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Analyzing the Volume of Floating Plastic Debris in the Louhajang River's Surface Water, Tangail, Bangladesh

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Abstract

Plastic pollution in an aquatic ecosystem may have detrimental effects on ecology and aquatic species. Plastics produced on land often end up in aquatic ecosystems, such as rivers, and a significant portion finally gets its way to the sea. The purpose of this study was to quantify the amount of floating plastic debris in a certain river's surface water. A framed pocket net sampler was used with dimensions of 1.5 x 0.7 x 2 meters which was installed on the riverbank and operated one day once a month at four locations for 24 hours. The procedures that were carried out included sorting, counting, and weighing the plastic debris, respectively. The total weight and items number of plastic debris was 7.580 kg and 515 items found within the study area respectively. In terms of mass composition, Polyethylene Terephthalate (PET) made up 16%, High-Density Polyethylene (HDPE) 32%, Low-Density Polyethylene (LDPE) 25%, Expanded Polystyrene (EPS) 17%, Polystyrene (PS) 10%, and other resins 0%. Conversely, in terms of items number, it was 10% PET, 25% HDPE, 44% LDPE, 16% EPS, 4% PS, and other resins 1%. Both white and colored plastic pieces, cork sheets, and plastic bags were all examples of the various types of plastics found in a significant number within the study area. The findings from this study could offer an initial evaluation of the abundance, items number, and characterization of the polymer-type analysis of floating macroplastics (MaPs) in the Louhajang River based on observations at different locations. Having precise information on plastic waste in rivers is crucial for enhancing both global and local modelling approaches, thereby increasing the effectiveness of strategies for prevention and collection.

Keywords Pollution, Ecosystem, Plastic debris, Macroplastics, Riverine, Louhajang

Introduction

In the contemporary world, plastic has become a prevalent and essential element of human existence, permeating several aspects of daily life with its applications (Zhang et al. 2020). Our current period has been dubbed the ‘‘Plastic Age’’ (Thompson et al. 2009). Plastics originating from land-based sources are identified as a primary contributor from the river to marine plastic pollution (Jambeck et al. 2015). It is widely believed that the primary mode of transportation for these plastics to the ocean is through rivers (Lebreton et al. 2017; Schmidt et al. 2017). According to recent data, research has shown that the production of plastic amounted to approximately 5 million metric tons in 1960 (Europe and EPRO 2019). The worldwide yearly production of plastic has experienced swift growth in the following decades, reaching approximately 359 million tons by 2018 (Plastics Europe 2019). Projections indicate that by the year 2050, between 60% and 80% of marine litter is composed of plastic and the mass of plastic in oceans is expected to surpass the mass of fish (World Economic Forum 2016).

Plastic is an artificial substance that has several distinct characteristics, including cost-effectiveness, strength, long-lastingness, and light-weightness (Li et al. 2019;

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Ogunola and Palanisami 2016). They are used in household and personal products, garments, and product packaging. Plastics are used in so many ways that they pollute the environment. Over 80% of ocean plastic comes from land, mainly from thrown-away plastics, either intentionally or unintentionally and is finally carried by rivers into the sea (Li et al. 2016). Some plastic items will either sink or become stranded in the river, while others will ultimately reach the river mouth (Co zar et al. 2014; Kukulka et al. 2012; Ryan 2015). According to a recent study, a minimum of 50% of the collected plastics within the Great Pacific Garbage Patch in the North Pacific Ocean originated from marine-based sources (Lebreton et al. 2018). Plastic pollution became a problem when it gathered in nature and improperly thrown-away plastics stayed there (Andrady 2003).

Plastic waste can be classified based on its size into macro (>2.5 cm), meso (between 5 mm and <2.5 cm), micro (between 0.1 μm and <5 mm), and nano (<0.1 μm) categories (Barnes et al. 2009). Every single year, an estimated amount of plastic ranging from 1.15 to 2.41 million tons will ultimately find its way into the ocean through rivers.

Over 74% of plastic emissions occur during the period from May to October due to heavy rainfall at this time. However, it is worth noting that Asia's top 20 polluted rivers contribute to 67% of global plastic pollution (Lebreton et al. 2017). Bangladesh's annual plastic waste production amounts to 0.8 million tons (Waste concern 2019).

Macroplastics can break down into tiny particles called microplastics and end up in the environment under specific conditions (Napper et al. 2015; Wagner et al. 2014). In contrast to organic substances, the majority of traditional plastics do not undergo biodegradation when exposed to the open atmosphere. They experience gradual fragmentation into smaller elements through photochemical, physical, and biological degradation processes (Miller 2020). The degradation of plastic spans from hundreds to thousands of years (Barnes et al. 2009; Gallo et al. 2020). Bangladesh has become the first nation to prohibit plastic bags, prompted by their obstruction of drains during a significant flood event dating back to 2002 (Alimba and Faggio 2019). However, still Bangladesh has not reduced its production and consumption.

Plastic pollution poses serious risks to ecological systems, and human well-being (Conchubhair et al. 2019; Derraik 2002; Rochman et al. 2015). Marine creatures such as turtles, birds, and fish face significant risks of harm or mortality when they ingest or become entangled in plastic debris (Gall and Thompson 2015; Wilcox et al. 2015). Some plant species, like mangrove forest trees and the wildlife that accompanies them, are adversely affected by plastic litter (Ivar do Sul et al. 2014; Martin et al. 2019). Plastic pollution has also a detrimental effect on humans since it clogs urban drainage systems and raises the risk of flooding (Njeru 2006; Windsor et al. 2019). Moreover, plastic pollution leads to significant economic damages as it causes the ruin of vessels and fishing equipment, adversely impacts the tourism sector, and necessitates higher efforts for beach cleanup (McIlgorm et al. 2011). Despite the rising in collection and recycling rates over time, a significant portion, approximately 79%, of the total plastic produced has ultimately been disposed of in landfills or has escaped into the natural environment (Geyer et al. 2017).

