Characterization of Microplastics from Otammiri River Imo State, Nigeria

Original Research Article

Abstract

This study characterized microplastics from Otammiri River, Imo state, Nigeria. The study was carried out according to the National Oceanic and Atmospheric Administration (NOAA) protocol for surface water trawling for microplastics. The microplastics characterized were at the range of 0.3 mm to 5mm which were resistance to wet oxidation and exhibited flotation in a 5M NaCl. Fourier-transform infrared spectroscopy (FTIR) examination was used to characterize the microplastics for identification. FTIR results revealed that polypropylene (PP), polyethylene (PE), polyethylene terephthalate (PET) polystyrene (PS), and polyurethane were the predominant polymers (microplastics) found across Otammiri river.

Keywords: Fourier-transform infrared, Microplastics, Otammiri River

1.0 Introduction

The term "plastic" is a broad one, referring generally to any synthetic, water-insoluble polymer, typically of petrochemical origin, that can be molded when heated and shaped into various forms [1]. Microplastics occur in the environment as a consequence of plastic pollution. Manta nets the most used in the marine environment for sampling and monitoring microplastic (MP) contamination [2]. A Manta net consists of a frame part and the collecting net terminates in a collector. The three main parts of this net are: the floating/stabilizing part, the opening mouth and the net bag, and each of them can have its own specifications. Sampling requires the use of a motorboat or similar vessel, or a sailing boat. Usually, microplastic detection can be categorized into two steps, one being physical (i.e., color, size), and the other being chemical (i.e., composition, structure) identification [3,20,21,22,23]. Visual analysis, i.e., unaided eyes with forceps, is used to identify larger and some small colored MPs [4]. There is a high chance, however, that most small particles will be missed during analysis. There are two methods of chemical characteristics as destructive and nondestructive methods. Non-destructive methods are Raman spectroscopy and FTIR, while destructive methods are liquid chromatography (LC), gas chromatography connected with mass spectrometry (GC-MS), subsuming pyrolysis gas chromatography-mass spectrometry, and thermal desorption gas chromatography [5] [6]. FTIR is a mostly used non-destructive technique for the detection of microplastics. The aim of the study was to characterize microplastics from Otammiri River, Imo State, Nigeria

2.0 Methodology

2.1 Study Area

The Otammiri River, situated in Imo State, Nigeria. Geographically, located between latitudes 5˚17'N and 5˚30'N, and longitudes 6˚58'E and 7˚04'E. It originates from Egbu, an empyies in Imo River. The entire length of the river measures approximately 30 km [7].

