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SPECTROSCOPIC EVALUATION AND HEALTH RISK ASSESSMENT OF MICROPLASTICS (MPs) IN SELECTED BOREHOLES IN ABA AND UMUAHIA CITIES OF ABIA STATE, NIGERIA

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ABSTRACT

This study aimed to assess microplastics in borehole water in the cities of Aba and Umuahia, Abia state, Nigeria, using standard methods. Water samples were collected from randomly selected three (3) boreholes each in Aba and Umuahia. The water samples were vacuum-filtered through cellulose filter paper using a suction pump and subsequently subjected to spectroscopy and microscopy to determine MPs concentrations, shapes and polymer types. The results revealed that the borehole water samples from Ikot-Ekpene in Aba exhibited the highest concentration of microplastics with 20 particles/L, followed by Afara borehole with 18 particles/L. Boreholes from Aba-Owerri Road, Faulks road and Old Umuahia exhibited 7 particles/L each, while Umuopara borehole water had 5 particles/L. The three polymer shapes identified were fragments, beads and fibre with fragments being the most prevalent. The borehole water samples contained five different types of polymers including polystyrene, polyethylene terephthalate, polyester, polyethylene and polyvinyl chloride. The estimated daily intake was generally minimal, suggesting little immediate risk from daily consumption; however, children consumed more microplastics than adults. Therefore, although the intake is minimal, it is recommended of consumers of borehole water in both cities treat the water prior to consumption to mitigate potential health risks.

Keywords: Borehole water, Aba, Umuahia, Microplastics, Health risk.

1. Introduction

Water, which usually refers to the liquid compound formed by hydrogen and oxygen, is of fundamental importance for life on earth. It is an essential constituent and ingredient of animal and plant lives. It covers about 70% of the planet's surface where it occurs as flowing water (in oceans, rivers, springs and streams) and standing water (lakes) with different degrees of purity (Nnaji and Uzoekwe, 2018). Based on salt content, water can also be categorized as freshwater (in rivers, streams, lakes, swamps and ponds) which has little or no salt content; Brackish water (in estuaries) which has salinity of 100-1000 mg/lit salt as chloride and Marine waters (in seas and oceans) which has salinity greater than 1000 mg/lit as chloride (Nnaji and Uzoekwe, 2018).

Human activities such as domestic, agricultural and industrial operations militate against the use of water because they often pollute water bodies through the discharge of pollutants like sewage, organic pollutants and plastics. Plastics are extensively utilized due to their advantageous properties, including their superior waterproofing and moisture resistance, cost-effectiveness, chemical stability and electrical insulation (Cai *et al*, 2025). Global plastic production reached 3.907×10^8 tons in 2021, of which 90.2% comprised fossil-based plastics, 8.3% were post-consumer recycled plastics, and 1.5% were bio-based/biodegradable plastics (Plastics,2022). In addition to escalating production and consumption, the mismanagement of plastic waste exacerbates environmental plastic pollution, as plastics are produced with the addition of different types of chemical additives which include a large variety of toxic compounds such as plasticizers, pigments, antioxidants, acid scavengers, flame retardants, light and heat stabilizers, lubricants, antistatic agents and heath stabilizer (Hahladakis *et al*,2018). Global plastic production is projected to reach 3.3×10^{10} tons annually by 2050 (Seongjoon *et al*,2018).

Plastics undergo degradation into microplastics; a term introduced by Thompson in 2004 to report on small plastic fragments in marine environment (Thompson *et al* ,2004). Microplastics (MPs) are defined as solid plastic particles and fragments with a length or equivalent spherical diameter of < 5 mm, while those < 1 µm are classified as nanoplastics (Cai *et al*, 2025). Based on their origin and formation pathways, microplastics (MPs) are categorized as Primary MPs, which are directly released into the environment, and Secondary MPs which are derived from the fragmentation, abrasion, UV degradation, biodegradation, or photo-oxidation of larger plastic debris (Cai *et al*, 2025).

MPs are fundamentally composed of polymeric matrices characterized by diverse and intricate structures. These polymers are formed through the covalent bonding of monomeric units into linear or cross-linked polymeric chains (Cai *et al*, 2025). Variations in polymer types—such as polyethylene (PE), polypropylene (PP), and others, dictate their distinct physicochemical properties, which in turn govern their environmental behavior and fate.

Microplastics are emerging contaminants globally and pose several potential health risks to humans. When ingested or inhaled, they can accumulate in the gastrointestinal tract or lungs, potentially causing inflammation, oxidative stress, and disruption of the gut microbiota or respiratory function (Enyoh *et al*, 2020). Microplastics often contain chemical additives, such as phthalates and bisphenol A, and can also absorb environmental pollutants like heavy metals and persistent organic pollutants (Prata *et al*, 2020). These chemicals may leach into the body, potentially interfering with the endocrine system and contributing to reproductive, neurological, and immune disorders, as well as increasing cancer risk (Rahman *et al*, 2021). Recent studies have demonstrated that MPs can traverse biological barriers, infiltrating multiple physiological systems, including the digestive, circulatory, excretory systems and maternal–fetal interfaces (Cai *et al*, 2025). Equally, MPs have also been identified in human bone marrow (Guo *et al*, 2024).

Water, which serves as a major "sink" for pollutants, represents a primary source of chronic exposure to microplastics. Exposure can occur through drinking, bathing, during the primary production of food, cleaning and sanitation of food processing plants (Yahaya *et al*, 2024). In Nigeria, groundwater (boreholes and wells) is the predominant source of water due to its cost-effectiveness, availability, and easy maintenance. Given the threat posed by microplastics pollution through water, constant assessment of the pollution status of groundwater sources in the country is essential. Several studies have been conducted on microplastic pollution of water in Nigeria (Yalwaji *et al*, 2024; Aliyu *et al*, 2023; Attah *et al*, 2023; Ibeto *et al*, 2023). However, literature searches revealed no studies regarding microplastic pollution in boreholes

located in Aba and Umuahia of Abia State, Nigeria. Thus, evaluation of microplastic pollution status of groundwater in these cities becomes necessary to raise public awareness as microplastics can contaminate groundwater when plastic particles from domestic wastes, wastewater, agricultural activities and other sources enter the soil and migrate through the subsurface into aquifer systems (Panno *et al*, 2019). Therefore, this study aims to determine the abundance, polymer types, and health risks associated with microplastics in borehole water samples in Aba and Umuahia cities of Abia State, Nigeria.

