

2.2 Water Sampling and Analysis for MPs

The research material for the study consists of surface water samples collected from T-Badh. Nine physicochemical water quality parameters, such as pH, turbidity, electrical conductivity (EC), total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), chemical oxygen demand (COD), dissolved oxygen (DO), and biochemical oxygen demand during 5 days of incubation at 20°C (BOD_5), were tested in the Environmental Engineering Laboratory according to the recommended APHA (American Public Health Association) guidelines to determine the degree of pollution in the samples collected. The guidelines of the National Oceanic and Atmospheric Administration (NOAA) have been used to identify and compute the number of plastic particles found in the samples. A stainless-steel sieve with multiple layers was utilized featuring mesh sizes of 0.075 mm and 5 mm to filter a substantial volume of 1500 L water samples. The filtrated samples were transferred to a 500 ml beaker and then heated to 80°C for a day (Hidalgo-Ruz et al., 2012). For carrying out the wet peroxide oxidation process, 20 ml of a 0.05M aqueous solution of Iron (II) and 20 ml of a 30% hydrogen peroxide solution were added to a beaker. By adding a 30% hydrogen peroxide solution, any organic matter associated with MPs, including bio-films and macro-fouling organisms, was effectively eliminated (Thevenon and Carroll, 2015). Before adding a stir bar to the beaker, the solution was allowed to stand at the ambient temperature for five minutes. The substance was carefully placed underneath a watch glass and heated on a hotplate until it reached a precisely controlled temperature of 75°C. Once gas bubbles become visible at the surface, the beaker was detached from the hotplate and heat it at 75˚C for another 30 minutes. Approximately, 5 M Sodium chloride was added to densify the aqueous solution. Then the solution was taken to perform density separation. After transferring all the remaining solids to the beaker, the solution was rinsed meticulously with distilled water. To ensure the proper settling of the solids, it was covered lightly with aluminum foil and left to settle overnight. Then, the sample was filtered with Whatman filter paper 44.

The identification of the MPs was confirmed through the use of the ATR-FTIR (Fourier Transform Infrared) technique. With FTIR spectroscopy, it is possible to accurately identify polymeric polymer particles by analyzing their unique infrared spectra (Bergmann et al., 2015). The Scanning Electron Microscopy (SEM) technique was employed with a JCM-6000Plus Versatile Benchtop Scanning Electron Microscope to define the shape and size of the MPs. The concentration of MPs in particles per cubic meter (particles/m^3) has evaluated by counting the number of MPs present in a filtered sample with an Optical Microscope (Masura et al., 2015). To identify the effects

between MPs and water quality parameters the CCA has been performed using PAST 4.03 statistical analysis software.

3 Results and Discussions

MPs were found in small amounts in the water sample taken from the T-Badh. Figure 2 shows the picture of MPs collected from T-Badh. The amount of MPs (expressed as particles/m^3) found in the water samples is 12–18 (mean=15) particles/m^3. It demonstrates unequivocally that the amount of MPs in the inland water body (T-Badh) is relatively low.

Figure 2. MPs extracted from the water sample around T-Badh

Based on examined functional groups, FTIR test findings revealed two different types of polymers, such as Polyethylene (PE) with peak characteristics of 2920 cm^{-1} and Polyesters (PES) with peak characteristics of 1743 cm^{-1}. (Figure 3). The SEM analysis depicts the shapes and sizes of MPs. The identified two main shapes are Fragments and Fibers (Figure 4). According to size, MPs have categorized into three kinds, including 150-300 μm; 301μm – 600 μm and 601μm – 1000 μm. Experts suggest that MPs with a size of less than 250 μm come from primary sources. Conversely, MPs with a size larger than 250 μm are a result of smaller plastic particles breaking off from bigger plastics and are known as secondary microplastics (Estahbanati et al., 2016). The size of MPs that predominated surface water bodies is less than 1000 μm (Fitriyah et al., 2022). Aquatic species can ingest MPs of this size in water, leading to their entry into the food chain (Zhang et al., 2017).