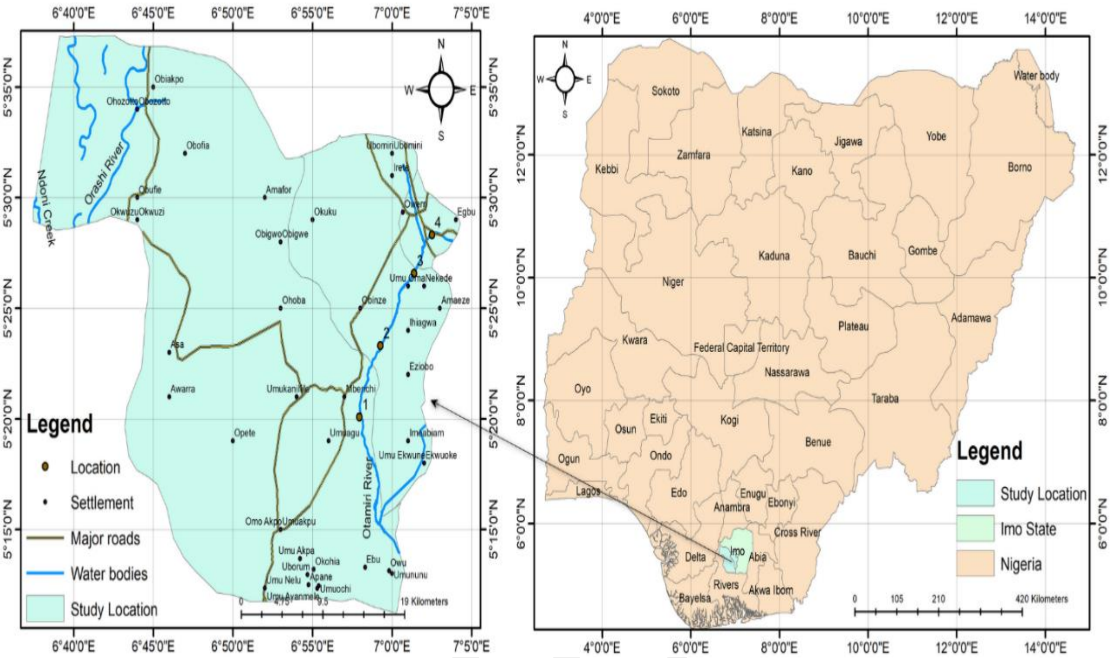


Fig 1: Location and Accessibility Map of the Study Area [8]

2.2 Collection Points of Samples

The location and accessibility points for samples collection from Otammiri River, Imo State Nigeria are listed below [8].

a) Wetheral, Owerri, 460281, Lat 5.4718910 and Long 7.04160 (upstream).

b) Nekede 460106, Lat 5.4429280 and Long 7.0228630 (middle stream 2)

c) Ihiagwa Otammiri Road, Ihiagwa 460113, Lat 5.388439^0 and Long 6.987726^0 (middle stream 1)

d) Ekwuato 464115, Lat 5.3347170 and Long 6.9656820 Imo, Nigeria (downstream)

2.3 Collection of microplastics from surface water of Otammiri

The collection of surface water microplastic samples was conducted using a surface manta trawl, adhering to the protocol outlined by the National Oceanic and Atmospheric Administration (NOAA) for surface water trawling for microplastics [8] [9].

2.4 Collection of microplastics from sediment samples of Otammiri

The sediment samples were obtained utilizing a grab sampler [8] [1] and deposited into clean glass jars. At each sampling point, five sediment samples were collected, ensuring representation across the area, and subsequently harmonized for analysis. Proper labeling was applied to each sample, and they were transported to the laboratory for further analysis.

2.5 Characterization of Microplastics from Otammiri River

Fourier-transform infrared spectroscopy (FTIR) examination was used to characterize microplastics from Ota-miri River for identification. This was done at SpringBoard Research Laboratory, Awka, Nigeria.

3.0 Results

3.1 Characterization Microplastics Present in Surface Water and Sediment Samples across Otammiri River

The graph in Fig. 2 showed that Ekwuato (downstream) had the highest wavelength for surface water microplastics as 3821.291 cm^{-1} while 831.7145 cm^{-1} was the least recorded wavelength. Polyurethane exhibited the highest presence with a wavelength of 2044.24 cm^{-1}, while polycarbonate had the least presence at 1855.77 cm^{-1}.

Fig. 3, showed that the highest wavelength as 3818.904 cm^{-1} and the least as 695.0075 cm^{-1} for microplastics at the surface water for Ihiagwa location. Polystyrene was predominant with a wavelength of 1440.46 cm^{-1}, whereas polypropylene had the lowest presence at 695.01 cm-1.

The highest wavelength in fig 4 was 3815.881 cm^{-1} while the least was 769.2611 cm^{-1} for surface water at Nekede location. Polypropylene (1400.57 cm^{-1}) prevailed over polyvinyl chloride (1879.29 cm-1), as shown in Figure 4..

Figure 5 demonstrates that the polyamide group was predominant at 2131.05 cm^{-1}, while the polypropylene group had the lowest presence at 682.53 cm^{-1}. The highest wavelength was 3806.17 cm^{-1} while the least was 682.53 cm^{-1} for the surface microplastics at Wetheral (upstream) of Otammiri River.

In Figure 6, Ekwuato location (downstream) had the highest sediment microplastics wavelength as 3818.51 cm^{-1} and the least 818.8468 cm^{-1}. Polystyrene was prevalent at 1382.67 cm^{-1}, with polyamide observed as the least occurrence at 1141.33 cm^{-1}.

Polyurethane exhibited the highest peak at 2022.58 cm^{-1}, while polyamide had the lowest presence at 3353.91 cm^{-1}, recorded for microplastics obtained from the sediment at Ihiagwa location, as depicted in Fig 7. The highest wavelength was recorded as 3815.846 while the least was 840.3417 cm^{-1}.

Fig. 8 shows that 3871.776 cm^{-1} was the highest wavelength for the microplastic obtained at sediment of Otammiri River at Nekede location and the least 734.06 cm^{-1}. Polyethylene terephthalate had the highest peak area at 3871.78 cm-1, while polyamide had the lowest presence at 3445.66 cm^{-1}.