2. Materials and Method

Study Area

The study was carried out in Aba and Umuahia cities of Abia state. Aba is a densely populated commercial city in Abia state, South Eastern Nigeria, which is located within the coordinates 5º 07' N and 7º 22' E. Its inhabitants are mainly traders, artisans and local farmers. Whereas, Umuahia is the capital city of Abia state and located within the coordinates 5º 31' N and 7º 28' E. The main occupation of inhabitants here includes: civil service, education, trading and farming (Ihemekwa *et al*, 2026).

Sampling

Borehole water samples were collected from the source with 1L glass bottles at the sampling sites with coordinates as shown in Table 1 and Fig. 1. The samples were properly labeled (as shown in Table 1) and transported in an ice chest to the laboratory for analysis.

Table 1: Labels, Location and Coordinates of the Water Samples

Labels	Location	Latitude	Longitude
	Aba Borehole Water		
A	Aba – Owerri Road	N5º4'7.673"	E7º20'2.0652"
B	Faulks Road	N5º6'59.076"	E7º20'40.5708"
C	Ikot Ekpene-Road	N5º6'43.2792"	E7º23'40.7256"
	Umuahia Borehole Water		
D	Afara	N5º29'21.0912"	E7º28'21.6264"
E	Umuopara	N5º32'29.9004"	E7º27'16.974"
F	Old Umuahia	N5º29'19.6044"	E7º28'42.6396"

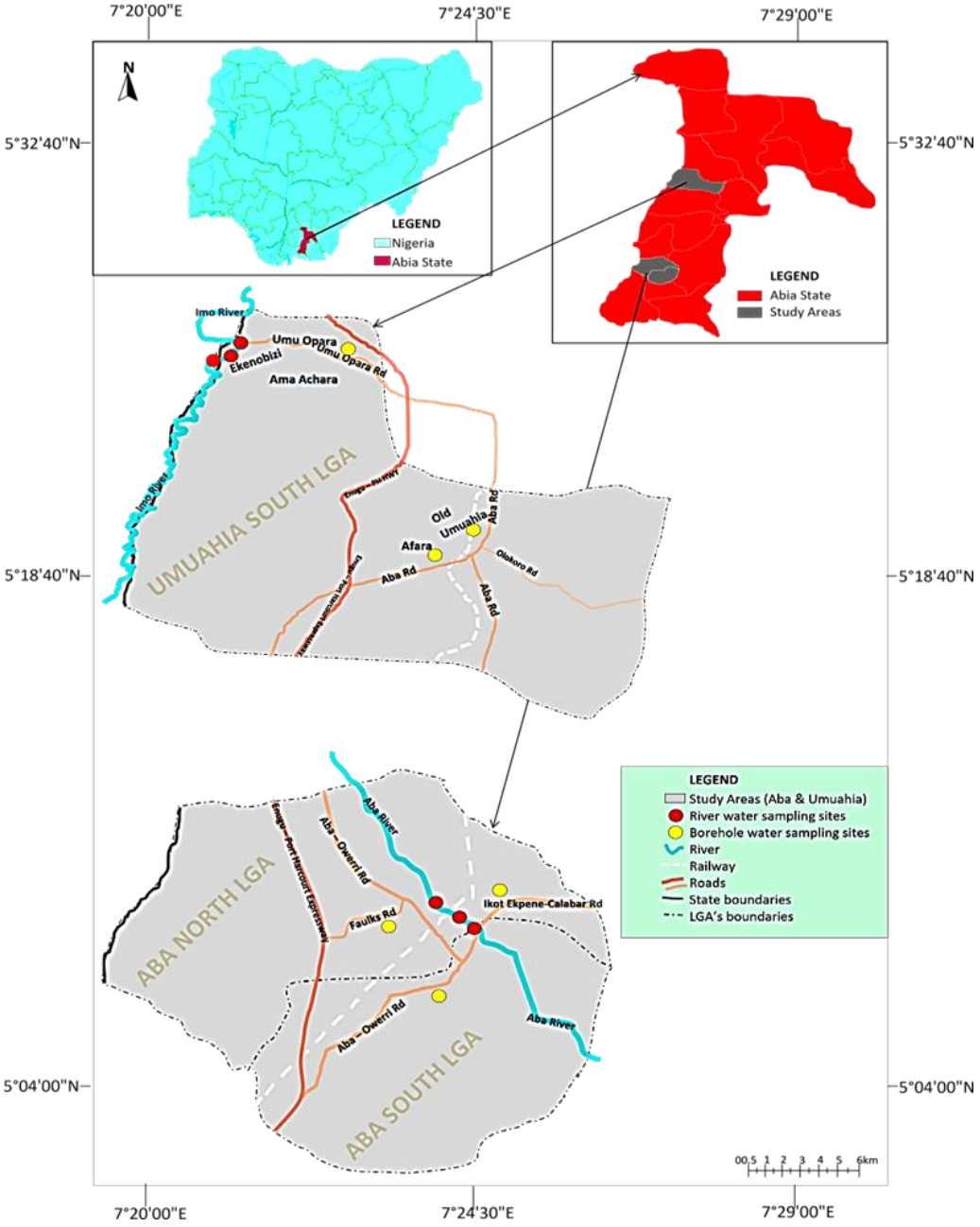


Figure 1: Map of Nigeria showing Abia State and sampling sites in Aba and Umuahia

2.1 Sample Processing

The water samples were vacuum filtered with the aid of a suction pump using a cellulose filter paper with pore size 45µm in other to separate the microplastics, (MPs), from the bulk water (Ibeto *et al*, 2023). The filtration set-up was covered with watch glass to avoid external contamination of the samples. After filtration, the filter papers were oven-dried at 10°C for two hours and were kept in a sterile aluminum capped container and left in a dark cupboard before particle counting and identification was done (Ibeto *et al*, 2023).

2.2 MP Observation and Identification

Visual inspection and identification of particles was done using an Olympus optical microscope (Model 0706962) with a camera and through a red-light shielding plate. The filter papers were each placed in an uncovered petri dish on the stage of the microscope with an objective lens of 40-fold magnification (Ibeto *et al*, 2023). Particles were counted, sorted and photographed.

