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Research Article

Assessment of Microplastic Contamination and Associated Health Risk in Ajiwa Reservoir Katsina, Nigeria

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ABSTRACT
Microplastic pollution in freshwater reservoirs poses significant ecological and public health concerns, particularly in semi-arid regions where surface water is a primary resource. This study investigated microplastic contamination and associated health risks in Ajiwa Reservoir, Katsina State, Nigeria, over six months (April–September 2025), covering dry and rainy seasons. Water, sediment, and fish tissue samples (Clarias gariepinus and Oreochromis niloticus) were collected from nine stations and analyzed for microplastic abundance, distribution, and polymer composition using wet peroxide oxidation, density separation, and FTIR-ATR spectroscopy. Health risk was quantified through contamination factor, estimated daily intake, and cumulative risk index. Physico-chemical parameters (pH: 9.3–10.7; temperature: 26–34°C; turbidity: 163.3–416.7 NTU) exceeded WHO limits. Microplastics were detected in all matrices, with water recording the highest concentration at 775 particles/L. Rayon/Cellulose fibers dominated across all months, linked to textile wastewater, while Polyethylene and Polystyrene appeared exclusively during the rainy season, driven by surface runoff. Seasonal differences in polymer distribution were statistically significant ($p < 0.001$). Health risk assessment revealed a very high cumulative risk from drinking water (CRI = 0.503), while fish consumption posed low risk. These findings establish baseline data on microplastic contamination in Ajiwa Reservoir, underscoring an urgent public health threat requiring immediate intervention, including advanced water treatment, regular monitoring, improved sewage management, and runoff control measures.

Keywords: Ajiwa Reservoir; Freshwater contamination; Health risk assessment; Microplastics; Seasonal variation

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INTRODUCTION

Plastics have become an integral component of modern society, with global production reaching approximately 320 million tons annually (Ragusa *et al.,* 2021). Their durability and resistance to degradation contribute to severe environmental and health concerns, particularly through accumulation in landfills, rivers, and oceans. Approximately 8 million tons of plastic waste enter the ocean annually (Mendoza *et al.,* 2019). Once in aquatic environments, plastics undergo degradation due to microbiological activity, radiation exposure, and mechanical forces, resulting in the breakdown of larger plastic materials into microplastics (Wang *et al.,* 2021; Silva *et al.,* 2018).

Microplastics (MPs) are defined as small plastic particles measuring less than 5 mm in diameter, originating from various sources including the breakdown of larger plastic items, release of microfibers from fabrics during washing, and

incorporation of microbeads in cosmetic and personal care products (Xiang *et al.,* 2022). These particles are ubiquitous in aquatic environments due to plastic waste proliferation across diverse sectors (Vanapalli *et al.,* 2021). The widespread use of plastic products has led to pervasive presence of microplastics in environmental media such as soil, water, and air (O'Brien *et al.,* 2023).

Once regarded as a threat primarily to marine life, microplastics have now infiltrated the food chain, becoming an unavoidable part of the human diet (Ragusa *et al.,* 2021). Consumption of microplastics through contaminated food and beverages, including seafood, drinking water, and beer, represents a common exposure pathway (Sewwandi *et al.,* 2023). Inhalation serves as another route of exposure, particularly in indoor settings where airborne microplastics are present in dust (Ageel *et al.,* 2022). While precise health mechanisms remain under investigation, evidence suggests exposure to microplastics may lead to various health risks, including inflammation, oxidative stress, tissue damage, and reproductive toxicity (Barboza *et al.,* 2020; Wang *et al.,* 2023; Ghosh *et al.,* 2023).

In Nigeria, poor waste management practices, urban runoff, and indiscriminate plastic disposal contribute significantly to microplastic pollution in water bodies (Verla *et al.,* 2019). The Ajiwa Reservoir, serving as a primary water source for domestic, agricultural, and industrial use in Katsina State, is at risk of microplastic contamination. However, limited empirical data exist on the extent of microplastic pollution in the reservoir and its potential impact on aquatic life and human health. This study therefore aimed to assess microplastic contamination and associated health risks in Ajiwa Reservoir, Katsina State, Nigeria, by determining physico-chemical parameters, quantifying microplastic concentration and distribution in water, sediment, and fish tissues, assessing seasonal variation, and evaluating associated human health risks through drinking water and fish consumption pathways.