Lastly, in Figure 9, the highest wavelength recorded for the microplastics at the sediment of the upstream (Wetheral) of Otammiri River was 3806.174 cm^{-1} and the least 775.6332 cm^{-1}. Polyamide exhibited the highest presence at 2107.54 cm^{-1}compared to polyethylene terephthalate at 3151.55 cm^{-1}.

Fig 2: FTIR of Microplastics from Ekwuato, Downstream of Otammiri River Surfaces

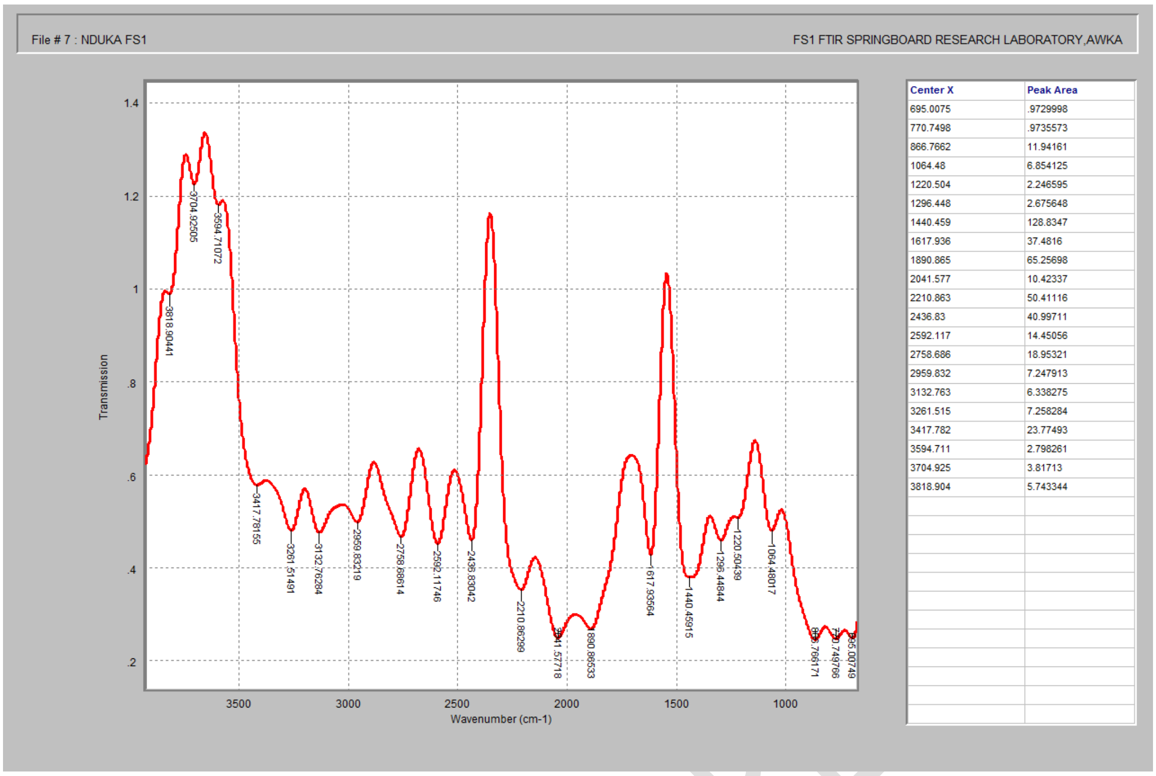


Fig 3: FTIR of Microplastics from Ihiagwa, Otammiri River Surfaces.

