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Microplastic Pollution in the Shore Sediments of Narmada River Along Jabalpur City

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Abstract*— *Microplastics, due to their microscopic size, constitute a concern to aquatic species since they are easier to consume and the recent discovery of microplastic in human blood shows that these may also have undisclosed health effects on humans. This study provides microplastic characteristics and abundance of microplastics in the shore sediments of Narmada river flowing along Jabalpur City. The information about the presence of microplastics can be crucial in preventing further pollution and developing management interventions. Sediments samples were collected from 4 sites along a 50 km stretch of the river. Sample pretreatment was performed using ZnCl2 solution for density separation and H2O2 for oxidation of organic material. Microplastics examination was carried out using Fourier Transform Infrared Spectroscopy (FTIR). Microplastics in the 20-1000 µm size range were found to be more abundant (114-273 MP/Kg) than larger microplastics in the 1-5 mm size range (18-110 MP/Kg). This research presents the first accounts of microplastic pollution in the shore sediments of Narmada River and it emphasizes the need for more in-depth research into microplastic pollution in fresh water sources.

I. INTRODUCTION

Plastic production has surged dramatically since its invention in the early nineteenth century, from 1.5 million tonnes in 1950 to 368 million tonnes in 2019 globally [1]. The global plastic waste generation is expected to reach 230 million tonnes in 2025 and 300 million tonnes annually by 2040 [2]. The particles of plastic with size <5 mm fall under the category of microplastics, which are further classified as primary microplastics and secondary microplastics. Primary microplastics are manufactured in microscopic sizes to be used in facial cleansers, scrubs and other cosmetics and these can be easily traced back to their sources. Secondary microplastics are even smaller fragments of plastic formed by weathering or breakdown of larger plastic particles and these cannot be easily traced back to their sources [3], [4]. Secondary microplastics are predominant pollutants in the riverine system [5]. Microplastics can enter the riverine system through numerous sources including industrial, domestic drainage or surface runoff due to rain [6]. The extensive use of fishing gear that is often discarded in the water bodies, fibers form washing clothes made of polyester, nylon etc. [7], [8], accompanied by newly introduced surge in use of surgical masks due covid-19 outbreak [9] can causes a substantial amount of pollution in the rivers and oceans. Microplastics are transported though river water and the sediments along the shore lines can act as a sink of microplastics [10]. Presence of these microplastics in the riverine system raises serious concerns about the ecological system as well as human health. Being small in size microplastics can easily be consumed by aquatic animals [11], [12] and may eventually end up inside humans through consumption of sea food [13], [14]. The recent discovery of microplastics in human blood stream raises serious health concerns[15]. Clearly, the abundance of microplastics in the water bodies is bound to increase with increase in production and poor disposal of plastic waste. The studies on presence of microplastics in India are limited to some major rivers like Ganga, Brahmaputra, Indus and Nethravati [6], [16], [17] and for a better knowledge of its abundance and environmental implications, this type of study's scope should be expanded to include a significant number of water bodies that serve as the primary supply of water for the majority of Indian population. There is no published data currently available on microplastic contamination in Narmada River. This study attempts at providing the first account of microplastic pollution in the river shore sediments of Narmada river and bridge the research gaps on microplastic pollution in the freshwater sources of central India.

II. STUDY AREA AND SITE SELECTION

The Narmada River is the largest west flowing river in India with a catchment area of around 98,796 sq. km which is around 3% of the total geographical land area of India, spanning majorly over Madhya Pradesh and Gujarat and very little parts of Chhattisgarh and Maharashtra. It raises from the Maikal ranges at the height of 1057 meter above the sea level in Amarkantak Plateau in Anuppur district Madhya Pradesh, India and traverses a length of about 1312 Km before falling into the Arabian Sea.

It first follows a tortuous course through the hills near Mandla and then turns northwest to pass the city of Jabalpur. Then it enters the structural trough between the Vindhya and Satpura ranges at Marble Rocks Gorge. It is also known as "Life Line of Madhya Pradesh and Gujarat" for its huge contribution of water to both the states. The length of this river flowing through Jabalpur district is around 80 Km and this region of the river is considered as the study area here.

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The maps of the area under consideration are represented in figure 1-(a), 1-(b), 1-(c).