2.3 MPs Characterization

All sorted particles were capped in sterile petri-dishes and then analyzed with SEM-EDS (SEM Quanta FEG 450-FEI; APPOLLO X-EDAX). Samples (0.5 g) of each of the particles were coated with Au/Pd film and the SEM images were obtained using a secondary electron detector. The pictures of the isolated microplastic particles were taken and classified into three dominant shapes namely; fragments, microbeads and microfibers.

2.3.1 FTIR Analysis

Buck Scientific FTIR spectrometer (Model M30 USA) was used for the analysis. This instrument was equipped with deuterated triglycine sulphate (DTGS) detector and beam splitter of potassium bromide. The software of the Gram A1 was used to obtain the spectra and to manipulate them. Samples (1.0g) and 0.5ml of nujol were added, mixed properly and placed on a salt pellet. During measurement, FTIR spectra were obtained at frequency regions of 4,000 – 600 cm^{-1} and co-added at 32 scans and at 4 cm^{-1} resolution. FTIR spectra were displayed as transmitter values (Vander Weerd *et al*, 2004).

2.3.2 Health Risk Assessment – Health risk assessment was done according to Verla (2019) by calculating the Microplastics Contamination Factors (MPCfs), Microplastic Pollution Load Index (MPPLI), and Estimated Load Index (EDI).

MPCf refers to the contamination of MPs in the analyzed drinking water compared to the background values. EDI is the estimated daily intake of MPs due to the ingestion of contaminated water. The MPCfs in the water samples was calculated using eqn. 1.

$$\text{MPCfs} = \frac{\text{MP}_\text{i}}{\text{MPb}} \quad (1)$$

Where: MPi = quantity of MPs in ith sample; MPb = the minimum baseline concentration taken from the lowest MPs abundance; (Enyoh, *et al*, 2021).

The MPCF (microplastics contamination factor), is known as a standardized monitoring and assessment approach for determining the level of contamination between different samples (Ibeto *et al*, 2023). The MPCFs were categorized as follows: values with MPCF <1 are low contamination, 1≤ MPCF < 3, are moderately contaminated, 3 ≤ MPCF ≤ 6, are considerably contaminated and MPCF ≥ 6 are very highly contaminated (Verla *et al*, 2019). MPPLI and EDI were calculated using equations 2 and 3.

$$\text{MPPLI}_{\text{area}} = (\text{MPCF1 x MPCF2 x MPCF3-----MPCFn})^{1/n} \quad (2)$$

$$\text{EDI} = \text{MPixRI/Bw} \quad (3)$$

Where: EDI = Estimated daily intake of MPs based on quantity through ingestion of drinking water (particle/L/BW- day); MPi =Average quantity of the MPs in drinking water (MP particle/L); RI = Ingestion rate (2.2L/day for adults, 1.8L/day fo children; Bw = Average body weight (70kg for adults, 15kg for children).

2.3.3 Quality Assurance

All equipment and materials used were devoid of plastics and pre-washed with de-ionized water, maintaining a clean laboratory environment. Throughout the analyses, plastic-free laboratory attire, including coats, gloves, and goggles, were worn. Each sample was meticulously labeled with pertinent information such as the date, time, GPS coordinates, and location.

3. Results and Discussion

3.1 MP Abundance and Shapes in the Water Samples

The Table 2 below shows the abundance and shapes of the microplastics (MPs) after filtration and counting with the aid of microscope.

Table 2: MP Abundance of Aba and Umuahia water samples

Sample ID	Shapes of MPs (particle/L)			Total
	Microfragments	Microbeads	Microfibre	
A	7	0	0	7
B	7	0	0	7
C	19	0	1	20
D	14	4	0	18
E	5	0	2	7
F	4	0	1	5

The dominant shapes observed were fragments, beads and fiber. In Aba, Samples A and B (had a total of 7MP particles/L each for fragments only, no fibre and beads observed; while sample C had a total of 19 MP particles/L fragments and 1 MP particle/L fibre. Similarly, in Umuahia, sample D had 14 MP particles/L fragments and 4 MP particles/L microbeads. Sample E had 5 MP particles/L fragments and 2 MP particles/L fibre, while sample F had 4 MP particles/L fragments and 1 MP particle/L fibre. Hence, in all the borehole water samples, it was observed that fragment shape was the highest (87.5%), followed by beads (6.25%) and fibre (6.25%). The high quantity of fragments observed is in agreement with the studies of Ibeto *et al. (*2023), Mason *et al.* (2018) and Enyoh *et al.*, (2020); who in their various studies also observed a high quantity of fragments. Sample C from Aba had the highest MP particles of 20 particles/L, followed by sample D in Umuahia with 18 particles/L. A microplastic (MP) range of 5.0 to 10.5 particles/L were found in water in China by Chen *et al.*, (2022) while a microplastic (MP) range of 10 to 34 particles/L was reported in borehole water in Northwest Mexico by Alvarado-Zambrano *et al. (*2023).

Figure 2 below shows the % Distribution of MP shapes from Aba and Umuahia Borehole water samples.