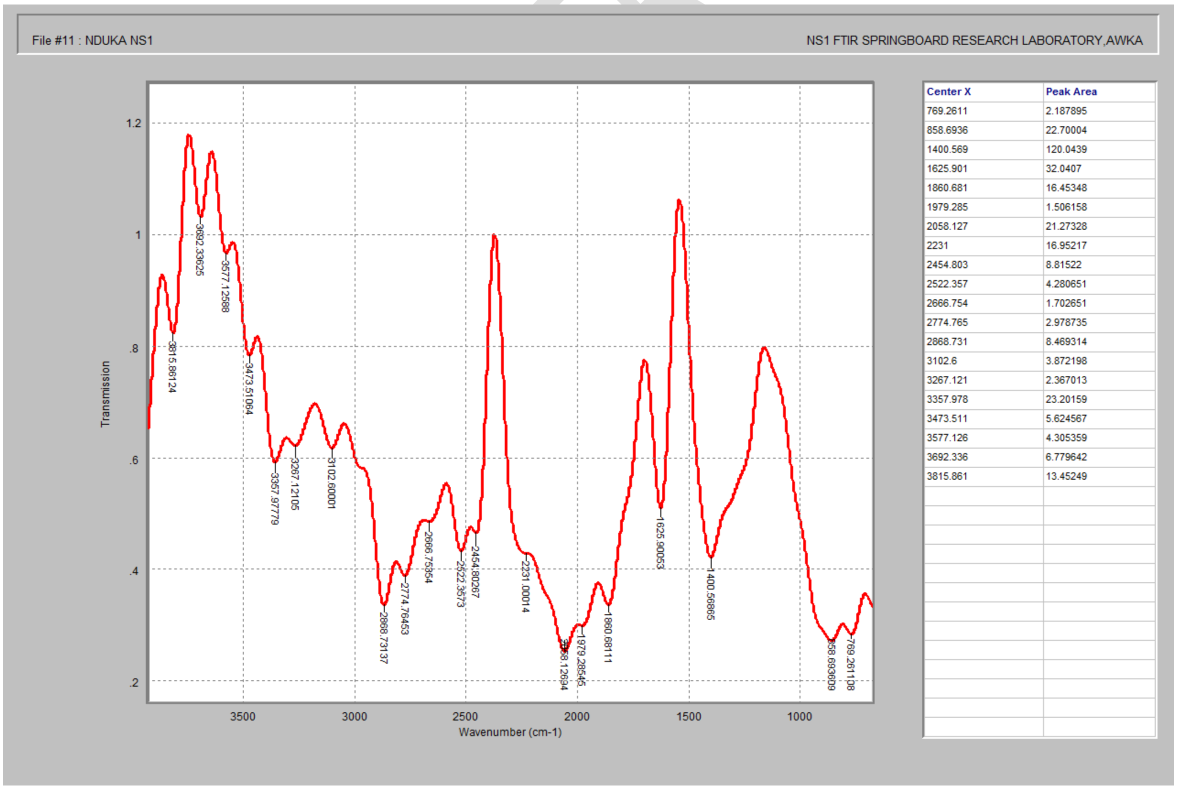
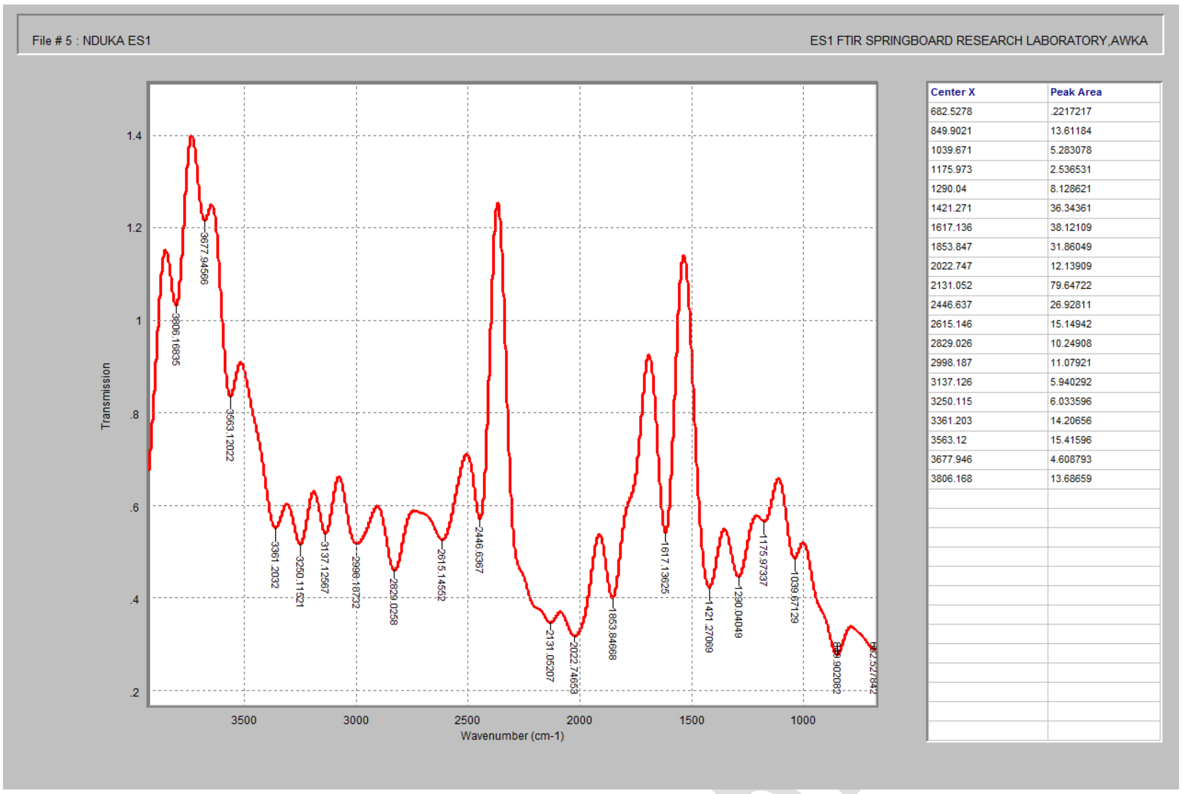