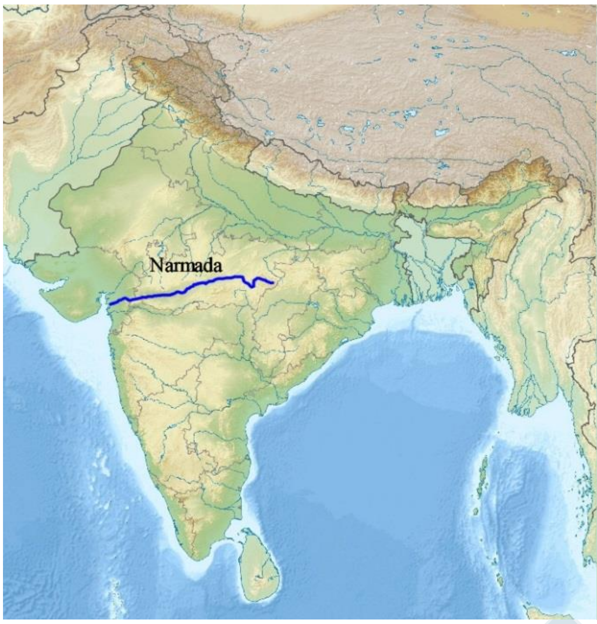

Fig. 1-(a). Location of Narmada River

Fig. 1- (b). Sampling Sites

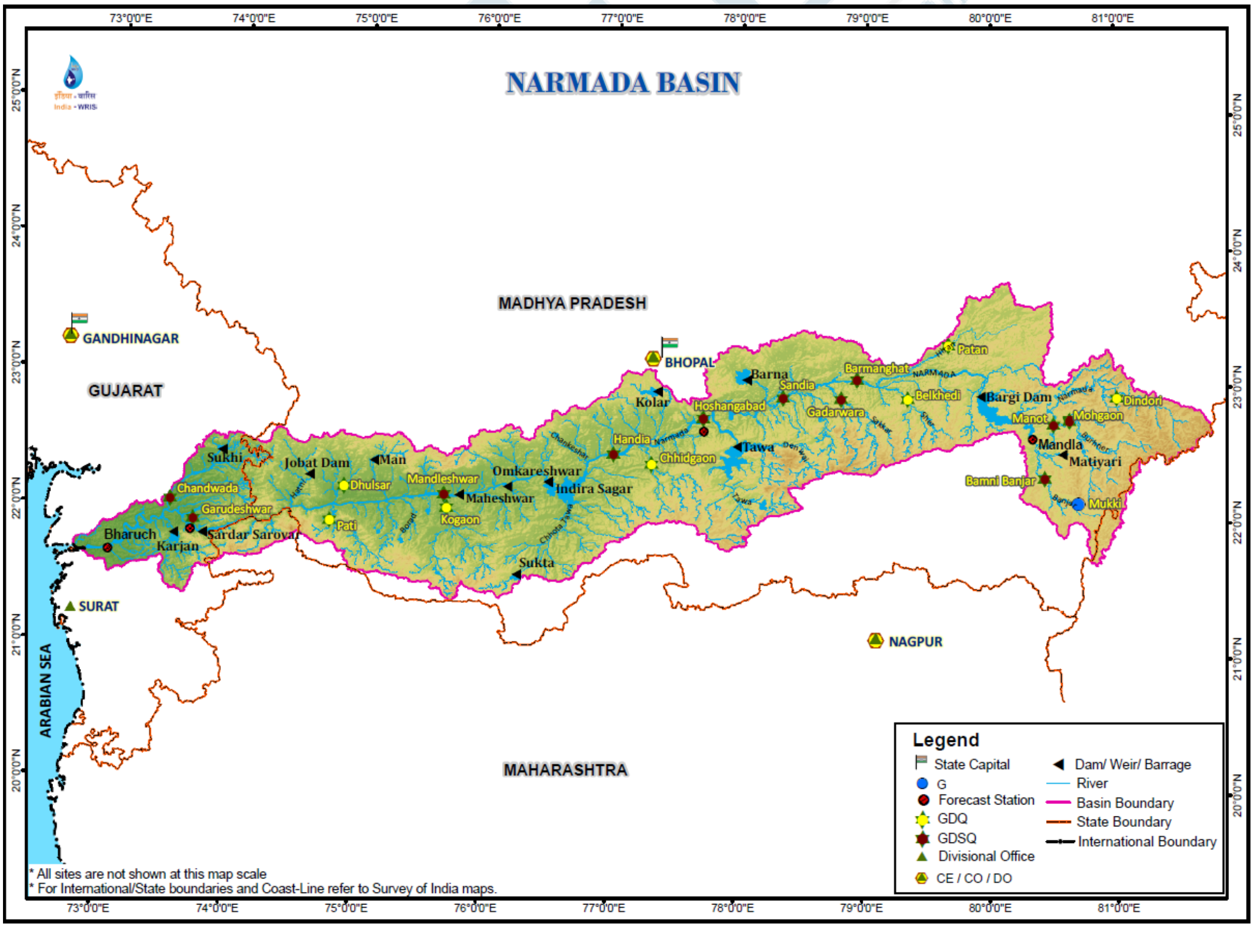

Fig. 1-(C). Narmada river basin

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Jabalpur city houses a number of ghats out of which 4 locations named N1 - Jamtara, N2 - Gwari Ghat, N3 – Tilwara Ghat and N4 – Bhedaghat were selected for collection of sediment samples.