Increasing rates of urbanization, economic expansion, and population growth all contribute to the hastening of the accumulation of waste plastics (Blettler et al. 2018). Plastic is harmful to the environment because it's everywhere and stays around for a long time

(Carbery et al. 2018). Although plastic contamination in the ocean has received significant attention, there has been comparatively less focus on freshwater habitats (Blettler et al. 2018; Blettler and Wantzen 2019). But nowadays, Plastic pollution's effects on the environment are attracting global attention from researchers, policymakers, businesses, and ordinary people (Sathish et al. 2020). Bangladesh boasts one of the most expansive river systems globally, encompassing almost 700 rivers and canals, including tributaries, with a combined estimated length of 24,140 km (Chowdhury 2012; Rahman and Yunus 2016). Between 1950 and 2015, we generated 300 million tons of plastic. After use, these plastics need to go somewhere. It is unfortunate that sometimes it finds its way into a river and finally makes its way to the ocean (Bay of Bengal in our case) (Financial Express 2019). In Bangladesh coastal areas, there are 70.9 million people, and each person generates 0.43 kg of waste daily, with 8% of that being plastic (Jambeck et al. 2015). In Bangladesh, the daily volume of plastic waste surpasses the monthly volume of plastic waste generated by certain countries (Shimo 2015). However, no study has been carried out so far addressing the abundance, distribution, and polymer composition of plastics in riverine areas in Bangladesh. (Blettler et al. 2018).

The Louhajang River plays a significant role in the region's agriculture and local economy. It is considered a major river in the region, contributing to the local irrigation system and supporting the livelihood of communities. Rivers like Louhajang are vital for the environment and the daily life of the people in rural Bangladesh. This study aims to evaluate the presence of considerable plastic debris (macroplastics) in the Louhajang River, located in Tangail, Bangladesh. The objectives of the study relate to the abundance and item numbers of macroplastics, and to characterize the isolated macroplastics based on the polymer type analyses.

Materials and Methods Site Description

Bangladesh is predominantly a country characterized by rivers located in a humid lowlying alluvial region and experiencing a sub-tropical monsoon climate (MOFA 2016). The study was carried out at the Tangail Municipality, Bangladesh. Geographically, its coordinates are 24.2513°N latitude and 89.9167°E longitude (Islam et al. 2021). In Tangail Sadar Upazilla, the soil has a sandy loam texture. The composition of the soil includes vary-

ing percentages of sand (ranging from 36.8% to 64.43%), silt (ranging from 9.34% to 28.08%), and clay (ranging from 25.23% to 44.33%) (Rahman and Mian 2016). In Tangail district, the temperature ranges from a maximum of 38.33˚C to a minimum of 10.13˚C and the annual rainfall is 1830 mm (BBS 2013). Louhajang River is located at Tangail District which is in the center of Bangladesh. It branches out from the Jamuna near Gabsain at Bhuapur, Tangail District. The Louhajang River flows through Tangail, Karotia and Jamurki etc. and joins the Bangsai River in the Dhaka district. The Louhajang River is hydraulically linked to the Dhaleshwari River. The length of the Louhajang River is about 76 kilometres and its width is 40 meters; the riverbank spans an area that is 104 kilometres squared. The average depth is 1 metre (3 ft.) and the maximum depth is metres (9ft.) (The Daily Star 20017). The monthly observation and collection of riverine debris were conducted at four sampling sites along the Louhajang River in Tangail district, specifically Bhabanipur Patuli Para Bridge, College Road Bridge (Airport Road), and Dighulia Bridge, Notunpara Road (Markaj masjid).

Table 1 Monitoring Location

Sampling ID	Location	GPS Coordinates
St-1	Bhabanipur Patuli Para Bridge	24.237681N; 89.906011E
St-2	College Road Bridge (Airport Road)	24.234061N, 89.906400E
St-3	Dighulia Bridge	24.247942N; 89.903869E
St-4	Notunpara Road (Markaj masjid)	24.251780N, 89.909734E

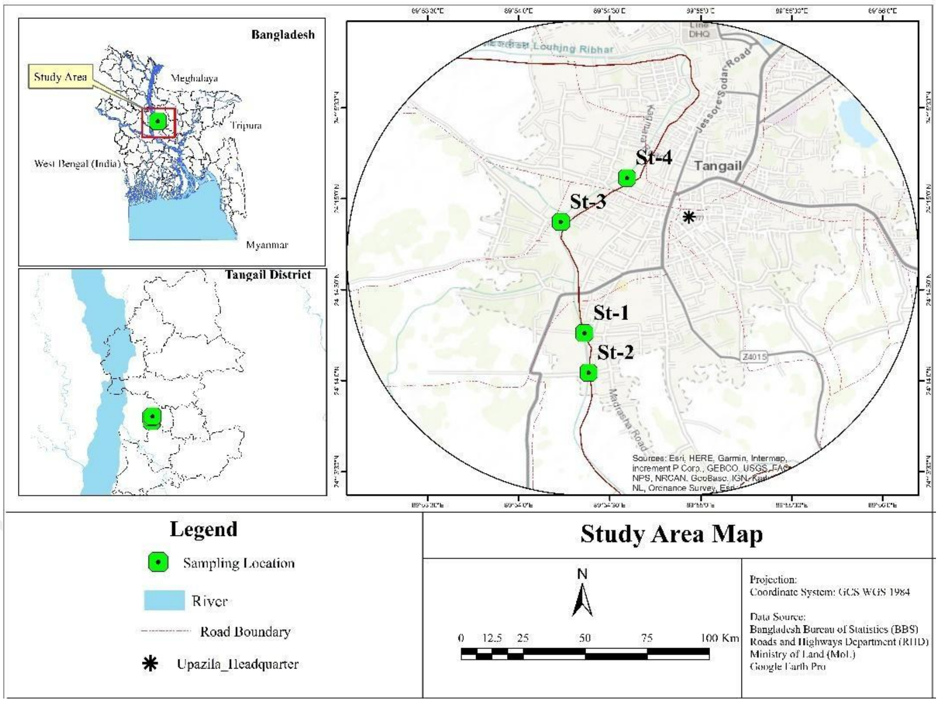

Fig. 1 Geographical location of the study area of the Louhajang River indicating sampling points prepared by using ArcMap 10.3.1 software.