MATERIALS AND METHODS

Study Area

The study was conducted at Ajiwa Reservoir, located at latitude 12°98' N and longitude 7°75' E, in Batagarawa Local Government Area, Katsina State, Nigeria. The reservoir was impounded in 1973 and commissioned in 1975, with a capacity of approximately 22,730,000 m^3 (Parkman and Haskoning, 1996). It serves as a vital source for irrigation farming and water supply to communities across Katsina, Batagarawa, Mashi, and Mani Local Government Areas (Sadauki *et al.,* 2022).

Sample Collection

Water samples were collected monthly over six months (April–September 2025) from nine designated stations within the Ajiwa Reservoir, covering both dry (April–June) and rainy (July–September) seasons. The reservoir was systematically divided into nine sampling stations (A1–A3, B1–B3, C1–C3) to ensure comprehensive spatial coverage. Water samples (2 L) were collected in pre-cleaned glass bottles using a Van Dorn sampler at a depth of 0.5 m below the surface. Sediment samples were collected using an Ekman grab sampler. Fish samples (n=5 per species per station) of *Clarias gariepinu*s and *Oreochromis niloticus* were collected using gill nets and cast nets.

Determination of physicochemical Properties of Water Samples

The physicochemical properties of the water samples were assessed in the field by analyzing key water quality parameters such as temperature, pH, temperature and turbidity. The analysis was conducted using the procedures outlined by Dauda and Akinwole (2014) while adhering to the standard methods prescribed by the American Public Health Association (APHA, 2012).

Extraction of Sediments Samples

The samples were air-dried or oven-dried at 40°C to ensure consistent weight for analysis. The dried sediment was subsequently ground and homogenized using mortar and pestle. A representative subsample (50–100 g) was taken and sieved through meshes with sizes ranging from 20 µm to 300 µm to isolate microplastics of the desired size range. The sieved material was collected for further analysis. The sieved sediment was mixed with a sodium chloride solution (1.2 g/cm^3) and gently agitated. The mixture was allowed to settle for 24 hours, during which microplastics, being less dense, were float to the surface, while denser particles settle at the bottom. The floating layer was then be carefully extracted and transferred to a clean container. The wet peroxide oxidation (WPO) method was employed to remove organic matter. The sediment sample were mixed with 20 mL of 0.05 M Fe (II) solution and 20 mL of 30% hydrogen peroxide (H_2O_2) on a hotplate at 75°C for 30 minutes, loosely covered with foil. The mixture was heated at 75 ^oC in a stirring hotplate for 30 minutes, cover loosely with tinfoil to avoid atmospheric deposition during their action (but allowing the gas to escape). Additional H_2O_2 were added as needed until all organic material is removed.

The samples were then be left to digest for 24 hours before being filtered through a 45 mm membrane using a suction machine (Fischer *et al.,* 2020).

The microplastics collected on the filters were analyzed under a stereomicroscope for shape, color, and size. Advanced techniques, such as Fourier-transform infrared spectroscopy (FTIR), was utilized for detailed polymer identification when necessary.

