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Assessment of Microplastic Pollution in Selected Water Bodies in Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study aimed to assess of microplastic pollution in selected water bodies in River State, Nigeria. Two water bodies, one fresh water (New Calabar River) and one estuary (Bonny River) were sampled in the present study for presence of microplastics in water, sediment and fish samples in the aquatic milieu. Microplastics were extracted using standard methods and were characterized using GCMS. Four plastic types namely polyethylene, polyethylene terephthalate, polystyrene, polypropylene was detected in all samples. Likewise, four plasticizers namely dioctyl terephthalates, polybrominated diphenyl ether, acrylic fibre and tetrabromobisphenol A were all detected in sediment, water and fish samples from Bonny River and New Calabar River. FTIR analysis of microplastics showed patterns typical of polystyrene. This study has shown that water,

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sediment and fish samples contain microplastics. This is a worrisome development as the water are used for domestic purposes among persons resident along the water courses and the fish species sampled is commonly available as source of protein for majority of persons. This calls for greater enlightenment on the possible danger of microplastics pollution in the study area and for measures to check macroplastics pollution, which bring about microplastics pollution in the aquatic environment. Such measures should include promotion of the use of plant material as food wrappings and to dissuade dumping of solid waste in the rivers.

Keywords: Microplastics; solid waste; organic polymers; hydrophobicity.

1. INTRODUCTION

Plastics are synthetic organic polymers with wide applications owing to their malleability, low cost, hydrophobicity, lightweight and durability [1,2]. Their production has been on the upscale since Bakelite, the first synthetic polymer from which the name was derived, was invented in 1907 and from the mid-20th century when industrial production commenced; to the extent there now exist a plastic product for almost every facet of human need [3].

Many assortments of plastics are produced globally with different properties depending on their intended use, among them are acrylic (AC), polyamide (PA), polyethylene [PE], polybutylene terephthalate (PBT), polyester (PES), polyethylene terephthalate (PET), polyoxymethylene (POM), polypropylene (PP), polystyrene (PS), polyurethane (PUR), polyvinyl alcohol (PVA) and polyvinyl chloride (PVC). Plastics by their nature are chemically inert and endure chemical, environmental and mechanical stress.

The boom in plastic production has not been matched by a commensurate stratagem for its sustainable use which includes recycling. Thus, plastic wastes have emerged as environmental pollutants of great concern, with global distribution and partitioning into air, land and water, and possible uptake by organisms in these environments [4]. About 9 billion tons of plastic ever produced since 1950 have ended up as waste [5]. From a current estimate of about 9 million tons of plastics entering the aquatic milieu per year, it is expected to triple in about a decade, on the assumption that key stakeholders commit to reduction of plastic waste, or else, it could possibly increase by 10 folds within the next decade [5]. According to Chatterjee and Sharma [6], the effects of the plastic evolution of the 20th century will be evident and menacing in the 21st century. With figures of the global plastic market merged with population surge, sub-Saharan African is expected to dominate in plastic waste generation aided by week environmental regulations, enforcement and management of waste.

Larger plastic (macroplastics) waste are glaringly visible and sundry impacts have been demonstrated for them, including the entanglement of wildlife in fishing gear, blockage of guts of bird, distortion of habitat and obstruction of waterways [7]. Microplastic (plastics≤5 mm), in contrast, are less visible and their potential negative impacts are equally less obvious. The array of microplastics in any environment today is expectedly extensive, owing to improvement in technology over the last half a century that brought about various polymer blends, creation of micro sized plastics and sundry additives that impact distinctive features on products [7].

On the perception of the emerging environment threat of microplastics, GESAMP [7] averred that there is a dearth of knowledge and appreciation of magnitude of this particular problem. But the body of literature suggests the growing importance of microplastics pollution research, as microplastics have been repeatedly recovered from food and water, and shown to be transferable across cells, build up in tissues and transferred across trophic levels.