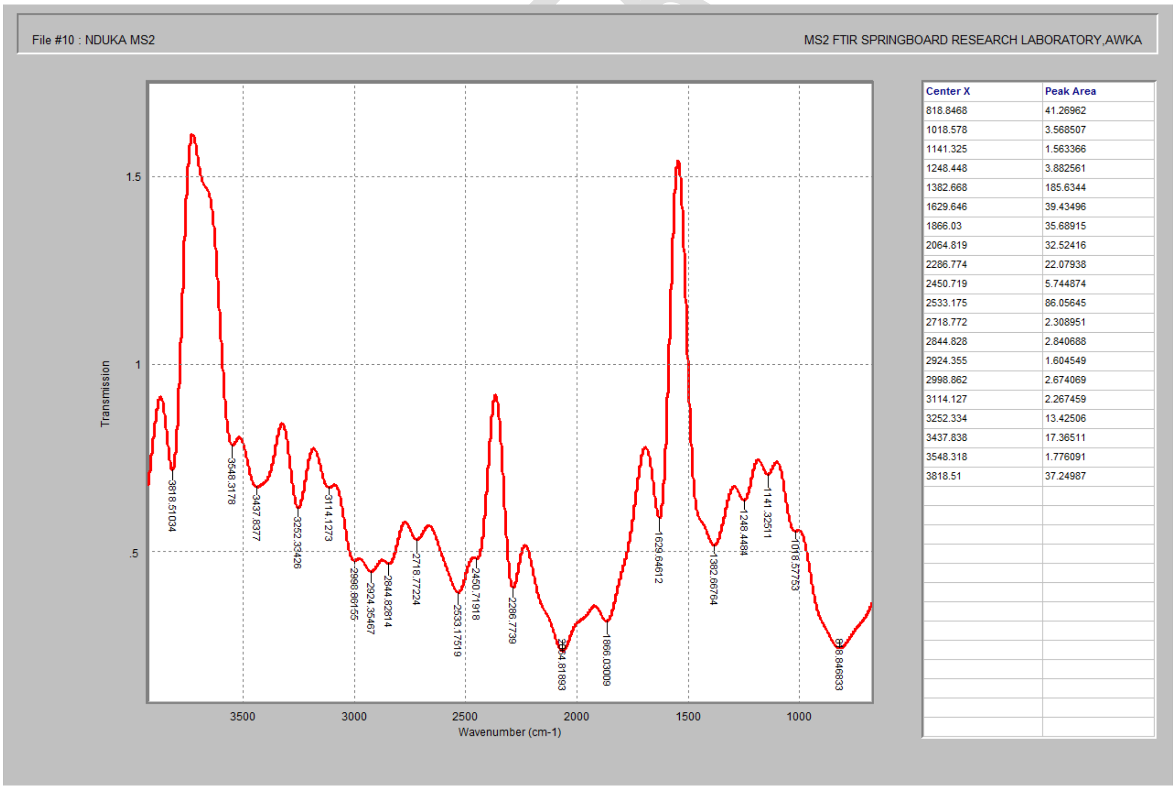