III. SAMPLING METHOD

Five samples were collected at random spots 1-2 metres along the river shoreline from each site. Stainless steel spoons and containers were used to collect the sediments from an area of approximately 30 cm^2 and approximately 4 cm depth. Later, the sediment samples collected from each spot were mixed into one combined sample and 1 kg of sediment from the combined samples was separated as the final sample.

Overall, four such samples were collected from four different sites, and the collected samples were brought to the laboratory at Jabalpur Engineering College and dried in an oven at 40 °C for 48 hours before pretreatment.

Pretreatment

For pretreatment, 50gm dry sample from each of the samples was taken and subjected to density separation using $ZnCl_2$ solution [18]. $ZnCl_2$ has a density of 1.7 g/cm^3 and the density of plastics varies in a range between 0.8 and 1.4 g/cm^3, specifically for polyethylene (0.92-0.97 g/cm^3), polypropylene (0.85-0.94 g/cm^3), polystyrene (0.05-1 g/cm^3) and others are also in the same range [19]. After density separation, the floating particles were separated by the filtering of the supernatant using a 20 m sieve. Later, oxidation of organic material was carried out using a 30% H_2O_2 solution in a borosilicate glass beaker for 12 hours. Then the sample was filtered through the same 20 m sieve. Finally, vacuum filtration was performed on cellulose filter paper (diameter 47 mm, pore size 5 m) using a setup comprising of a vacuum pump, a thoroughly rinsed Buchner flask, and a porcelain Buchner funnel.

Contamination Control

The sediments were collected in stainless steel containers using stainless steel spoons from the sites. While performing density separation and oxidation of organic matter, borosilicate glass apparatus was used, except for the wash bottles that were made of plastic. The Borosilicate glassware was rinsed twice with distilled water before being used for pretreatment. The filtration setup with a porcelain Buchner funnel was thoroughly rinsed with distilled water several times to prevent contamination. Fresh filter papers were used for filtration with a test run of 250ml of distilled water. The filtered samples were later stored in borosilicate glass petri dishes. The procedure was performed in a dedicated and clean laboratory with limited access.

Microplastic laboratory analysis

The information about the surface characteristics like type of particles (i.e. Fiber, Fragment or Bead), Dimensions (i.e. Length and diameter) and colour was derived and recorded by using a light microscope. Shape of the microplastics was classified into Fiber, Films, Spherical Beads and Fragments.

For the identification of the type of microplastic particles, Fourier transform infrared spectroscopy (FT-IR) was performed using an FTIR microscope (IRAffinity-1S, Shimadzu, Japan) equipped with a built-in automatic dehumidifier, a high-energy ceramic light source, and a temperature-controlled, high-sensitivity DLATGS detector.

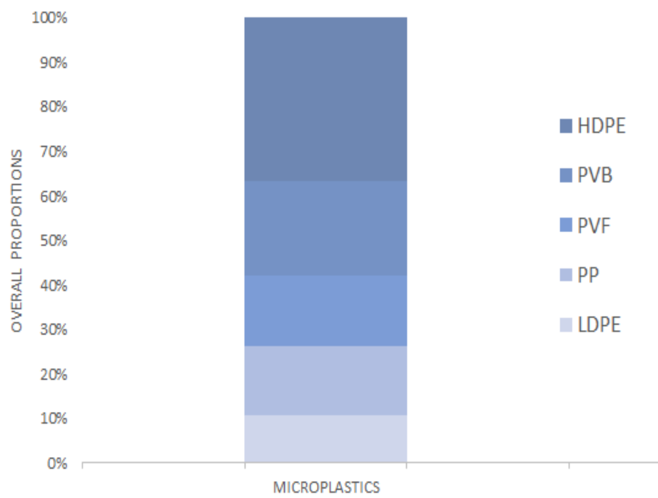
Each spectrum was obtained with a scan number of 32 and wave number of 4000 cm^{-1}–400 cm-1, with a spectral resolution of 4 cm^{-1}. The spectra obtained were compared with the spectrum library (including more than 7000 spectra), and the matching of spectra was based on correlation analysis. The limit for the identification of microplastics was kept at 70%–80% for all the polymer types.