Table 1. Water Quality Parameters Test Result

Sample ID	pH	Turbidity (NTU)	EC (μ-moh/cm)	TS (mg/L)	TDS (mg/L)	TSS (mg/L)	COD (mg/L)	DO (mg/L)	BOD_5 (mg/L)
T-Badh	6.5-6.9	8.29-8.34	1500	400	300	100	2.5-2.6	4.6-4.8	1.5-1.7

The results of water parameters show that a pH value of 6.5-6.9 indicates the acidic condition and affects microbes in the decomposition process (Lin et al., 2022). The obtained DO value is 4.6-4.8 mg/L. Sources of DO include atmospheric oxygen diffusion (35%), as well as the photosynthetic activity of marine plants and phytoplankton (LA Dhea et al., 2018). Additionally, the measured BOD_5 value ranges from 1.5 to 1.7 mg/L. The presence of DO concentrations in waterways facilitated the interaction of MPs and organic matter until the development of bio-films. The breakdown of MPs may be facilitated by the development of bio-films (Pan et al., 2023). Meanwhile, BOD_5 indicates the oxygen content used by microorganisms in the breakdown process (Aji et al., 2016). The obtained value of TSS is 100 mg/L. TSS impacts the abundance of MPs. TSS is related to MPs and the fragmentation of suspended particles (Besseling et al., 2017). Though MPs are lighter than water, they float on the surface of the water. These characteristics lead MPs to mix with suspended particles (Kooi et al., 2018).