Port Harcourt a city with a population of 2 million inhabitants generate tremendous amount of waste of which 35% is plastic mainly PE, PET, and PS used for packaging (Briggs *et al*., 2019). The waterways in Port Harcourt are conduit for solid waste transport into the Atlantic Ocean, as open dumping of waste is commonly practiced in the city. Thus, likelihood of elevated microplastics pollution of waterways in the city is very high.

2. MATERIALS AND METHODS

2.1 Study Area

Two river courses, New Calabar River and Bonny River, situated between latitude 4°44'N - 4°55'20'N and longitude 6°53'32'E-7°3'E, were sampled for microplastic pollution (Fig. 1). The rivers transverse Rivers State, South-South Nigeria. The New Calabar River is a freshwater habitat with salinity of 2.85 ppt while the Bonny River is a marine habitat with salinity of 19.64 ppt. The topography of the deltaic plain through which the rivers transverse is flat; with average height of about 11m above sea level. The flat terrain encourages water stagnation after rains and no good drainage system to channel runoff to the river.

The climate is humid tropical/equatorial zone with a mean annual temperature of about 29°C. The temperature ranges from about 22°C - 35°C within the rainy and dry seasons respectively. The highest rainfall occurs between the month of July and September and decrease as dry season approaches between December and January with mean annual rainfall of 2500 mm.

The anthropogenic activities around areas bordering the New Calabar River include manufacturing, oil servicing work yard, dredging, markets, schools and residential area. The Bonny River is a major transport channel that receives wastewater from its metropolis, market, dockyard of the Ibeto cement factory and from transportation of artisanal refined crude oil, timber and other goods.

2.2 Samples Collection

Microplastics samples were collected from the surface water using plankton nets of 50 µm mesh and filtered afterwards through a 5 mm sieve so as to make certain only particles less than 5mm were collected. Sediment samples were collected at the four sampling stations using a sterile soil auger into sterile glass bottles. A total of twelve samples of *Pseudotolithus elongatus* (three from each sampling station) were collected at random at New Calabar River by New Calabar River