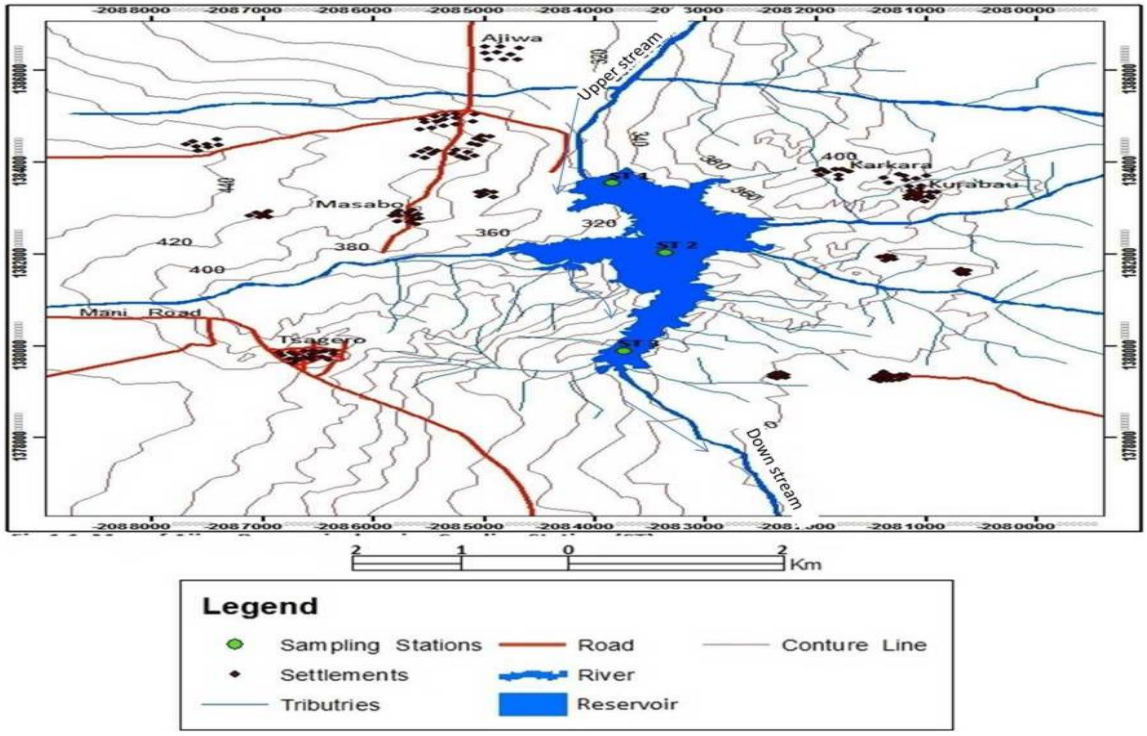

Figure 1: Map showing Ajiwa reservoir in Katsina State (Sadauki *et al.,* 2022)

Extraction of Microplastics in Water

The water samples were filtered through a 250 mm mesh brass sieve to remove suspended materials. The sieve was then be thoroughly rinsed with distilled water three times, each rinse lasting approximately five minutes per sample. To ensure uniform consistency, the water sample was stirred using a stirring plate. The wet peroxide oxidation (WPO) method was used to remove organic matter from the water samples. A total of 250 mL of the water sample was measured into a clean, dried 500 mL beaker, followed by the addition of 20 mL of a 0.05 M Fe (II) solution and 20 mL of 30% hydrogen peroxide (H_2O_2). The mixture was heated at 75°C on a stirring hotplate for 30 minutes, with the beaker loosely covered with tinfoil to prevent atmospheric deposition while allowing gases to escape. An additional 20 mL of 30% H_2O_2 was added as needed throughout the stirring and heating process. This process was repeated until no visible natural organic material remains. The samples were then be left covered to digest for 24 hours. After digestion, the water samples were filtered using a 45 mm filter membrane with a suction machine, following the protocols of Yang *et al*. (2015) and Anderson *et al*. (2017).

The Fe (II) solution was prepared by dissolving 6.95 g of $FeSO_4 \cdot 7H_2O$ in 500 mL of water and adding 3 mL of concentrated sulfuric acid

Extraction of Microplastics from Fish Tissues

Fish samples were first rinsed with distilled water before dissecting the muscle, liver, and gills using sterile stainless-steel tools. Tissue samples (5–10 g wet weight) were placed in a clean glass beaker and dried in an oven. Once dried, the samples were ground using a mortar and pestle. For digestion, 2 g of the homogenized tissue was treated with 100 mL of a 10% potassium hydroxide (KOH) solution to break down proteins and lipids. To prevent contamination, the beaker was covered with aluminum foil and incubated at 50–60°C for 24 hours.