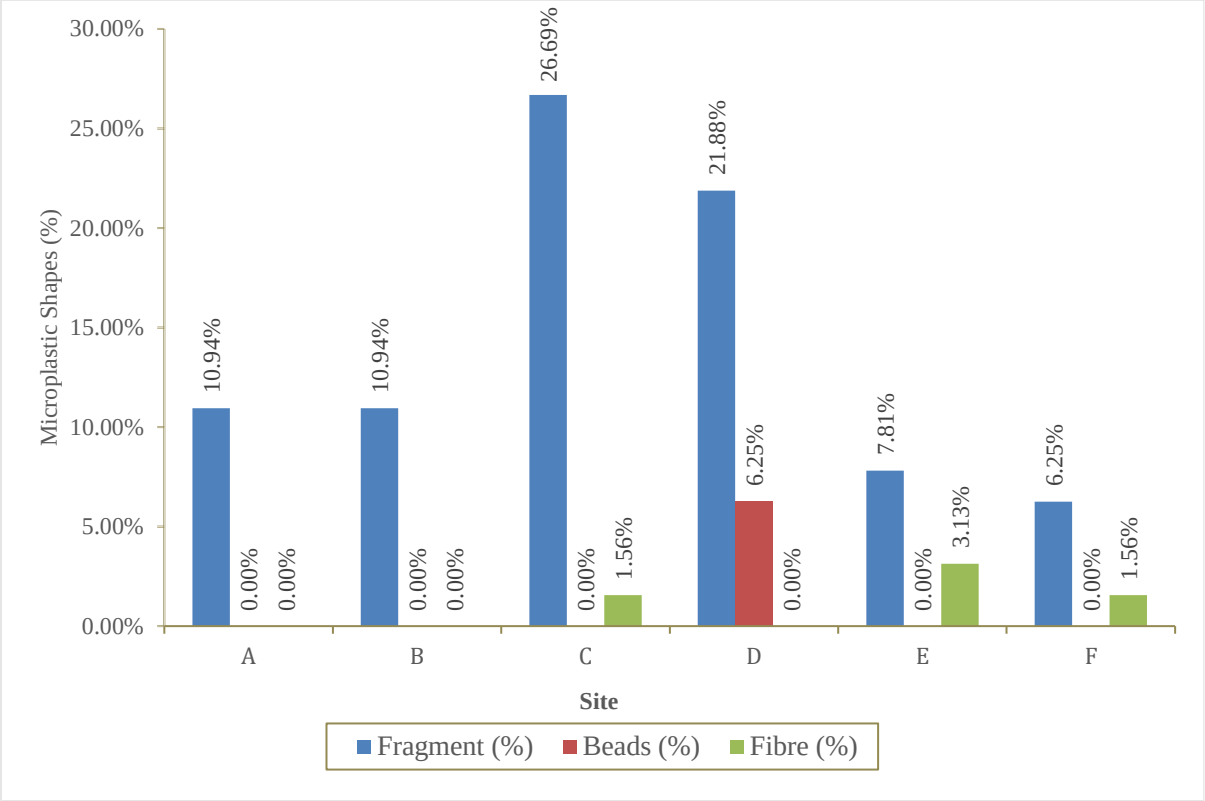


Fig. 2: Percentage distribution of MP shapes in borehole water samples collected from Aba and Umuahia

3.2 Identification of MP Polymer Types

Figures 3-8 below show the FTIR spectra for the borehole water samples (A - F).

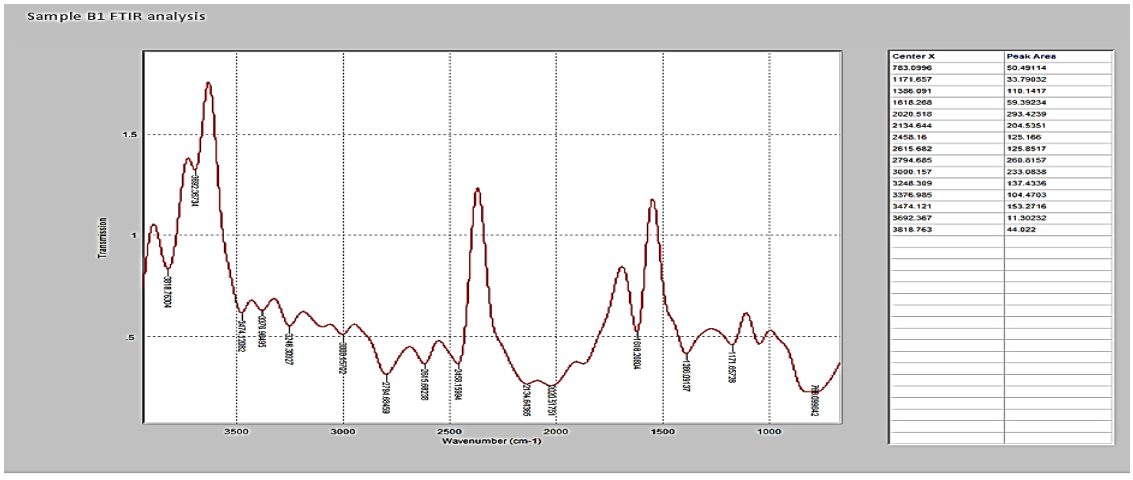


Fig 3: FTIR Spectra for Sample A: ABA-OWERRI ROAD BOREHOLE

Table 3: Description of FTIR peaks for Sample A: (Aba-Owerri Road Borehole)

Peak	Peak sharp	Peak intensity	Bond	Compound
783.0996	Strong	Broad	Sp2 C-H bending	1,2,3-trisubstituted alkene
1171.657	Medium	Sharp	C-N stretching	Amine
1386.091	Medium	Sharp	C-H bending	Aldehyde
1618.091	Strong	Broad	C=C stretching	cyclic alkene
2020.518	Strong	Broad	N=C=S stretching	Isothiocyanate
2134.644	Strong	Sharp	N=N=N stretching	Azide
2458.18	Medium	Sharp	P-H stretching	Phosphine
2615.685	weak	Sharp	S-H stretching	Thiol
2794.685	Medium	Sharp	C-H stretching	Aldehyde
3000.157	Weak	Broad	O-H stretching	Alcohol
3248.309	Medium	Broad	O-H stretching	Carboxylic acid
3376.985	Medium	Broad	N-H stretching	aliphatic primary amine
3474.121	Strong	Sharp	N-H stretching	primary amine
3692.367	Medium	Sharp	O-H stretching	Intermolecular bonded Alcohol
3818.763	Medium	Sharp	O-H stretching	Free Alcohol