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Sampling Approach Visual counting for Site selection floating plastic debris

Observing floating plastic debris from bridges in rivers can provide valuable data on the amount and types of debris in the water. An uncomplicated way to calculate plastic movement is to visually count the plastic debris (Gonza lez and Hanke 2017; van Emmerik et al. 2018) across the river's width at several points. Floating debris was observed from the bridge and riverbank at each location. During the observation on the bridge, each visible plastic piece was counted for 30 minutes. As a point of monitoring, this river was divided into one or two sections so that the station was covered in one hour or less. The observer noted the section that emitted the most plastic aiding in determining a suitable section for installing the framed pocket net sampler. Each floating and seemingly submerged plastic particle has been counted according to its size. The average size of the plastic debris was estimated to be about 1 cm. If its composition could not be determined, debris was not classified as plastic. Plastic debris counts have been done over time.

Sampler installed

A framed pocket net sampler is a type of sampling device used to collect plastic debris from the water. Sampler installation involves installing a device that actively collects plastic debris as water flows through it. This method is often used for larger plastic debris and involves placing a screen or barrier in the water to intercept and collect the debris. A study was conducted from September 2022 to February 2023 to collect plastic debris in four different areas inside the main urban area of Tangail, Bangladesh. This study began collecting plastics from the riverbank between the 1st and 10th day of each month, operating for 24 hours once a month at four different locations. The trash was collected using

the framed pocket net sampler. The plastic was gathered utilizing a pocket net sampler with a frame. A frame pocket net as a sampler was created with dimension of 1.5 x 0.7 x 2 meters. The net's mouth was framed with rectangular iron that was sized 1.5 x 0.7 m. A mesh size of 0.2 centimeters was used for the net. When the net sampler was put up in the water, buoys and ballast were used (where it's needed) to keep its frame straight. To

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facilitate the process of connecting the net sampler to the bridge or the pole on each riverbank, a pair of ropes was attached to the net sampler. The net sampler was set up and used for a full day once a month at each site, operating continuously for 24 hours in the river **(Fig. 2**).

A B C

Fig. 2 Sampler installed (A), exposed to air (B), and weighed (C) individually procedure for plastic debris.

Sample analysis Plastic dries under the sun and segregates

After having collected the plastic debris while it was still damp. They were exposed to air at ambient temperature for several days in order to dry out. After that, they were sorted, counted, and weighed by a digital scale individually in the laboratory before being categorized according to size and type (Tramoy et al. 2019) (**Fig. 2**). The debris was subsequently sorted in the laboratory in big plastic bags. The plastic was manually sorted into seven categories: HDPE, LDPE, PVC, PET, PS, EPS, and other resins (Lippiatt et al. 2013; Padgelwar et al. 2021; van Calcar and van Emmerik 2019).

Table 2 Categorized the plastic polymer composition based on their common use

Types of plastic	Characteristics	Usage

HDPE (High-Density Polyethylene)	This product is widely regarded as secure, preventing the presence of chemicals in food substances. Currently, the utilization of these materials is on the rise due to their lightweight, exceptionally robust, durable, weather-resistant, and impact-resistant attributes.	Trash bags, shopping bags, containers of oil, milk conditioners, shampoos, detergents, and soap.
LDPE (Lowdensity polyethylene)	Due to its resilience against impact, moisture, and chemicals, LDPE is recognized as a secure and health-friendly plastic. Given its infrequent recycling, it is advisable to consider reusing or repurposing it instead of discarding it after a single use.	Food wrap, sandwich bags, Beverage bottles, and plastic grocery bags.
PVC (Polyvi-nyl chlo-ride)	PVC is increasingly replacing traditional building materials in the production of pipes,	Bottles, packaging, containers, plumbing and pipes and furniture coverings.
	tiles, and electronics parts, owing to its versatile characteristics, including lightweight, durability, cost-effectiveness, corrosion resistance, and ease of processing.	

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PET (Polyethylene terephthalate)	PET has become the rapidly expanding choice for food packaging due to its distinctive characteristics like being lightweight, durable, tough, and having resistance to grease, oil, and heat.	Beverage bottles, clothing, carpet, fiber, medicine, pots, rope, sleeping bags, pillows, and transparent plastic bottles.
PS (Polystyrene)	A thermoplastic polymer, finds extensive application in the production of both solid plastic material and rigid foam material.	Rigid foam material, tea cups, plastic boxes and cutlery, egg cartons and packing foam.
EPS (Expanded Polystyrene)	Exhibits robust resistance to water, soap, detergent, acids, and bases, thereby enhancing its strength and durability.	Yogurt containers, diapers, straws, sauce bottles, plastic bottle caps, plastic rope, and small net pieces.
Other res-ins	Conventional recycling practices due to their distinctive properties.	Cigarette filter, balloons.

Source: Lippiatt et al. 2013; Padgelwar et al. 2021; van Calcar and van Emmerik 2019

Results and discussion Macroplastic dry mass and number of items in the surface water

The mean value of macroplastics was 315.83 gm/day in terms of weight and the maximum weight was 1,114.97 gm/day in December in St-4 and the minimum weight was 9.3 gm/day in January in St-1. In the surface water of Louhajang River, the result showed that the average amount of macroplastics was found in St-4 which was 646 gm at the Notunpara Rd (Markaj masjid) of Louhajang River and continuously reduced in St-3, St-1, St-2, respectively. However, from the statistical analysis, a one-way ANOVA using Tukey showed that the total weight of macroplastics was significantly differences among the

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surface water stations in the Louhajang River study area (F = 8.155, P = <0.05). While Duncan[a] revealed that, there was a relationship between the stations in the study area of the Louhajang River. The results indicated that there were no noteworthy distinctions

among St-1, St-2, and St-3 stations. The fluctuation of dry mass among St-1, St-2 and St-3 was slight, while figures stood significantly high enough as far as St-4 was concerned (**Fig. 3**).