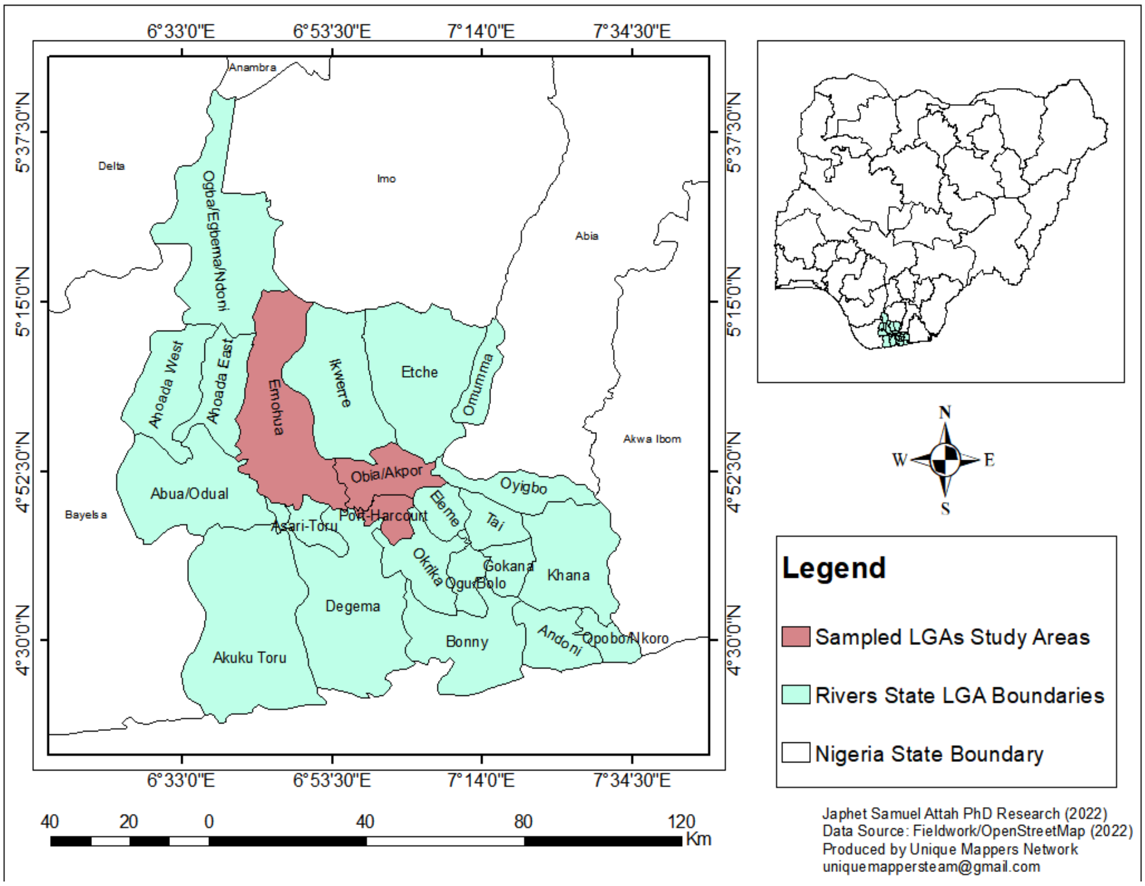

Fig. 1. Sampled LGA in Rivers State, Nigeria

(station 1 and station 2) and Bonny River by Bonny Jetty (station 1 and station 2). The fish were caught using a hand net and were wrapped in a sterile nylon bag. The samples were transported to the laboratory within a minimum time for microplastic extraction.

2.3 Sample Preparation and Extraction of Microplastics

The extraction of microplastics from water, sediment and fish samples was by density separation as per NOAA protocol [8]. The water and sediment samples were sieved through a 5mm sieve in order to ensure no particles greater than 5 mm was retained in the sample. Sieved water sample was washed in 500 mL beaker and 250 ml of sterile salt solution (NaCl) added to cause microplastics to float and be filtered off. The fish (*Pseudotolithus elongatus*) exterior was cleaned carefully with sterile distilled water and then cut horizontal to extricate the gut content. The gut content was poured in a 500 mL with 250 ml of sterile salt solution (NaCl) added to separate out the microplastics. Retrieved microplastics were air dried and analysed using GCMS (Agilent 5973).

2.4 Fourier Transform Infra-Red (FTIR) Spectroscopy Analysis of Microplastics

FTIR Spectroscopy analysis was carried using Agilent T as described by Ibiene et al. [9]. Bits of microplastics were mixed with KBr to form a lump and fixed to the FTIR sample platter. Spectra were taken in triplicate at 350 to 4000 wave-numbers cm^{-1} for each sample.

3. RESULTS

Table 1 shows microplastics noticed in water, sediment and fish samples from Bonny River jetty while Table 2 shows microplastics noticed in water, sediment and fish samples from New Calabar River. Four plastic types namely polyethylene, polyethylene terephthalate, polystyrene, polypropylene, and four plasticizers namely dioctyl terephthalates, polybrominated diphenyl ether, acrylic fibre and tetrabromobisphenol A were all noticed in sediment, water and fish samples from Bonny River and New Calabar River.

3.1 FTIR Analysis

Fig. 2 shows FTIR spectrum of microplastic from New Calabar River 1, which is a typical pattern for polystyrene. Fig. 3 shows FTIR spectrum of microplastic from New Calabar River 2, which is a typical pattern for polyethylene. Fig. 4 shows FTIR spectra of microplastic from Bonny River 1 which is a typical pattern for polyethylene. Fig. 5 shows FTIR spectrum of microplastic from Bonny River 2, which is a typical pattern for polystyrene.

4. DISCUSSION

Microplastic pollution has emerged as an ecological menace as they increasingly being detected in water bodies which serve as vehicles and sinks for these intractable pollutants. Researchers have continued to point to the possible trophic level transfer to microplastics to draw attention to the risk of this emergent pollutant. The present study focused on screening of water, sediment and fish (*P. elongatus*) samples in Rivers State, to the determine the incidence of microplastics in this environment.