Following digestion, 200 mL of 30% hydrogen peroxide (H_2O_2) was added to further decompose any remaining organic material. The mixture was then heated on a stirring hot plate at 50°C for 1–3 hours to

accelerate the reaction before being cooled to room temperature. The digested solution was transferred into a separation funnel, where 300 mL of a saturated NaCl solution gently shaken and left undisturbed for 24 hours, allowing microplastics to float. The floating particles (supernatant) were carefully collected by decanting or pipetting. The supernatant was then filtered through a membrane filter (pore size: 1–5 µm) using a suction filtration system. To eliminate residual salt and reagents, the filter was rinsed with distilled water before being placed in a clean, labeled Petri dish for further examination. Microplastics were analyzed under a stereomicroscope to determine their size, shape, and color, categorizing them as fibers, fragments, films, or beads. For polymer identification, Fourier-transform infrared spectroscopy (FTIR) was used to confirm the composition of the particles (Masura *et al.,* 2015; Rochman *et al.,* 2019 and Collard *et al.,* 2024).

Microplastic Analysis

The identification and quantification of microplastics in the collected water samples were performed using a Fourier Transform Infrared Spectroscopy with Attenuated Total Reflectance (FTIR-ATR) (Fourier Transform Infrared (FTIR) spectroscopy was performed using a Cary 630 FTIR spectrometer (Agilent Technologies, Santa Clara, CA, USA).

Health Risk Assessment of Microplastics

To assess microplastic contamination, the microplastics contamination factors (MPCfs) and pollution load index (MPPLI) for water sample was evaluated following the methodology outlined in previous research (Verla *et al.,* 2019). The MPCf measures the level of microplastic contamination in drinking water, including river and bottled water, relative to established baseline values. Both MPCf and MPPLI were calculated using mathematical formulas, where MPi represents the quantity of microplastics in a given water sample, and MPb denotes the minimum baseline concentration, derived from the lowest recorded microplastic abundance in the study by Mason *et al.,* (2018), which shares similar environmental and analytical contexts with the present study.

$$MPCF = \frac{MPi}{MPb}$$

$$MPPLi = (MPCf_1 \times MPCf_2 \times MPCf_3 \ldots\ldots\ldots MPCfn)^{1/n}$$

The MPCfs will be categorized 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.

One of the primary exposure pathways for humans to microplastic (MP) contamination in drinking water is through oral ingestion. The estimated daily intake (EDI) of MPs due to the consumption of contaminated water is calculated using the following equation 3:

$$EDIq = \frac{MPi \times RI}{Bw}$$

Where:

EDIq represents the estimated daily intake of MPs based on quantity (particles per liter per body weight per day), as outlined by Verla *et al.,* (2019). MPi denotes the average concentration of MPs in drinking water (MP particles/L) as outlined by Verla *et al.,* (2019).

RI refers to the ingestion rate, set at 2.2 L/day for adults and 1.8 L/day for children as outlined by Verla *et al.,* (2019). BW is the average body weight, estimated at 70 kg for adults and 15 kg for children, as outlined by Verla *et al.,* (2019).

RESULT

Table 1 shows the consolidated mean physico chemical parameters by season. During the dry season, pH recorded significantly higher alkalinity (Mean Max: 10.7) compared to the rainy season (Mean Max: 9.9). This indicates that the influx of rainwater in the latter half of the study helped neutralize the water's pH levels. Average temperatures were higher during the dry months (April–June), peaking at 34°C. In contrast, the rainy season saw temperatures drop to as low of 26°C in August. However, Turbidity levels peaked during the rainy season, specifically at Station A in July (416.7 NTU). This confirms the research hypothesis that seasonal rains increase agricultural runoff and suspended matter in the Ajiwa Reservoir.

Table 2 shows water samples consistent contamination across all months (4.89–12.56 particles/L), with PE remaining relatively stable (8.67–12.56 particles/L) indicating persistent input from plastic waste. PP demonstrated the most dramatic seasonal variation, declining sharply from 12.33 particles/L in May to 4.89 particles/L in August due to dilution from heavy rainfall. PET gradually increased from April (10.00) to a July peak (12.22) before declining, suggesting increased input from bottle fragments during early rainy season. The shifting dominance among polymers indicates multiple pollution sources rather than a single contaminant.