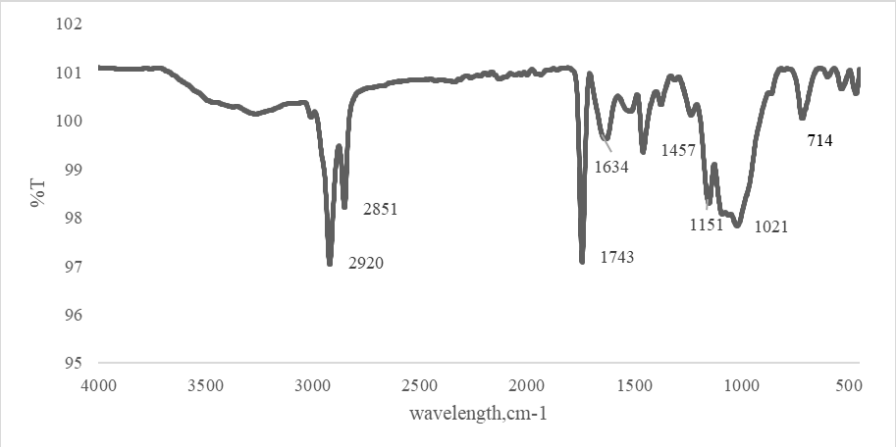

Figure 3. FTIR spectra for plastics identification

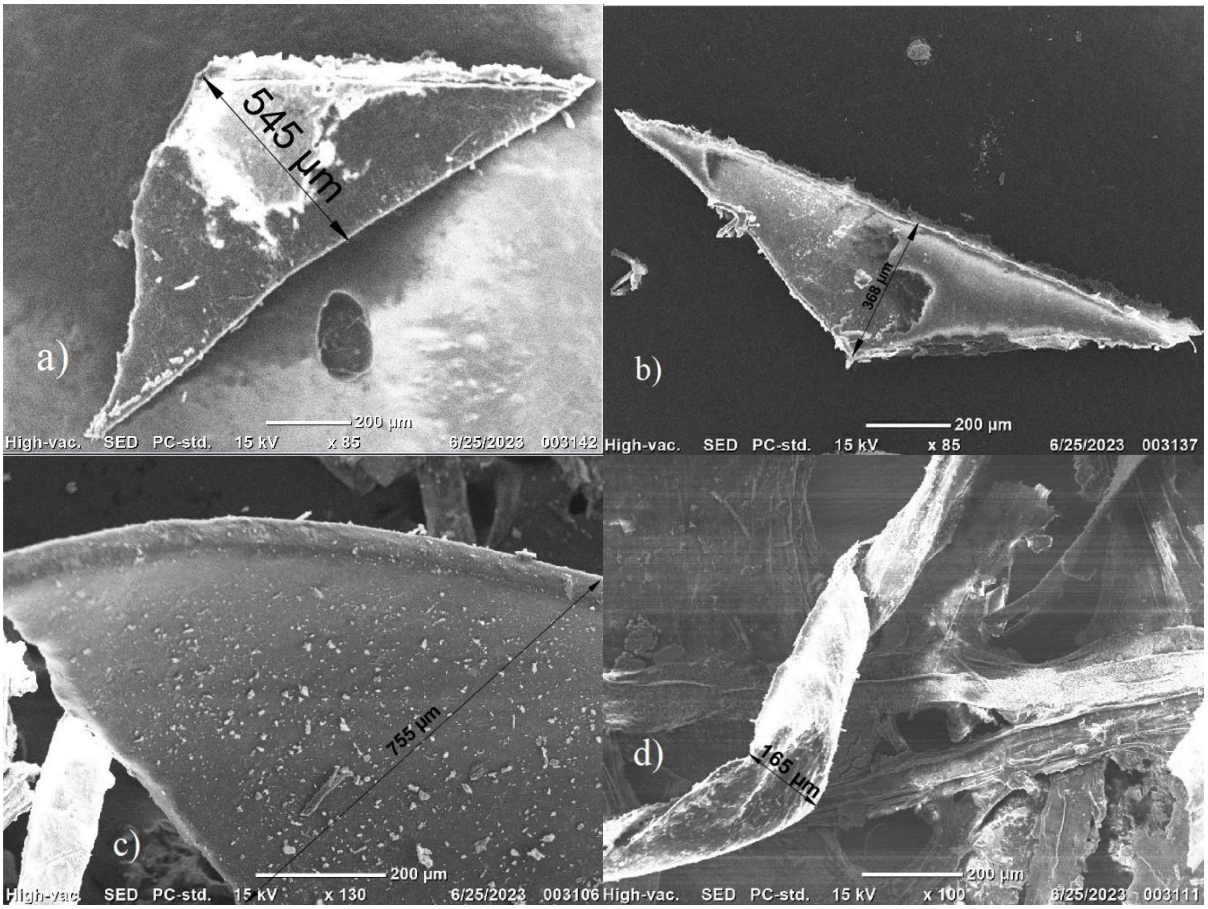

Figure 4. SEM images of MPs. a) Fragment, b) Fragment, c) Fragment, d) Fiber.

Figure 4 shows the correlation between MPs abundances and physicochemical parameters of the Padma River (T-Badh). The CCA analysis used nine independent physicochemical parameters (pH, EC, Turbidity, TS, TSS, TDS, COD, DO, BOD_5), three sizes (150-300 µm, 301-600 µm, 601-1000 µm) of MPs. According to the CCA findings, the abundance of MPs ranging from 301-600 µm and 601-1000 µm had a significant correlation with pH and DO and a medium correlation with the entire parameters. Similarly, the presence of MPs ranging from 150-300 µm strongly correlated with TSS, turbidity, BOD_5, and moderately correlated with the other parameters. The significant correlation between the parameters and MPs sizes suggests that they affect the distribution of different microplastics sizes. Scores of the findings of the related variables reveal that the parameters of pH, TSS, DO, and BOD_5 have a strong statistical importance of 0.98, 0.93, 0.86, and 0.83, respectively. A considerably high score clarifies the strong correlation between the number of microplastics and the water quality parameters.

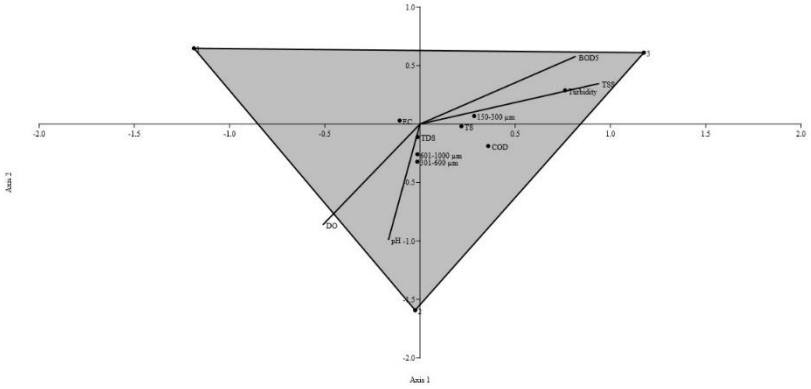

Figure 5. The result of CCA plotting

4 Conclusions

The findings have confirmed the MPs contamination at T-Badh in the Padma River. According to the study, the number of MPs present in T-Badh is relatively small and the shapes of MPs are mostly fragments and fibers. The size of the MPs can be divided into three ranges (150-300 µm, 301-600µm, 601-1000µm). Based on the correlation analysis, it was found that the pH, TSS, DO, and BOD_5 parameters had a significant impact on the MPs present in the sample.

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