In the present study, microplastics were detected in all water, sediment and fish (*P. elongatus*) samples from Bonny River and New Calabar River, of which PE, PET, PS and PP were identified in all the samples. PE, PET, PS and PP are commonly reported microplastics present in sediment samples globally [10]. A study in Thailand revealed that fishing gears made with PE were foremost fonts of microplastic contaminants in the Chi River [11]. Low density PE have been recovered in water, sediment and fish [11,12]. Imhof et al. [13] in their study reported high profusion of PE and PS microplastics in lakeshore sediments of Lake Garda, Italy. This is not surprising as PE and PS are among commonly used plastic materials that end up in the environment.

Microplastics were detected in all fish (*Pseudotolithus elongatus*) samples from both freshwater and saltwater habitats, giving a prevalence of 100%. Similar to the finding of this study, Adeogun et al. [14] screened for and detected microplastics in the belly of freshwater fishs from Eleyele, Oyo State, Nigeria. The authors reported microplastics in all eight (8) species (*Oreochromis niloticus, Paranchanna obscura, Coptodon zillii, Chrysicthys nigrodigitatus, Hepsetus odoe Sarotheron melanotheron, Lates niloticus,* and *Hemichromis fasiatus*), with a prevalence of 69.7%, which is lesser than in the present study. Presence of microplastics in fish is an important issue for which there is concern for human health risk.

Table 1. Microplastics and additives detected in Bonny River water, sediment and fish samples

		Water				Sediment				Fish			
		Station 1		Station 2		Station 1		Station 2		Station 1		Station 2	
S/N	Plastic/Additives	R.T. (min)	Peak Area (ppm)	R.T. (min)	Peak Area (ppm)	R.T. (min)	Peak Area (ppm)	R.T. (min)	Peak Area (ppm)	R.T. (min)	Peak Area (ppm)	R.T. (min)	Peak Area (ppm)
1	Polyethylene	8.426	42.28	8.676	42.96	8.674	47.18	8.611	48.28	8.742	13.96	8.543	19.96
2	Polyethylene terephthalate	10.638	22.19	10.722	24.74	10.812	26.54	10.256	29.67	10.683	5.74	10.686	8.74
3	Dioctyl terephthalates	13.254	2.43	13.243	1.52	13.683	1.67	13.724	1.50	13.178	0.52	13.286	0.38
4	Polybrominated diphenyl ether	13.746	1.52	13.852	1.83	13.912	3.18	13.938	0.18	13.952	0.83	13.771	0.62
5	Tetrabromobisphenol A	14.684	0.77	14.693	2.76	14.228	1.60	14.652	3.96	14.374	0.76	14.634	0.75
6	Polypropylene	16.792	7.81	16.404	6.13	16.821	9.38	16.804	8.17	16.891	4.13	16.820	0.81
7	Acrylic fibre	17.585	1.54	17.972	1.39	17.674	1.25	17.635	0.63	17.727	0.39	17.981	1.19
8	Polystyrene	19.674	8.31	19.867	5.52	19.638	6.96	19.911	6.48	19.638	6.96	19.911	6.48

Table 2. Microplastics and additives detected in New Calabar River water, sediment and fish samples

		Water				Sediment				Fish			
		Station 1		Station 2		Station 1		Station 2		Station 1		Station 2	
S/N	Plastic	R.T. (min)	Peak Area (ppm)	R.T. (min)	Peak Area (ppm)	R.T. (min)	Peak Area (ppm)	R.T. (min)	Peak Area (ppm)	R.T. (min)	Peak Area (ppm)	R.T. (min)	Peak Area (ppm)
1	Polyethylene	8.731	50.73	8.771	47.64	8.627	51.34	8.721	48.20	8.631	28.18	8.441	38.42
2	Polyethylene terephthalate	10.850	28.68	10.912	26.82	10.861	27.52	10.903	30.31	10.854	7.34	10.867	12.16
3	Dioctyl terephthalates	13.291	1.52	13.364	1.93	13.224	1.67	13.177	0.83	13.178	0.22	13.218	0.08
4	Polybrominated diphenyl ether	13.863	2.33	13.819	1.17	13.698	2.19	13.643	1.21	13.942	0.03	13.725	0.13
5	Tetrabromobisphenol A	14.794	1.71	14.726	0.53	14.714	1.55	14.864	0.89	14.503	0.26	14.901	0.46
6	Polypropylene	16.811	7.89	16.913	6.47	16.820	6.17	16.784	5.74	16.947	1.14	16.638	2.02
7	Acrylic fibre	17.958	2.52	17.764	1.96	17.731	2.39	17.801	1.63	17.835	0.82	17.577	0.64
8	Polystyrene	19.471	4.41	19.552	3.42	19.874	4.21	19.693	3.22	19.674	1.76	19.836	1.39