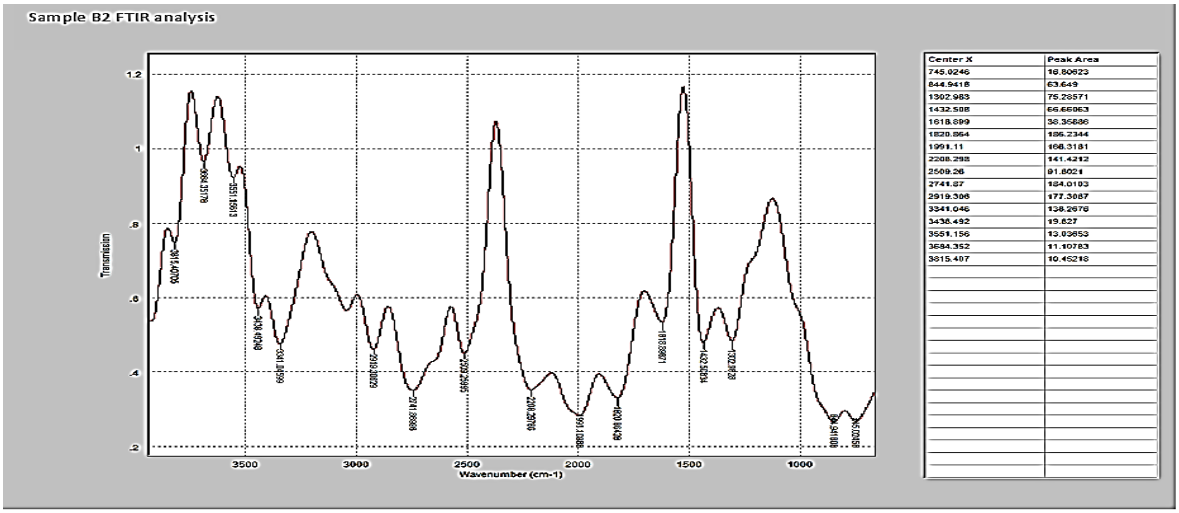


Fig 4: FTIR Spectra for Sample B: FAULKS ROAD BOREHOLE

Table 4: Description of FTIR peaks for Sample B – Bore-Hole at Faulk's Road Aba

Peak	Peak sharp	Peak intensity	Bond	Compound
745.0246	Strong	Broad	C-H bending	1,2-disubstituted aromatic compound
844.9418	Strong	Broad	C-Cl stretching	Halo compound
1302.983	Medium	Sharp	C-N stretching	Aromatic amine
1432.508	Strong	Sharp	O-H bending	carboxylic acid
1616.899	Strong	Sharp	C=C stretching	α,β-unsaturated ketone
1820.864	Strong	Broad	C-H bending	aromatic compound
1991.11	Medium	Broad	N=C=S stretching	isothiocyanate
2208.298	Strong	Broad	N=C=O stretching	isocyanate
2509.26	Strong	Sharp	(O=) PO-H	Phosphonic acid
2741.87	Strong	Broad	O-H stretching	carboxylic acid
2919.306	Medium	Sharp	C-H stretching	Alkane
3341.046	Medium	Sharp	N-H stretching	aliphatic primary amine
3438.492	Strong	Sharp	C-H stretching	Alkynes
3551.156	Medium	Sharp	N-H stretching	Primary amine
3684.352	Medium	Sharp	O-H stretching	Alcohol
3815.497	Medium	Sharp	O-H stretching	Free Alcohol

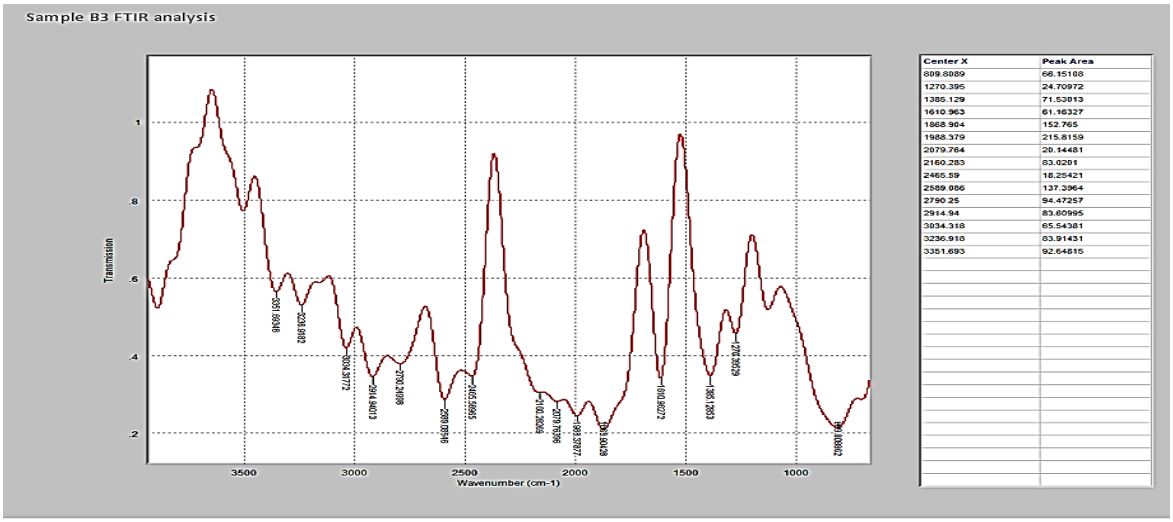


Figure 5: FTIR Spectra for Sample C: Ikot-Ekpene Road Borehole

Table 5: Description of FTIR peaks for Sample C - Borehole at Ikot - Ekpene Road Aba

Peak	Peak sharp	Peak intensity	Bond	Compound
809.8089	Strong	Broad	Sp2 C-H out of plane bending	1,4-disubstituted aromatic compound
1270.395	Medium	Sharp	C-N stretching	Aromatic amine
1385.129	Strong	Sharp	S=O stretching	Sulfate
1610.963	Strong	Sharp	C=C stretching	Conjugated alkene
1868.904	Strong	Sharp	C=O stretching	Anhydride
1988.379	Medium	Sharp	C=C=C stretching	Allene
2079.764	Weak	Broad	C-H bending	aromatic compound
2160.238	Strong	Broad	S-C≡N stretching	Thiocyanate
2465.59	Strong	Sharp	P-H stretching	Phosphine
2589.086	Medium	Sharp	C-H stretching	Terminal alkyne
2790.25	Medium	Broad	C-H stretching	Aldehyde
2914.94	Medium	Sharp	C-H stretching	Alkane
3034.318	Medium	Sharp	C-H stretching	Alkene
3236.918	Medium	Sharp	N-H stretching	Secondary amine
3351.693	Medium	Sharp	N-H stretching	Aliphatic primary amine