The mean value of macroplastics was 21 items/day in terms of number of items and the maximum items number was 63 item/day on December in St-4 and the minimum items number was 2 item/day on February in St-2. The average number of macroplastics was found in St-4 which was 40 items at the Notunpara Rd (Markaj masjid) in the Louhajang River followed by St-3, St-1 and St-2, respectively. From the statistical analysis, oneway ANOVA using Tukey showed that there were statistically considerable variations in the items number (every piece of plastic counted separately) of macroplastics among the stations in the Louhajang River (F = 10.421, P = <0.05). In contrast, Duncana revealed that there was a relationship between the stations in the study area. The findings showed that St-1 (a) and St-2 (a) had no substantial changes, similarly, St-3 (b) and St-4 (b) also showed no changes in the items' number of macroplastic content. But there were considerable variations in the item's number of macroplastics between St-1 (a), St-2 (a) and St3 (b), St-4 (b) (**Fig. 4**).

In St-4, despite the overall trend of the station indicating the highest macroplastic dry mass in December, January, and February. During December, January, and February, which coincided with Bangladesh's dry season, the country experienced a period characterized by reduced precipitation and distinct climatic conditions. Due to the estimated slow water flows during a specific period, causing plastic debris to accumulate in a confined area, the framed pocket net sampler proved particularly effective in capturing most of the plastic debris.

According to Lebreton et al. 2017, this is because there are a lot of people living in the area and not enough people taking care of waste management. Every day, approximately 4,000 to 4,500 tons of solid waste are generated and over half of this waste

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is irresponsibly disposed of in low-lying areas or released into freshwater bodies (Arefin and Mallik 2018). The country relies on rivers and the ecosystem services they offer, and the diverse aquatic systems play a crucial role in shaping its way of life and culture (Chowdhury 2012). Nevertheless, these aquatic ecosystems encounter severe pollution and confront various threats. Among various forms of solid waste, mishandled plastic stands out

as a significant pollutant, placing Bangladesh in the 10th position among the top 20 countries worldwide with high levels of mismanaged plastic waste (Kibria 2017).

The occurrence of plastic waste in freshwater ecosystems can be linked to humanrelated factors, as the quantity of plastic in rivers is closely connected to population density, urban expansion, wastewater management, and waste disposal methods (Best 2019; LI et al. 2016). Plastic waste gets into rivers either naturally, through processes like wind (Bruge et al. 2018) and rain causing runoff, or through direct dumping (Bruge et al. 2018; Moore et al. 2011; Tramoy et al. 2019)

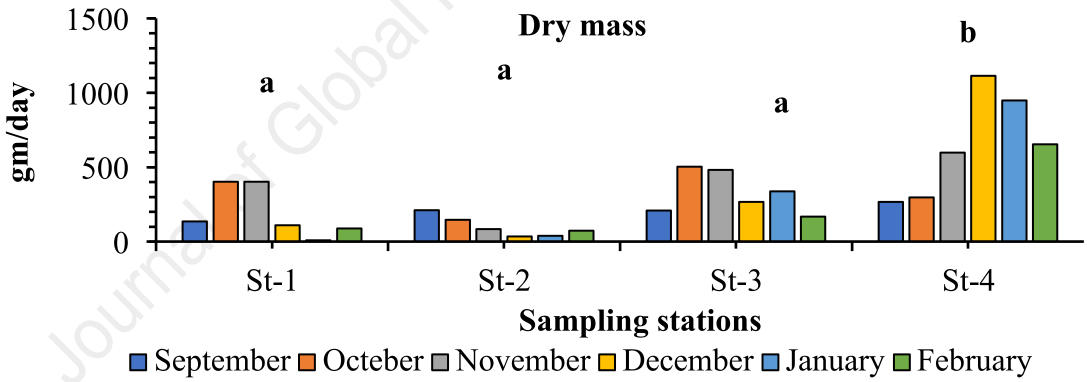

Fig. 3 The discharge of plastic waste in the Louhajang River at four different locations by weight.

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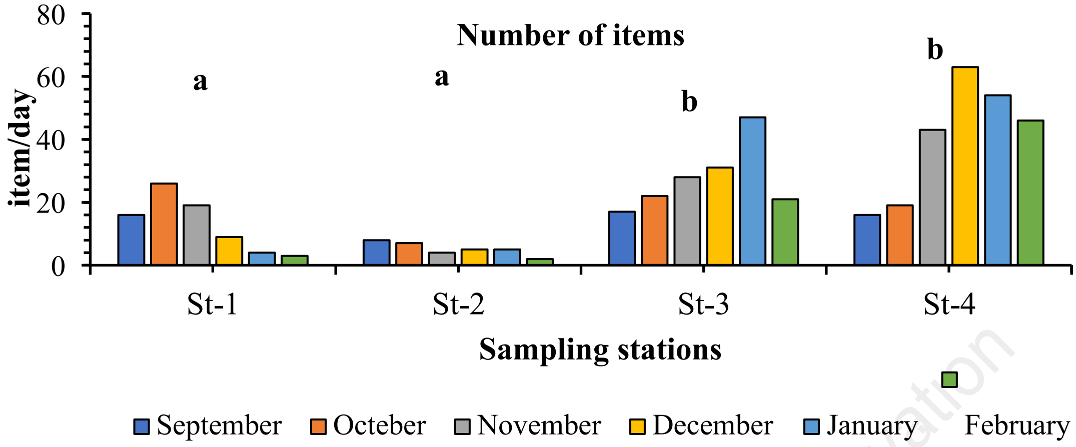

Fig. 4 The emission of plastic waste in the Louhajang River is measured based on the number of items at four specific stations.