Fig 4: FTIR of Microplastics from Nekede 460106, Otammiri River Surfaces.



Center X	Peak Area
682.5278	.2217217
849.9021	13.61184
1039.671	5.283078
1175.973	2.536531
1290.04	8.128621
1421.271	36.34361
1617.136	38.12109
1853.847	31.86049
2022.747	12.13909
2131.052	79.64722
2446.637	26.92811
2615.146	15.14942
2829.026	10.24908
2998.187	11.07921
3137.126	5.940292
3250.115	6.033596
3361.203	14.20656
3563.12	15.41596
3677.946	4.608793
3806.168	13.68659

Fig 5: FTIR of Microplastics from Wetheral, Owerri, Upstream, Otammiri River



Center X	Peak Area
818.8468	41.26962
1018.578	3.568507
1141.325	1.563366
1248.448	3.882561
1382.668	185.6344
1629.646	39.43496
1866.03	35.68915
2064.819	32.52416
2286.774	22.07938
2450.719	5.744874
2533.175	86.05645
2718.772	2.308951
2844.828	2.840688
2924.355	1.604549
2998.862	2.674069
3114.127	2.267459
3252.334	13.42506
3437.838	17.36511
3548.318	1.776091
3818.51	37.24987

Fig 6: FTIR of Microplastics from Ekwuato, Downstream of Otammiri River Sediments.

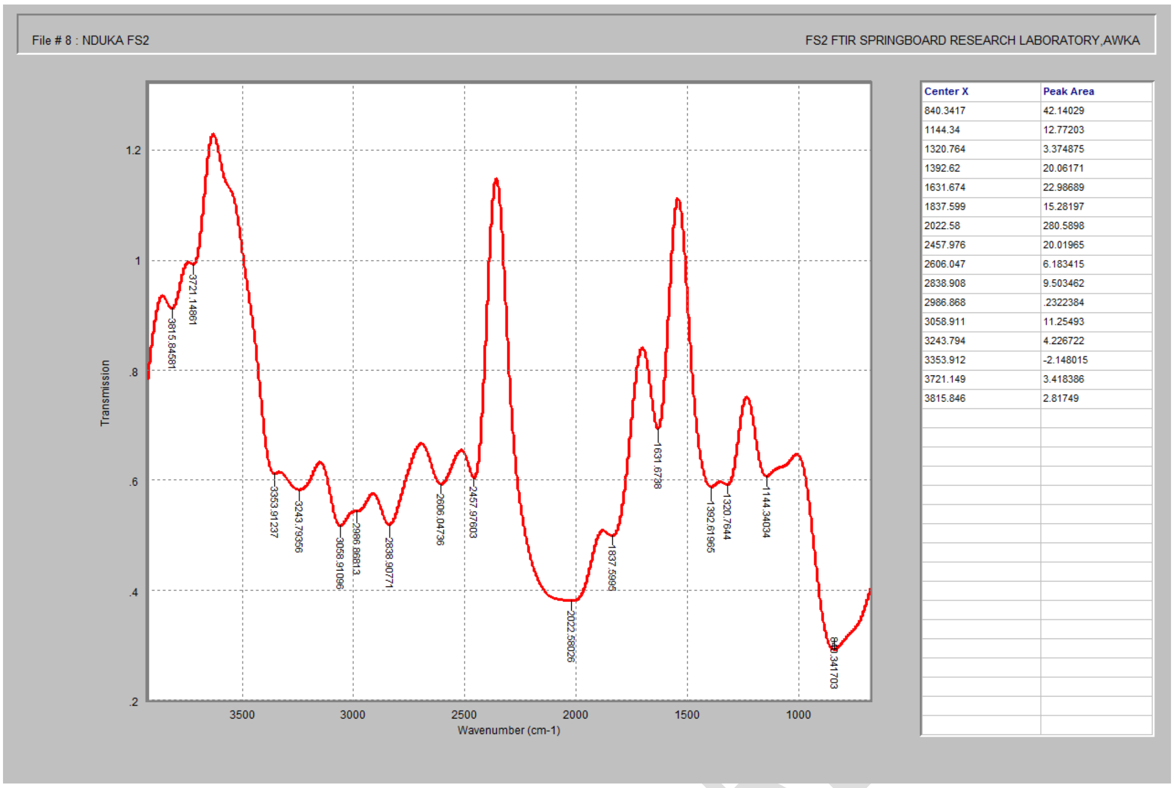


Fig 7: FTIR of Microplastics from Ihiagwa, Otammiri River Sediments.