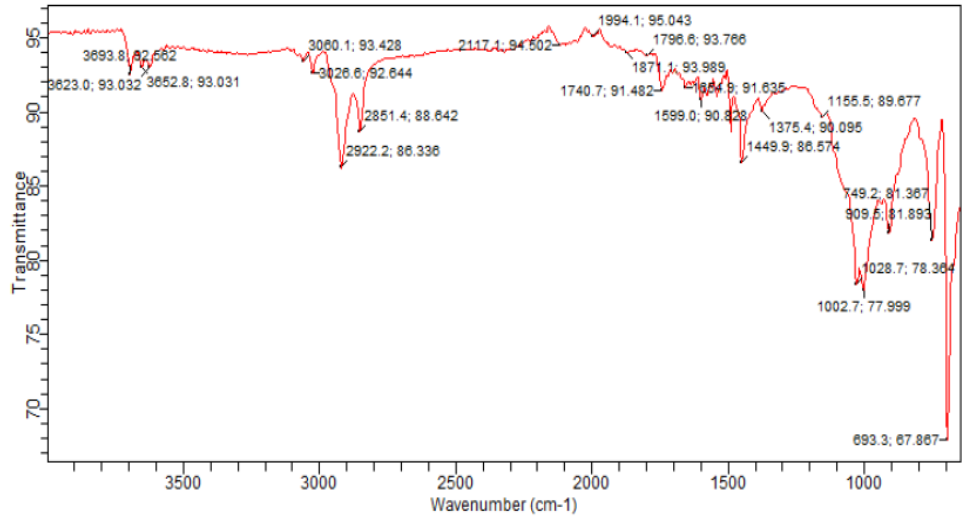

Fig. 2. FTIR spectrum of microplastic from New Calabar River 1

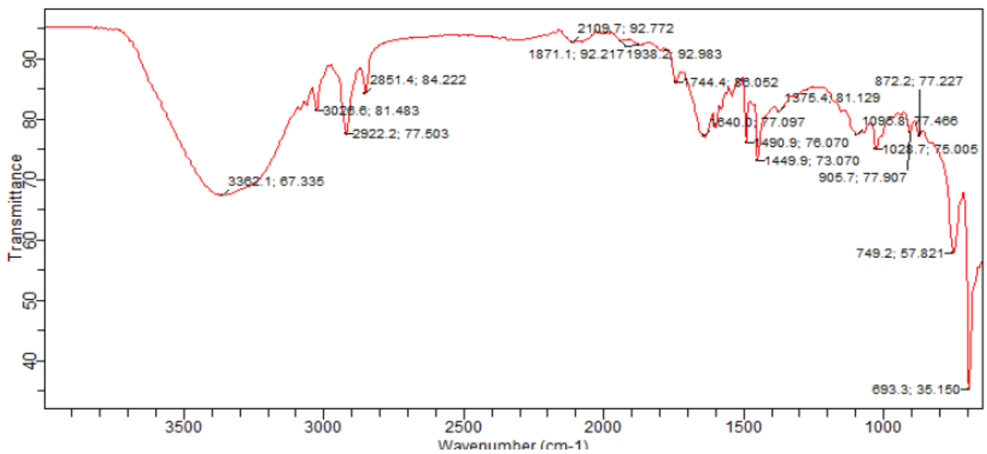

Fig. 3. FTIR spectrum of microplastic from New Calabar River 2

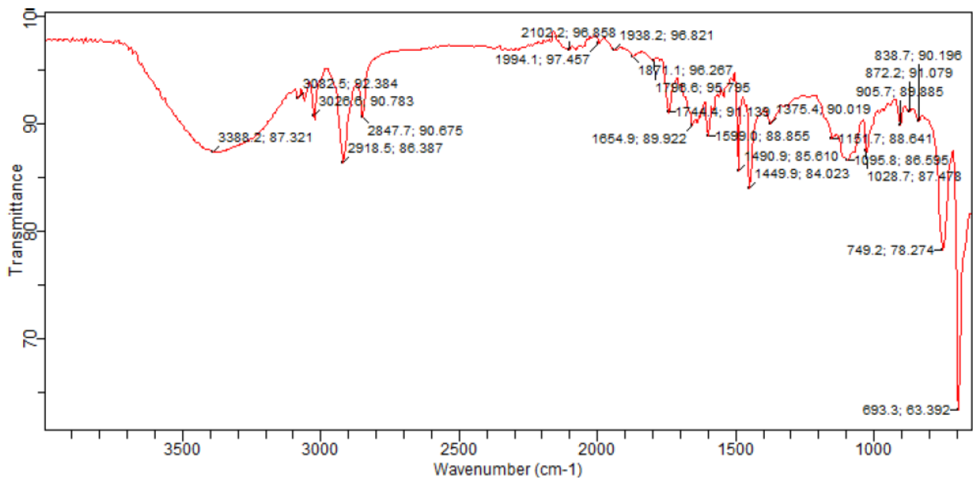

Fig. 4. FTIR spectrum of microplastic from Bonny 1

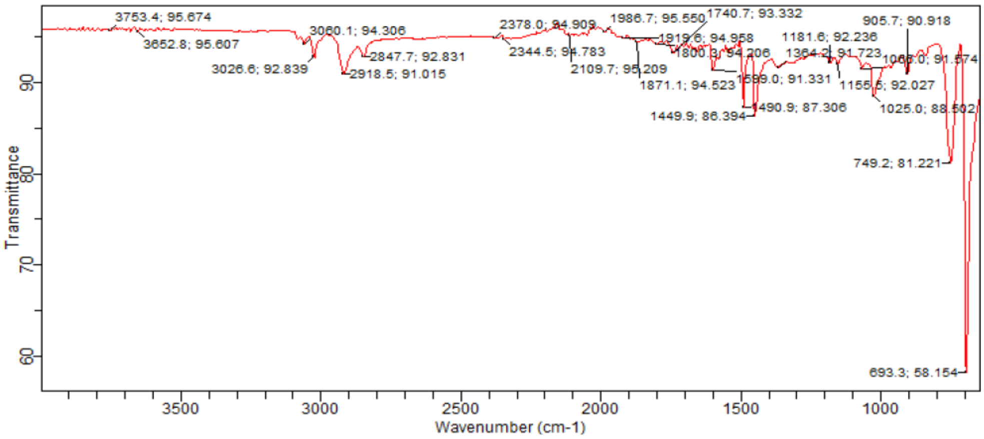

Fig. 5. FTIR spectrum of microplastic from Bonny 2

Four plasticizers namely dioctyl terephthalates, polybrominated diphenyl ether, acrylic fibre and tetrabromobisphenol A were all detected in sediment, water and fish samples from Bonny River and New Calabar River. Plastic additives leech into the surrounding environment more readily than the parent polymer [15]. The presence of plasticizers in fish corroborates the report by Huerta et al. [16] that plasticizers are present at toxic levels in aquatic animals, including fish, across the world, owing to leaching from plastics. These plasticizers can exert biological effects on biota living in or using the water bodies and sediment [17]. Their detection in commonly consumed fish in the study location, is a public health scare, owing to their toxicity.

5. CONCLUSION

Microplastics were noticed in water, sediment and fish samples collected from New Calabar and Bonny Rivers in Rivers State, Nigeria. This is an indication that microplastics settle to the bottom of the rivers and are picked up by biota habiting the water bodies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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