Comparing the results to previous studies and examining the present state of macroplastic dry mass and items number in surface water

It was difficult to make a direct comparison the amount of macroplastic dry mass and item number found in this study and the findings of other studies because there was no globally standardized method for monitoring. Nevertheless, the study able to compare the results to those studies that utilized sampling methods and quantification units that are comparable to the study. Table 3 provides a concise summary of the findings obtained from research conducted on both macroplastic items and abundance found in surface waters all over the world.

In terms of dry mass, 7 kg 573 gm or 315.58 gm/day of dry mass was found across all the stations for the six-month observations. The findings of the study were lower than those of the study on the Citarum River (Hariyadi et al. 2022); the Danube River in Austria (Lechner et al. 2014), the Deli River in India (Hasibuan et al. 2022) and comparable similar range in Hilo (Hawai'i) rivers in the USA (Carson et al. 2013).

In terms of items number, a total of 515 items of plastic pieces were found in this study. The items number of macroplastics in surface water was higher than the study those from the United Kingdom in the Cynon River (Williams and Simmons 1997) and lower than the study of Thames River in the United Kingdom (Morritt et al. 2014), Seine

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River in France (Tramoy et al. 2019), Tiber river in Italy (Crosti et al. 2019), Klang river in Malaysia (Geraeds et al. 2019), Seine in France (van Emmerik et al., 2019).

Table 3 Overview of macroplastics comparison with other parts of the world riverine surface water in dry mass and the number of items

Study	River	Country	Monitoring period	Result	
				Variable	Unit
Present study	Louhajang	Bangladesh	6 months	Emission Amount	7 kg 580 gm or 315.83 gm/day 515 Items
Williams and Simmons 1997	Cynon	United Kingdom	3 months	Amount	150–400 items
Tramoy et al. 2019	Seine	France	45 years	Amount	20,259 items
Morritt et al.2014	Thames	United Kingdom	3 months	Amount	8,490 items
Carson et al. 2013	Hilo (Hawai'i) rivers	United States	205 days	Emission	0.32 kg/day
Crosti et al. 2019	Tiber	Italy	1 year	Transport	10–130 items/h
Geraeds et al. 2019	Klang	Malaysia	1 year	Transport	1,500 items/hr
van Emmerik et al. 2019	Seine	France	2 weeks	Transport	100–1,000 items/h
Hariyadi et al. 2022	Citarum	India	5 months	Emission	St-1: 1130 kg/hour St-2,3: 0.5 kg/hour
Lechner et al. 2014	Danube	Austria	-	-	1,533 tonnes
Hasibuan et al. 2022	Deli	India	-	-	19.25 kg/hour

Category of plastic debris

Both White and colour plastic pieces and plastic bags were the most common plastic types found in large quantities at Bhabanipur Patuli Para Bridge (St-1) (Figure 5-a). In the College Road bridge (St-2) contained the fewest number of plastic pieces' items where cork sheets were the most common plastic items (Figure 5-b). Due to the ample storage capacity in this location, the availability of cork sheets was notably abundant. Dighulia Bridge (St-3) was a fully residential area, and the building was under construction. Pieces of white plastic were the most kind of plastic that was typically found in large numbers (Figure 5-c). The sewage drain was connected to the river at Notunpara Road (St-4. Both the white plastic and coloured plastic pieces were the most identical plastic items in Notunpara Road (St-4) (Figure 5-d).