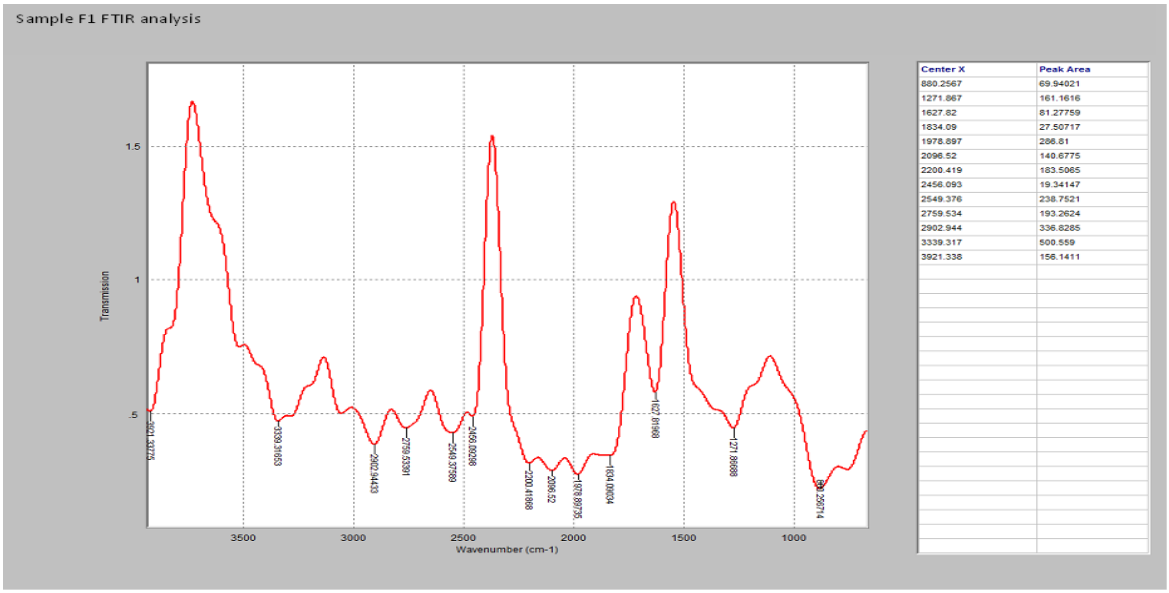


Figure 6: FTIR Spectra for Sample D: AFARA BOREHOLE (UMUAHIA).

Table 6: Description of FTIR Peaks for sample D- (Borehole at Afara- Umuahia).

Peak	Peak intensity	Peak shape	Bond	Compound
880.2567	Strong	Sharp	C-H bending	Alkene
1271.867	Strong	Sharp	C-O /C-N stretching	Ester / amine
1627.82	Strong	Very sharp	C=C stretching	Alkene
1834.09	Strong	Broad	C≡O stretching	Acid anhydride
1978.897	Weak	Broad	C-H bending	Aromatic compound
2096.52	Weak	Broad	C≡C stretching	Alkyne
2200.419	Strong	Sharp	C≡N stretching	Nitrile
2458.093	Strong	Sharp	C≡C stretching	Terminal alkyne
2549.376	Medium	Broad	O-H stretching	Carboxylic acid
2759.534	Medium	Broad	C-H stretching	Aldehyde
2902.944	Medium	Sharp	C-H stretching	Alkane
3339.317	Strong	Sharp	N-H stretching	Amine
3921.338	Stretching	Sharp	O-H stretching	Free alcohol

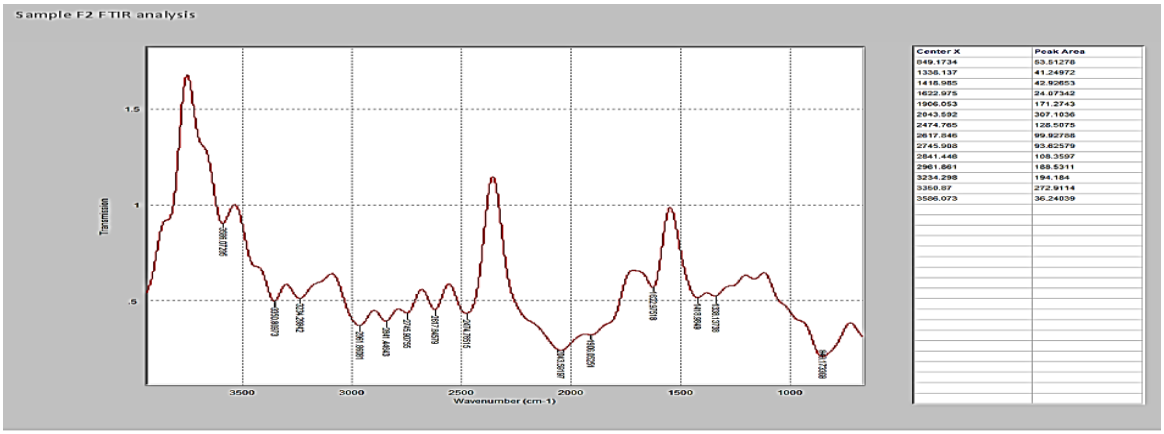


Figure 7: FTIR Spectra for Sample E: OLD UMUAHIA BOREHOLE.

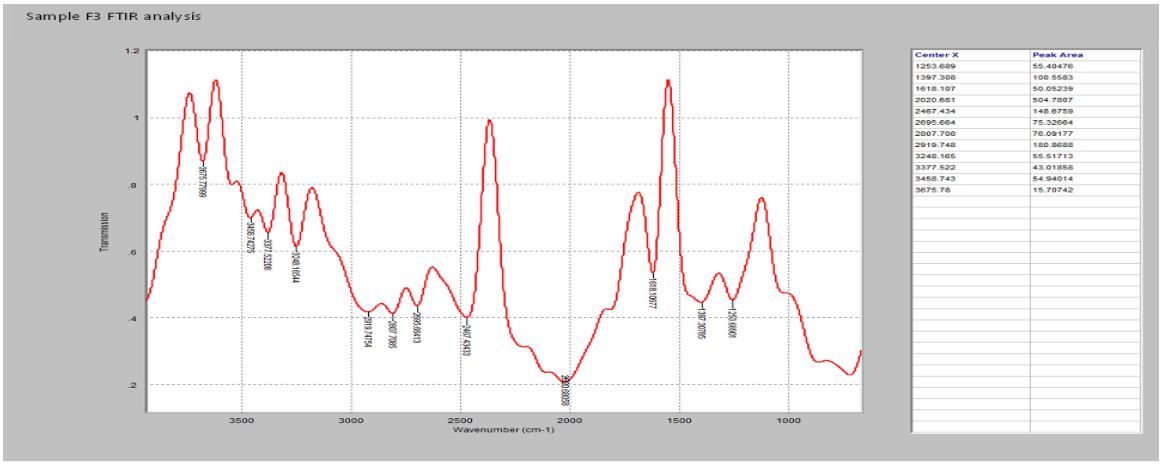


Figure 8: FTIR Spectra for Sample F: UMUOPARA BOREHOLE.