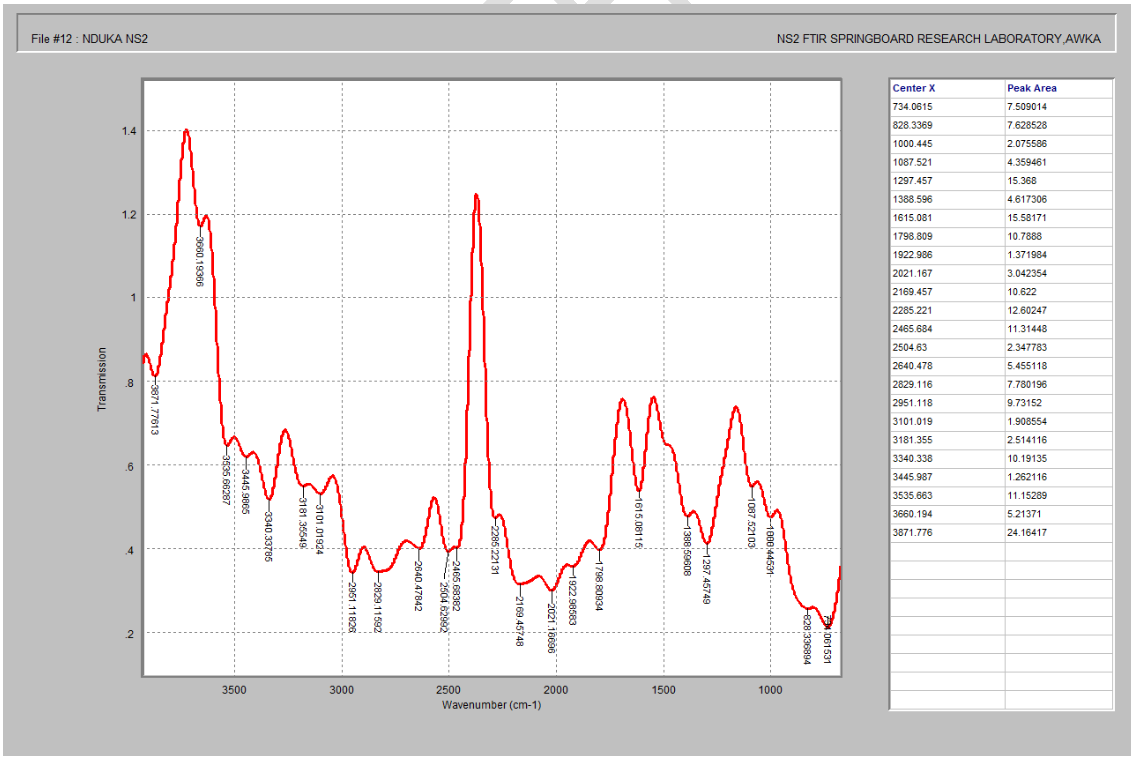


Fig 8: FTIR of Microplastics from Nekede, Otammiri River Sediments.