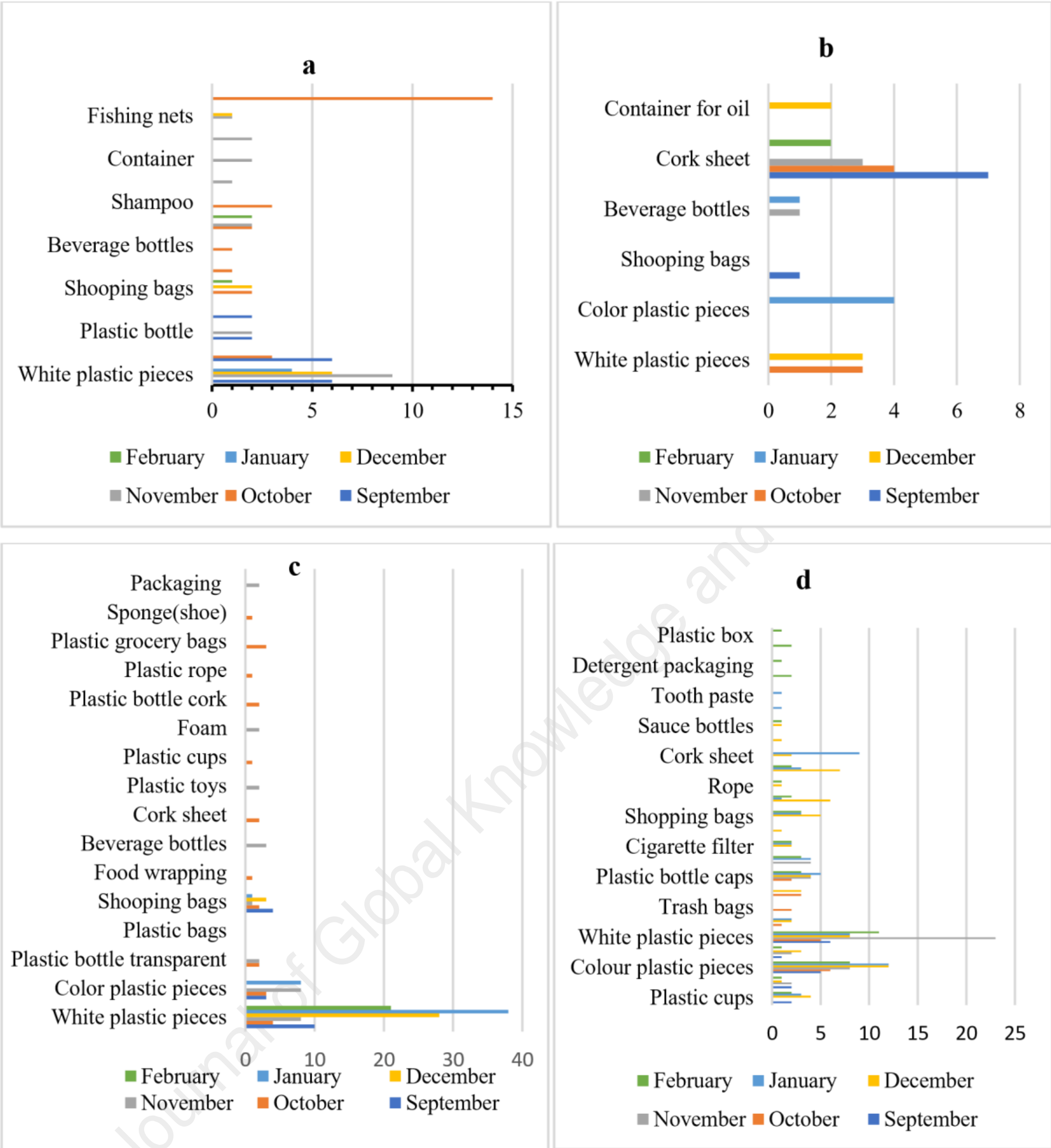

Fig. 5 The variety of plastic debris observed in **a** Bhabanipur patuli para bridge (St-1); **b** College Road Bridge (St-2); **c** Dighulia Bridge (St-3); **d** Notunpara road (St-4) at each month of observation.

The most common type of items was found plastic bags, followed by white plastic pieces, colour plastic pieces, cork sheets (**Fig. 5**). Macroplastics category in Citarum River were found in high numbers including clear plastic bags, sachets (plastic packaging),

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styrofoam, plastic bags, plastic with aluminium, toothpaste plastic, and caps of drinking bottles (Hariyadi et al. 2022). Other studies of surface water (Seine River) as reported by Morritt et al. (2014), food wrappers/containers and plastic cutlery; relatively few plastic bags were observed due to recreational activities. The predominance of food wrap-

pers/containers and plastic cutlery is probably due to recreational activities, with direct or indirect dumping into the Seine in addition to runoff. Plastic items, including pieces, bags, sheets, bottles, and cover/ packaging, represented around 77% of the floating macro-litter in Rhone River waters confirming the predominance of plastic pollution, in agreement with the top items list identified by RIMMEL across Europe (Gonzalez Fernandez et al. 2018).

The proportion of polymer composition based on dry mass and items number in the quantitative distribution

Plastic debris in terms of mass composition**,** where PET made up 16% (1.25 kg), HDPE 32% (2.42 kg), LDPE 25% (1.9 kg), EPS 17% (1.26 kg), PS 10% (743 gm) and other resins 0% (1.33 gm). PS was the lowest amounts and other resins comprised the least dry mass (only cigarette filters and balloons). HDPE was found in significantly higher amounts percentage in Bhabanipur Patuli Para Bridge (St-1), Dighulia Bridge (St-3), and Notunpara Rd (St-4), and the least amount of plastic debris was found in College Road Bridge (St-2). **(Fig. 6)**.

In terms of number of items, there was 10% (49) PET, 25% (128) HDPE, 44% (226) LDPE, 16% (85) EPS, 4% (20) PS and Other resins 1% (7). LDPE and HDPE had the highest numbers of items found in the study area. LDPE is commonly considered a secure and beneficial plastic due to its notable durability against impact, moisture, and chemicals. Because of its durability and flexibility, LDPE has gained popularity in manufacturing various everyday items such as food wraps, beverage bottles, and plastic grocery bags. Due to its infrequent recycling, it is advisable to repurpose or reuse LDPE instead of discarding it after a single use (Padgelwar et al. 2021). HDPE is widely regarded as secure, preventing the presence of chemicals in food substances. Currently, the utilization of these

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materials is on the rise due to their lightweight, exceptionally robust, durable, weather-resistant, and impact-resistant attributes (Padgelwar et al. 2021).

(Fig. 7).

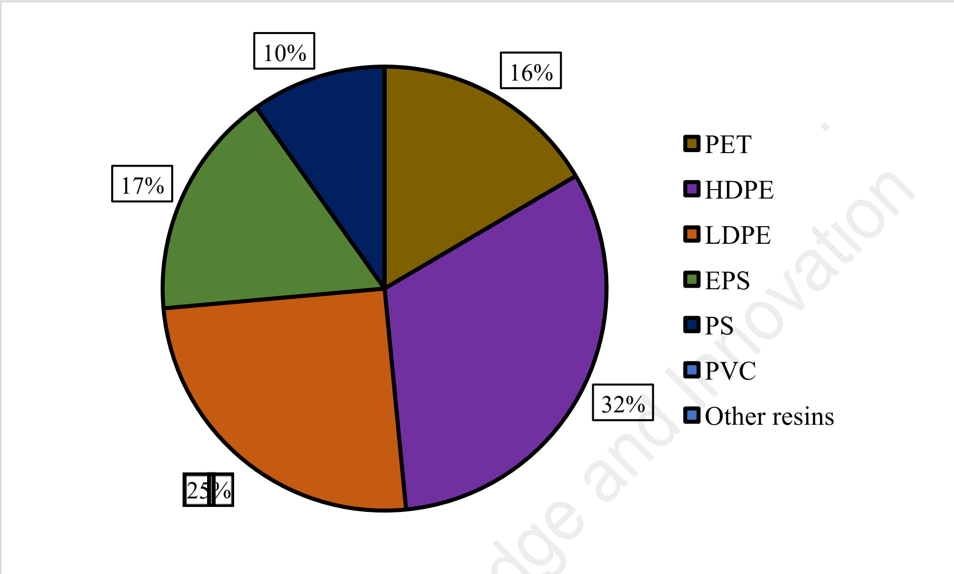

Fig. 6 Polymer composition of macroplastics weight in the surface water across all stations