TABLE 7: Description of FTIR Peaks for sample E: (Borehole at Old- Umuahia)

Peak	Peak intensity	Peak shape	Bond Compound
849.8208	Strong Sharp	C-Cl stretching	Halo compound
1335.524	Strong Narrow	S=O stretching	Sulfonate
1620.513	Strong Sharp	C=C stretching	unsaturated ketone
1855.561	Strong Sharp	C=O bending	Acid halide
2071.398	Strong Broad	N=C=S stretching	Isothiocyanate
2446.007	Medium Sharp	N-H+ stretching	Ammonium ion
2601.993	Strong Sharp	S-H stretching	Thiol
2760.53	Weak Broad	O-H stretching	Alcohol
2959.532	Medium Sharp	C-H stretching	Alkane
3114.084	Medium Sharp	C-H stretching	Alkane
3418.122	Medium Sharp	N-H stretching	Amine salt
3821.401	Medium Sharp	O-H stretching	Free alcohol

TABLE 8: Description of FTIR Peaks for sample F (Borehole at Umuopara- Umuahia).

Peak	Peak intensity	Peak shape	Bond	Compound
1253.689	Medium	Sharp	C-O stretching	Ether
1397.306	Strong	Broad	O-H bending	Phenol, carboxylic acid
1618.107	Strong	Sharp	C=C stretching	Alkene
2020.681	Strong	Broad	C≡C stretching	Alkyne
2467.434	Strong	Sharp	O-H stretching	Carboxylic acid
2695.664	weak	Sharp	S-H stretching	Thiol
2807.708	Weak	Sharp	O-H stretching	Alcohol
2919.748	Medium	Broad	C-H stretching	Alkane
3248.165	Medium	Sharp	C-H stretching	Alkyne
3377.522	Medium	Sharp	N-H stretching	Aliphatic primary amine
3458.743	Medium	Sharp	O-H stretching	Alcohol
3675.78	Medium	Sharp	O-H stretching	Alcohol

Sample A, indicated the following polymer types – polystyrene (PS) from the FTIR spectra which showed peaks at 3000cm^{-1} due to C-H stretching, aromatic C=C stretching at 1618cm-^{1} and C-H bending observed at 783cm^{-1}. Also, PE (LDPE) is present due to vibrations at 1386.091cm-^{1} for CH_2.

In sample B, the FTIR spectra exhibited absorption peaks at 1821cm^{-1} due to C=O stretching, 1432cm^{-1} and 1616cm-^{1} for aromatic C=C stretching and 1302cm^{-1} for asymmetric C-O, suggesting the presence of polyethylene terephthalate (PET). Polyester (PES) is also inferred with peaks at 1821cm^{-1} due to C=O stretching, 1667cm^{-1} due to aromatic C=C stretching, 1303cm-^{1} due to C-O stretching of the ester group, and CH_2 stretching vibration seen at 2741-2919cm-^{1}. This is in line with the study of Aliyu *et al* (2023), who also noted PES in water samples, although the absorption peak for C=O was at 1714cm-^{1}.

In sample C, the FTIR spectra showed absorption peak at 3034cm-^{1} due to C-H stretching, 2915cm-^{1} for asymmetric CH_2, 1385cm-^{1} due to CH_3 bending, 1270cm-^{1} due to C-C stretching suggesting polyethylene (PE). Aliyu *et al*, (2023), also noted PE with vibration at 2914cm^{-1} for CH_3 asymmetric. Also, absorptions

at 1821cm^{-1}, 1432 and 1616cm-^{1}, 1302cm^{-1} and 2919cm-^{1} indicate C=O stretching, aromatic C=C stretching, asymmetric C-O stretching, aromatic C-H stretching and CH_2 stretching indicating PET.

In sample D the following MP types were identified; PS, as sample exhibited absorption peaks at 2901cm^{-1} and 1628cm^{-1} due to aromatic C-H stretching and aromatic C=C stretching, 880cm^{-1} due to C-H bending of aromatic ring. PET was also identified due to absorption peaks at 1834cm-^{1} for C=O stretching, 1629cm-^{1} for aromatic C=C stretching,1272cm^{-1} for C-O stretching, 3339cm-^{1} for aromatic C-H stretching and 2902cm^{-1} for CH_2 stretching. PES was observed as sample exhibited absorption peaks at 1834cm^{-1} due to C=O stretching, 1627cm-^{1} for aromatic C=C stretching, 1271cm^{-1} for C-O stretching and 2902cm^{-1} for CH_2 stretching. Aliyu *et al*, (2023) also observed PET and PES in their study of bottled water but with absorption peaks at 1241cm-^{1} due to C-O for PET; and 1714cm-^{1} due to C=O for PES.

In Sample E, PS was indicated with sample exhibiting absorption peak at 3114cm-^{1} due to aromatic C-H stretching, 1620cm-^{1} due to C=C stretching for aromatic, 2960cm-^{1} due to aliphatic C-H stretching and 850cm^{-1} due to C-H bending of aromatic ring. PES was also indicated with absorption peaks at 1855cm-^{1} due to C=O stretching for esters, 1335cm-^{1} due to C-O stretching and CH_2 stretching vibration seen at 2959 and 3114cm-$^{1.}$ Aliyu *et al*. (2023) also observed PES with peak at 1714cm^{-1} for C=O vibrations. PVC is also suspected based on C- Cl stretching vibration at 894cm^{-1}, CH_2 asymmetric vibration at 1620cm^{-1}.

The FTIR spectrum of sample F indicated PS due to absorption peaks at 2919cm-^{1} showing aromatic C-H stretching; and 1618cm-^{1} showing aromatic C=C stretching.