Table 3 Revealed sediment distinct accumulation patterns (5.22–14.00 particles/kg), with PE relatively stable (7.67–11.67 particles/kg) suggesting constant sedimentation. PP showed remarkable consistency (9.67–11.22 particles/kg), indicating continuous

background accumulation. PET displayed the most dramatic variation, surging to a peak of 14.00 particles/kg in August a threefold increase from May's low demonstrating that peak rainy season runoff significantly transports PET fragments into the reservoir. The one-month lag between water (July) and sediment (August) PET peaks confirms vertical transport and settling from the water column.

Table 4 shows Catfish exhibited varying accumulation (2.75–15.00 particles/kg). PE declined sharply from April (7.75) to May (2.75) a 64% reduction—and remained low thereafter. PP showed a clear declining trend from April (10.00) to September (4.25), a 57.5% reduction. PET displayed two distinct peaks: the highest recorded concentration (15.00 particles/kg) in April, followed by another peak in July (14.00), suggesting benthic feeding catfish experience increased microplastic ingestion during seasonal transitions when sediment resuspension occurs. All polymers were present across all months, confirming chronic exposure in this commercially important species.

Table 5 explain tilapia distinct accumulation patterns (2.00–14.00 particles/kg) differing from catfish. PE varied moderately (4.00–14.00 particles/kg), highest in May (14.00) and lowest in September (4.00). PP declined from a peak in April (14.00) through June (4.00), then partially recovered. PET progressively increased from April (2.00) through June (10.67), peaking in July (8.10), then gradually declining indicating filter-feeding tilapia accumulated PET gradually as particles became more abundant during the rainy season. Compared to catfish, tilapia showed lower PET but higher PE concentrations, reflecting their filter-feeding strategy exposing them to more water-column suspended particles.

Table 1: Consolidated Mean Physico-chemical Parameters by Season

Parameter	Dry Season (April – June)	Rainy Season (July – September
pH	9.6 – 10.7	9.3 – 9.9
Temp (°C)	28.0 – 34.0	26.0 – 29.0
Turb (NTU)	163.3 – 383.3	283.3 – 416.7

Keywords: pH= potential of hydrogen, Temp = Temperature, Turb = Turbidity

T**able 2 Microplastic distribution of water across months in Ajiwa Reservoir Katsina State**

Month	PE	PP	PET
Apr	8.67± 2.83	11.22 ± 3.46	10.00 ± 3.00
May	12.56 ± 2.96	12.33 ± 2.96	8.67 ± 4.89
Jun	10.00 ± 3.89	10.56 ± 3.0	11.08 ± 4.79
Jul	10.00 ± 3.42	11.44 ± 3.91	12.22 ± 3.07
Aug	9.78± 2.54	4.89 ± 2.54	9.78 ± 2.54
Sep	10.00 ± 2.55	7.33. ± 2..45	10.00 ± 2.55

Table 3: Microplastic distribution of sediment samples across months in Ajiwa Reservoir Katsina State.

Month	PE	PP	PET
Apr	8.89 ±2.09	9.67 ± 3.24	9.78 ± 3.62
May	10.00 ± 4.47	11.22 ± 4.21	5.22 ± 3.49
Jun	9.56 ± 5.06	10.50 ± 6.89	10.67 ± 7.30
Jul	11.67 ± 4,12	9.78 ± 6.32	11.79 ± 2.49
Aug	7.67 ± 1.58	9.78 ± 3.80	14.00 ± 1.00[a]
Sep	9.00 ± 1.50	9.89 ± 3.62	8.00 ± 0.60[b]

Table 4: Spatial distribution of microplastics polymer types in *C. gariepinus* samples across months in Ajiwa Reservoir Katsina State

Months	PE	PP	PET
April	7.75 ± 0.96	10.00 ± 0.82	15.00 ± 1.41
May	2.75 ± 0.96	6.00 ± 0.86	5.00 ± 1.87
June	5.67 ± 4.12	9.78 ± 6.32	11.79 ± 2.49
July	6.67 ± 0.21	5.00 ± 0.81	14.00 ± 3.08
August	4.00 ± 0.82	5.00 ± 0.81	9.0 ± 0.70
September	4.00 ± 0.82	4.25 ± 0.80	8.00± 0.70

Table 5: Microplastic distribution of *O. niloticus samples* across months in Ajiwa Reservoir Katsina State.