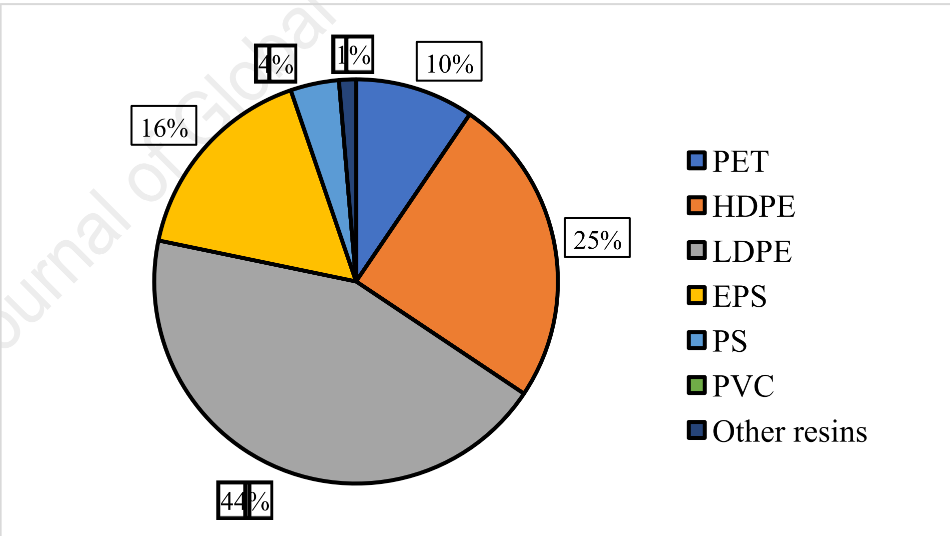

Fig. 7 Polymer composition of items number in the surface water across all stations

Comparing the proportion of plastic composition based on mass in the surface water from this study and other investigations

When compared with other study proportions of the world's surface water, macroplastic abundance in surface water in this study area was higher than those of the Ciliwung –

BKB-Angke (Lebreton et al. 2018), Rhine (Conchubhair et al. 2019) River and lower than those of the Chao Praya – up (Morritt et al. 2014), Pesanggrahan (Schmidt et al. 2017), Ciliwung – Haryono (Jambeck et al. 2015), Ciliwung – BKB-Grogol (Kukulka et al. 2012), Saigon – Thu Thiem (Lebreton and Andrady 2019). The results from studies of macroplastic items in surface water worldwide are summarized in **fig. 8**.

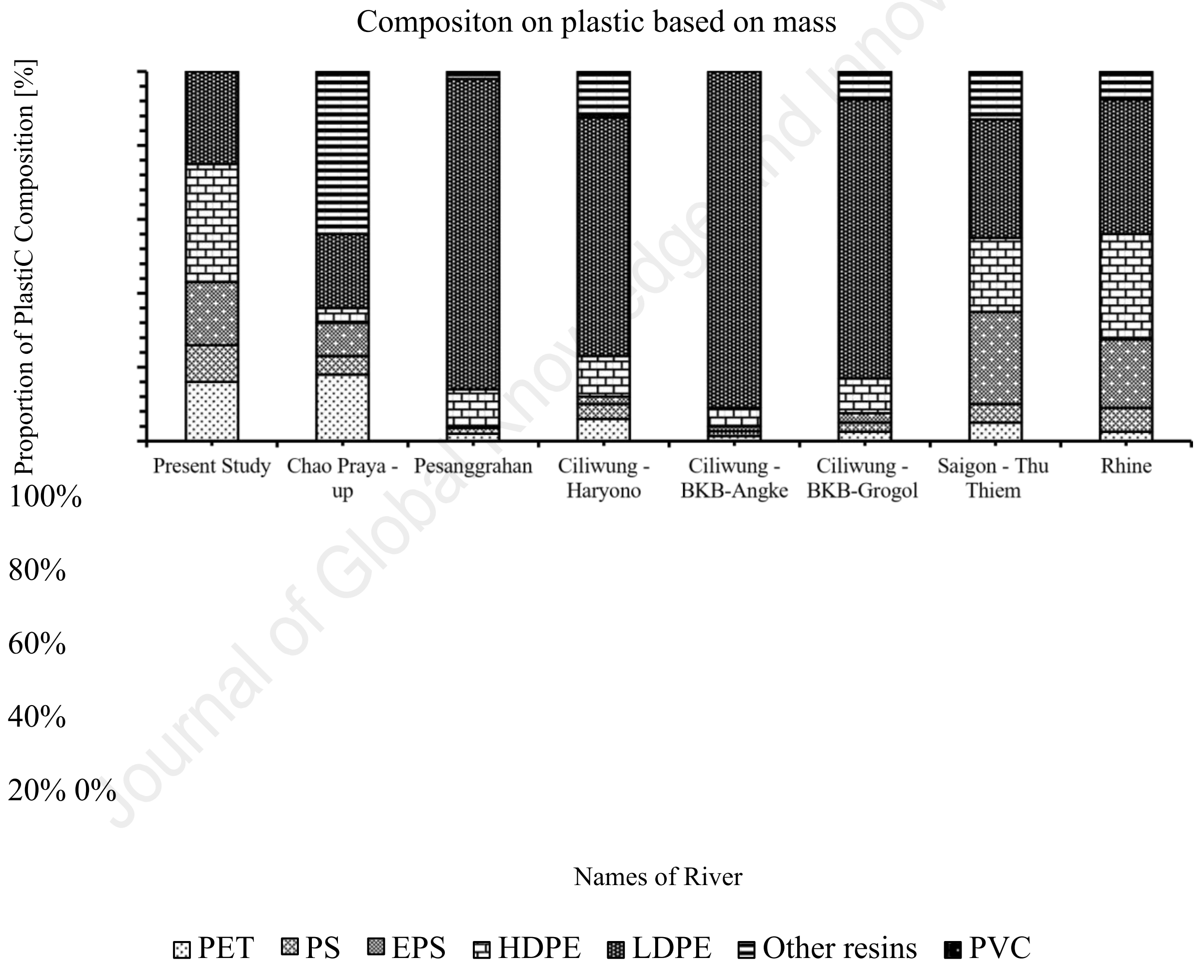

Fig. 8 The composition of the plastic samples for locations in Thailand (Chao Phraya), and the Netherlands (Rhine) in terms of mass.