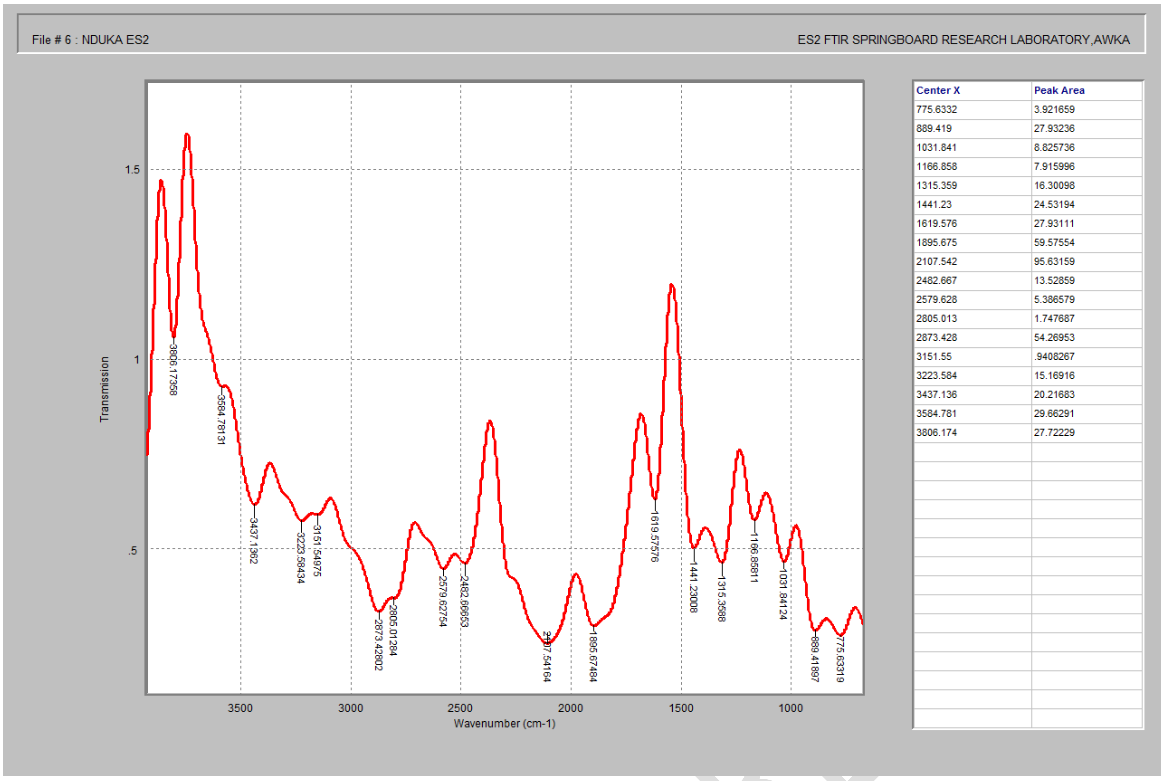


Fig 9: FTIR of Microplastics from Wetheral, Owerri, Upstream, Otammiri River Sediments.

4.0 Discussion

4.1 Surface

Generally, polystyrene and polypropylene were dominant in the surface water. The presence of these groups of microplastics indicates the wide use of "Styrofoam" as packaging material for fast foods, popularly called "take-away" in Nigeria. They have good buoyancy and floating ability in water [10] [11]. Estimated 60 million "pure water" plastic sachet water bags are disposed daily in Nigeria [12]. The poor recycling of the materials in Nigeria means that the polystyrene often ends up in the environment where they degrade overtime. Polystyrene particles with sizes below 10µm have been in a different study to penetrate blood vessels and cause destruction of red blood cells [13]. This means that the consumption of Otammiri river water by humans and animals poses a potential health risk due to the presence of micro-ranged polystyrene particles. Polyethylene, polyamide and polypropylene have been identified as common thermoplastics used in packaging products such as film, shopping bags, bottles, toys, house wares, juice containers, plastic packaging fibers and textiles. These plastic polymers groups possess lower density compounds to water, hence their dominance in the water phase. Their natural buoyancy makes them float on water surfaces.

Harmful consequences of MPs ingestion include endocrine, reproductive and developmental disruption, cellular and immune system damage, and negative impact on energy budget [14] [15]. The increased likelihood of aquatic organism to swallow and ingest MPs could also be of ecological concerns because they can be easily mistaken for food material, leading to artificial starvation and increased incidences of mortality. The indirect effects of MPs may include physical irritation, blockage of gills and occlusion of the digestive tract by smaller particles that are not easily dislodged [16].

4.2 Sediment

Polyethylene terephthalate (PET), Polyamide (PA) and Polystyrene were major polymer samples found in the sediments. This may be because of their densities and material sources. Polystyrene is an engineering solid polymer, used for some heavy items. Size, density and shape determine the rate at which plastics sink into deeper waters and sediments [17]. Their presence reflects long-time contamination for both terrestrial and aquatic environment resulting in long-term ecological pollution and impact [18] [19]. The ubiquity of microplastics in sediment samples showed that plastics can sink into deeper water.

5.0 Conclusion

The proliferation of microplastics in aquatic environments poses significant threats to both environmental and human health. Microplastics, due to their pervasive nature and durability, has been detected in Otammiri River and characterized with the potentials of bioaccumulation in marine and freshwater ecosystems. Therefore, there is urgent need by policymakers to enlighten the public on the adverse effects of microplastics and possible improvement in waste management systems.

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