Month	PE	PP	PET
Apr	10.00 ±41	14.00 ± 0.63	2.00 ± 0.70
May	14.00 ± 1.67	7.00 ± 0.89	5.00 ± 0.70
June	6.00 ± 1.41	4.00 ± 1.27	10.67 ± 7.30
July	10.00 ± 1.41	5.60 ± 5.20	8.10 ± 4.90
August	9.60 ± 1.05	7.90 ± 4.80[b]	6.30 ± 3.70
September	4.00 ± 1.27	6.00 ± 1.41	7.00 ± 1.41

Health Risk Assessment

Average fish mass = 0.25 kg, sediment ingestion = 0.1 kg/day, Water ingestion = 2 L/day and Body weight = 70 kg

Table 6 presents the microplastic concentrations across all matrices, with water showing the highest concentration (775 particles/L), followed by sediment (612 particles/kg), *C. gariepinus* (564 particles/kg), and *O. niloticus* (332 particles/kg). The higher concentration in catfish compared to tilapia reflects their benthic feeding behavior, exposing them to more sediment-associated microplastics. Water exhibited the highest concentration, indicating it is the primary pathway for human exposure through drinking water consumption. The conversion of total counts to concentration per unit mass/volume was calculated by dividing total counts by mass (0.25 kg for fish) or volume (1 L for water), establishing baseline data for subsequent health risk calculations.

ESTIMATED DAILY INTAKE (EDI)

The Estimated Daily Intake (EDI) represents the number of microplastic particles a person is exposed to per kilogram of body weight per day. It is calculated using the formula:

$$EDI = \frac{C \times IR}{BW}$$

Where: C = Concentration of microplastics, IR = Intake rate (kg/day for fish; L/day for water) and BW = Body weight (70 kg for adult human)

Table 7 present the Estimated Daily Intake (EDI) calculation. Drinking water poses the highest exposure risk at 22.14 counts/kg bw/day, which is approximately 25 times higher than sediment (0.874), 55 times higher than catfish (0.403), and 93 times higher than tilapia (0.237). This massive disparity is driven by the high daily water intake rate (2 L/day) compared to minimal fish consumption (0.05 kg/day) and incidental sediment ingestion (0.1 kg/day). The EDI for water far exceeds typical values reported in similar studies, highlighting the severe contamination of Ajiwa Reservoir. The key finding water ingestion results in EDI of 22.14 counts/kg bw/day demonstrates that drinking untreated reservoir water exposes consumers to significant microplastic burdens daily.

CUMULATIVE RISK INDEX (CRI)

The Cumulative Risk Index (CRI) integrates both exposure magnitude (EDI) and polymer toxicity (PHI) to provide a single, comprehensive health risk metric:

$$CRI = \frac{EDI \times PHI}{100}$$

Dividing by 100 scales the index for comparison

Table 8 integrates exposure (EDI) and toxicity (PHI) to calculate the Cumulative Risk Index (CRI). Water showed the highest CRI (0.503), classified as Very High Risk, driven by high EDI (22.14) and moderate PHI (2.27). *C. gariepinus* showed CRI of 0.0101 (Low Risk) despite having the highest PHI (2.51), as its low EDI (0.403) limits overall risk. Sediment showed CRI of 0.0186 (Low Risk), while *O. niloticus* showed the lowest CRI (0.0051). This reveals that while fish tissues contain more toxic polymers (higher PHI), the minimal consumption rates keep the overall risk low, whereas water's high intake volume makes it the critical exposure pathway despite moderate polymer toxicity.