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Comparing the proportion of plastic composition based on items number in the surface water from this study and other investigations

The items number of macroplastics observed in surface water from this study was lower than those from the Kuantan - main (Li et al. 2016), Pahang (Best 2019), Klang (Moore et al. 2011), Rach Cai Khe (Ryan 2015), Cai Tho (Co zar et al. 2014), Seine - down (Blettler et al. 2018), Seine – mid (Barboza et al. 2018), Seine – mid (Schwabl et al. 2019), Seine up (Barnes et al. 2009). Our results suggested that the number of items in surface water from the Louhajang River was comparable same range to those of surface water from the

Kuantan – tributary (Gonza lez and Hanke 2017), Thi Nghe (Baldwin et al. 2016).

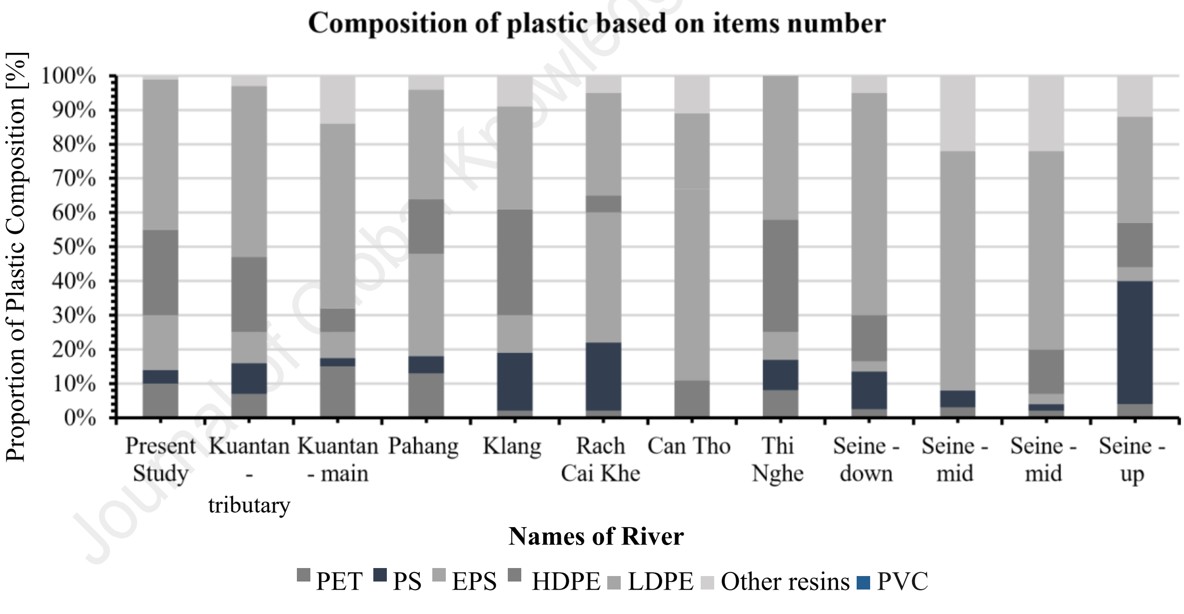

Fig. 9 The composition of the plastic samples for locations in Malaysia (Kuantan, Pahang, and Klang), Thailand (Chao Phraya), France (Seine), and The Netherlands (Rhine) in terms of plastic items.

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Conclusion

Transport of plastic waste by rivers is an important, albeit complicated, aspect of the global plastic pollution issue. This study is among the first to provide complete information on the amount and kind of floating plastic waste carried by rivers in urban areas by examining floating debris at a wide regional scale utilizing a deployed framed pocket net sampler method. The framed pocket net sampler was attached to a bridge or installed on riverbank and operated one day once a month at each location for 24 hours. The amount of plastic waste released into the Louhajang River remains notably high, surpassing 1,114.97 gm/day, particularly in the vicinity of Notunpara Rd (St-4). Although it was a limited quantity, the coverage area was confined to a small extent. In this study, the dom-

inant macroplastics were white and colour plastic pieces, and plastic bottles found in all station study areas. LDPE and HDPE were the leading polymers identified randomly in surface water. Purchasing fresh produce and grocery items could be the major sources of MaPs in the study area. This study suggested the implementation of the following approaches to decrease the influx of debris into local river systems: (i) Construction of structures like river booms, gross pollutant traps, and river bins helps reduce human-made debris in waterways. (ii) Implementing initiatives against littering is a widely accepted management approach and may prove more effective at various locations (iii) Imposing more taxes and incentives refers to a strategy where governments use financial measures to encourage or discourage certain behaviors related to waste management and environmental protection. Governments can impose taxes on businesses or individuals that contribute to plastic pollution, such as levies on plastic production, single-use plastic items, or waste disposal. The idea is to make it more expensive to produce and use plastics, thereby encouraging a shift towards more sustainable alternatives. On the other hand, incentives involve financial rewards for positive environmental actions. For example, companies or communities that reduce plastic waste, recycle more, or adopt eco-friendly practices could receive tax breaks, grants, or subsidies.

Net sampler methodd may miss smaller plastic particles, as it is typically designed to capture larger debris. The effectiveness of the net can be affected by varying water flow rates. The method may not capture plastics dispersed throughout the water column, as it mainly targets surface or near-surface plastics, possibly underestimating the total plastic load. Non-plastic debris, such as leaves or organic matter, can clog the net and reduce its efficiency in collecting plastics. Hence, a potential remedy for minimizing litter in the area involves directing focused efforts, initiatives, and educational resources towards local shop owners and grocery consumers.

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Declarations

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.

Conflict of interest

There is no conflict of interest regarding this manuscript.

Ethical Statement

Authors firmly abide by all ethical norms and follow the guidelines set by COPE.

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