IV. RESULT

In total, four samples were collected from four different cross-sections of the river. Overall, 46 microplastics were identified, among which the types of microplastics were high density polyethylene (HDPE), low density polyethylene (LDPE), polypropylene (PP), polyvinyl butyral, and polyvinyl formal. The abundance of microplastics is represented by the unit of microplastic per kilogram (MP/Kg), and the total number of microplastics was calculated by extrapolating the result of microplastics in 50gm of dry weight sediment sample to kilogram. The abundance of microplastics in the Narmada river on the basis of this study varies between 114-273 MP/Kg within a size range of 20–1000 m and 18–110 MP/Kg within a size range of 1 mm–5 mm. Fragment-shaped microplastics were the most abundant among all the types of plastics, followed by fiber and beads.

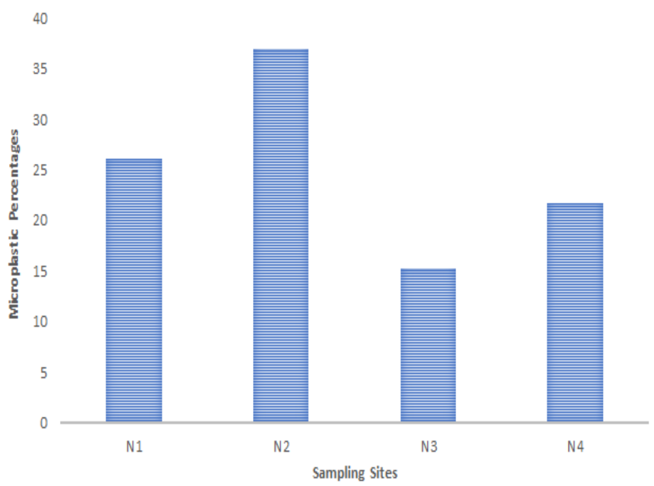
V. DISCUSSION

The majority of the microplastics found in this study were polyethylene-47.37% (including LDPE and HDPE both) and have a wide range of applications such as grocery bags, packaging materials, plastic containers, bottles, toys, pipes, etc., while other types of plastics like polypropylene, polyvinyl formal, polyvinyl butyral, which are generally used in food packaging, wire insulation, insulated glass, etc. These microplastics could have found their way to the shores of the Narmada river through the mismanaged disposal of plastic waste from industries or households. Jabalpur itself houses some industrial factories; the waste from them could easily diffuse into the vicinity of the Narmada river. The onsite conditions of the locations of sampling sites were also not completely sanitary due to littering of plastic waste. The overall proportion of types of microplastics is represented in fig.



The microplastics carried by the river water from upstream could also have been deposited on the shore sediments. The Narmada river has a huge catchment area and the deposition of microplastics through surface runoff containing mismanaged plastic waste could also be a pathway for microplastics deposition on the shores of the river.

Although similar types of prevalent microplastics were found on all the sites, the presence or absence of a few microplastics can be related to the source or pathway of microplastics. The absence of polyethylene on the sediments of site N1 (Jamtara) suggests that polyethylene may not be present in the upstream water of the river, and its presence on other sites suggests that it is mainly a result of plastic pollution in the city itself. Similarly, the absence of PVF and PVB in the sediments of the sites N4 (Bhedaghat) suggests that these pollutants have their source in Jabalpur city. The fragment type of particles were most abundant in all the sediment samples, indicating that most of the microplastic pollution along the shoreline of the Narmada river is due to weathering and fragmentation of the larger size of mismanaged plastic waste. Fig. depicts the percentage of microplastics found in the samples of each sites.



In comparison with other studies, the concentration of microplastics in the shore sediments of the Narmada river is low to intermediate. The industrialization along the Narmada river is limited to a few major cities in Madhya Pradesh, the contribution of microplastic pollutants through industries is not high. The study was performed only on a 50–60 km stretch of the Narmada river flowing through Jabalpur, which is only around 300 km away from the origin of the river. So, the concentration of microplastics may vary when the full length of the river flowing through Madhya Pradesh and Gujarat is studied in a deep manner.

VI. CONCLUSION

This study concludes that sediments along the shore line of the Narmada river act as a sink for the deposition of microplastics. The secondary microplastics were abundant among all samples, confirming that a major portion of microplastics originated from fragmentation and weathering of older, mismanaged plastic waste. The larger number of particles in the size range of 20–1000 m suggests that with the decrease in the size of microplastics, the abundance has increased. However, the concentration of microplastics was found to be lower as compared to other rivers.

This study provides the first accounts of microplastic pollution in the Narmada River’s shore sediments along Jabalpur city and emphasizes the need for further research on microplastic pollution in freshwater sources in India.

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