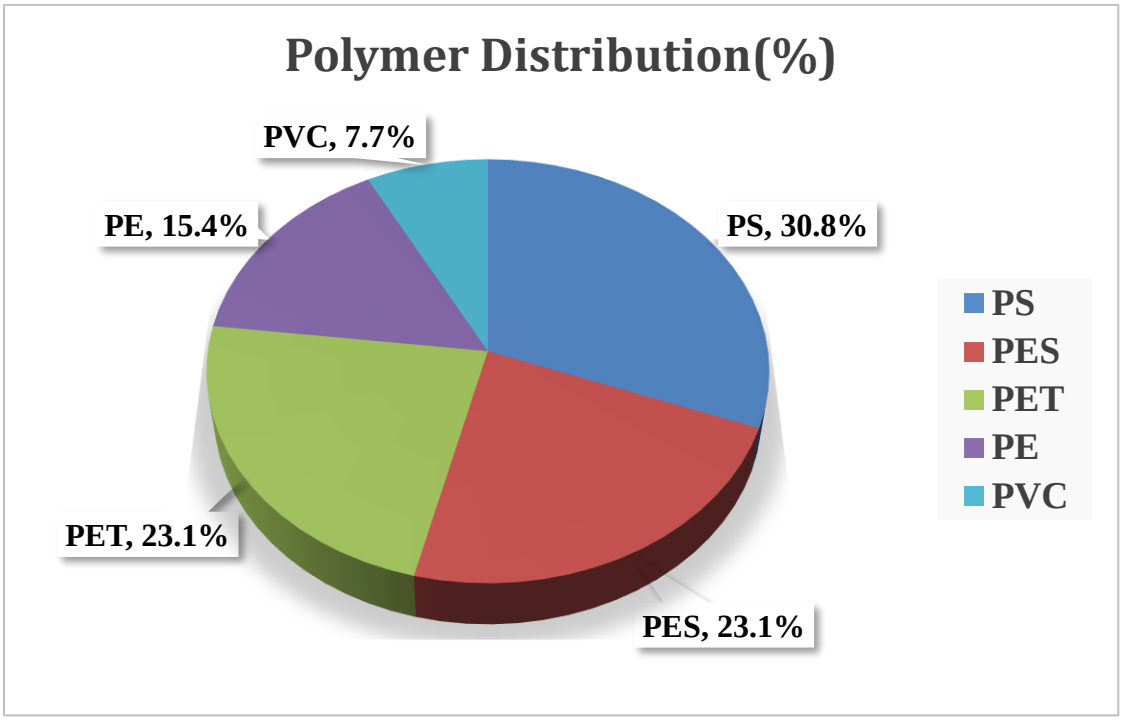


Figure 9: Distribution of MP Polymer Types in Borehole water samples.

Hence five different types of MPs were identified in the studied boreholes which were polystyrene (PS), polyethylene (PE), polyester (PES), polyethylene terephthalate (PET), polyvinyl chloride (PVC). From the study, even though the predominant polymer was polystyrene (PS), PE and PET predominated in borehole water samples from Aba.

Hence, the distribution order was as follows- PS (30.8%) > PET (23.1%), PES (23.1%) >PE (15.4%), > PVC (7.7%). It was however observed that PET and PES had equal distribution of 23.1% each. This is in contrast to the study of Ibeto *et al., (*2023), who observed that PET was the abundant polymer in their study on bottled water. Whereas Aliyu *et al., (*2023) noted that PET, PP and PVC were predominant in raw and treated water studied. The predominance of PE and PET in Aba boreholes agrees with the findings of Yahaya *et al.,* (2024), who reported that PE was the most abundant for boreholes studied in Birnin Kebbi, Northern Nigeria.

Figure 9 below shows the percentage polymer distribution in the borehole water samples.

Health Risk Assessment

The results for the computed estimated daily intake of MPs through consumption of the studied borehole water samples from Aba and Umuahia for adults and children were presented in Table 3 below. The microplastic pollution load index (MPPLI), microplastic contamination factor (MPCF) and estimated daily intake (EDI) were determined.

Table 3: Health Risk Assessment for Aba and Umuahia Borehole water samples

Sample Id	**Name**	**MPCF**	**EDI**	
			Adult	Child
A	Aba-Owerri Road Bore-hole	0.62	0.22	0.84
B	Faulks Road Bore-hole	0.62	0.22	0.84
C	Ikot-Ekpene Road Bore-hole	1.77	0.63	2.40
D	Afara Borehole	1.93	0.57	2.16
E	Old Umuahia Borehole	0.75	0.22	0.84
F	Umuopara Borehole	0.54	0.16	0.50
MPPLI= 0.899≈1				

The MPCF refers to the contamination of MPs in the studied borehole water samples. According to Verla *et al*, (2019), values with MPCF< 1 are low contamination, 1≤ MPCF<3 are moderately contaminated, 3≤ MPCF < 6 are considerably contaminated and MPCF ≥ 6, very highly contaminated. From the above results in Table 3; it could be observed that the values of MPCF for boreholes from Aba-Owerri Road and Faulks Road (Aba), Old Umuahia and Umuopara (Umuahia) were all less than 1, indicating low contamination of microplastics. Whereas, the MPCF values for boreholes from Ikot-Ekpene Road, Aba, (1.77); and Afara Umuahia, (1.93); were both greater than 1 but less than 3, thereby indicating moderate contamination of microplastics from these boreholes.

The EDI values for Aba-Owerri Road and Faulks road bore-hole (Samples A and C) for the adults and children were less than 1, while Ikot- Ekpene road bore-hole (sample B), had EDI value for children as 2.40, indicating moderate contamination. Similarly, the EDI values for Old Umuahia and Umuopara borehole water samples (samples E and F), for adults and children were less than 1, while Afara borehole, (sample D), had EDI value 2.16 for the children which was still moderate contamination. Generally, in both Aba and Umuahia water samples, it was found that the EDI values for children were higher than those of

adults, indicating that children could consume more MPs than adults. This result is in agreement with the study of Ibeto *et al*, (2023) and Aliyu *et al*, (2023) on bottled water, who reported a higher intake of MPs by children than adults and it should be noted that most bottled and sachet water sold in Nigeria are sourced from boreholes (Abdullahi *et al*,2019). Also, the MPPLI for the borehole water samples as shown in Table 7 indicated value ≈1, which indicated pollution of the boreholes by microplastics.

4. Conclusion

From the results, the maximum MPs concentration was 20 particles/L obtained from the borehole from Ikot-Ekpene road at Aba, followed by the borehole from Afara in Umuahia with MPs concentration of 18 particles/L. The three predominant shapes observed among these microplastics were fragments, beads and fibre, with fragments being the most prevalent. Also, five different polymer types found in the boreholes were PS, PES, PET, PE and PVC. Whereas PE and PET dominated in borehole water samples from Aba. PS was prevalent in Umuahia boreholes. The EDI values revealed a higher intake of microplastics for children than adults. Also, the MPPLI value of approximate 1.0 suggests that the microplastics may pose some health and environmental risks if unchecked. Therefore, consumers of groundwater in Aba and Umuahia cities should consider treating the water before consumption. Also, indiscriminate dumping of plastic waste into the environment should be highly discouraged.

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