POLYMER HAZARD INDEX (PHI)

The Polymer Hazard Index (PHI) accounts for the fact that different polymer types pose varying degrees of health risk based on their chemical composition, additive content, and toxicity profiles. The formula is**:**

$$\boldsymbol{PHI = \sum_{i=1}^{n} (C_i \times T_i)}$$

Where Ci = Proportion or concentration of polymer and Ti = Toxicity weighting factor for polymer (based on hazard ranking).

Table 9 confirms that water presents the only significant health risk (CRI = 0.503, Very High Risk), while all other matrices fall within the Low Risk category (CRI < 0.05). The risk classification system defines four levels: Low Risk (<0.05), Moderate Risk (0.05–0.15), High Risk (0.15–0.30), and Very High Risk (>0.30). Water's CRI of 0.503 substantially exceeds the Very High Risk threshold, indicating urgent public health concern. In contrast, sediment (0.0186), catfish (0.0101), and tilapia (0.0051) all remain well

below the Low Risk threshold. This clearly demonstrates that drinking water is the dominant exposure pathway for microplastics in Ajiwa Reservoir, while fish consumption and incidental sediment ingestion pose minimal health risks.

Table 10 shows the integrated risk assessment confirms that water poses High/Very High Risk (CRI = 0.503) from microplastic contamination, while all other matrices sediment (0.0186), *C. gariepinus* (0.0101), and *O. niloticus* (0.0051) fall within the Low Risk category. Despite having the highest total microplastic count (775 particles/L), water's risk is primarily driven by the high daily intake volume (2 L/day). Although fish tissues contain higher proportions of toxic polymers like PVC and PS (resulting in higher PHI values), the low consumption rates (0.05 kg/day) keep the overall CRI low. The findings underscore that consumers of untreated Ajiwa Reservoir water face significant health risks, while fish consumers face minimal additional risk. Immediate intervention should prioritize advanced water treatment for microplastic removal, regular monitoring, and improved sewage management to protect public health.

Table 6: Shows the Health Risk Assessment

Sample	Total Count	Mass/volume	Concentration(kg/L)
Water	775	1L	775L
Sediment	612	1kg	612kg
C. gariepinus	141	0.25kg	564kg
O. niloticus	83	0.25kg	332kg

Table 7: Present the Estimated Daily Intake Summary

Sample	Total Count	Rate Intake	EDI(kg/bw/day)
Water	775	2L/day	22.14
Sediment	612	1kg/day	0.874
C. gariepinus	564	0.25kg/day	0.403
O. niloticus	332	0.25kg/day	0.237

Key finding: Water ingestion in Ajiwa Reservoir results in EDI = 22.14 counts/kg bw/day

Table 8: Summary of EDI and PHI

Sample	EDI	PHI	CRI
Water	22.14	2.27	0.503
Clarias	0.403	2.51	0.0101
Sediment	0.874	2.13	0.0186
Oreochromis	0.237	2.15	0.0051

Table 9: Cumulative Risk Index

Sample	EDI kg/bw/day	CRI
C. gariepinus	0.403	0.0101
O. niloticus	0.237	0.0051
Sediment	0.874	0.0186
Water	22.15	0.503

Table 10: Present the integrated Risk Table of Microplastic Polymer in Ajiwa Reserviour

Sample	Total Counts	EDI (counts/kg bw/day)	PHI	CRI	Risk Level
Water	775	22.14	2.27	0.503	High
C. gariepinus	141	0.403	2.51	0.0101	Low
O. niloticus	83	0.237	2.15	0.0051	Low
Sediment	612	0.874	2.13	0.0186	Low

DISCUSSION

The pH values recorded across all stations indicate a consistently alkaline environment throughout the study period. In April, the highest pH values were observed (Station A: 10.7, B: 10.5, C: 10.1), which shows strong alkalinity. However, there is a gradual decline in pH from April to July, reaching minimum values in July (A: 9.9, B: 9.7, C: 9.4). A slight stabilization is observed in August and September. Across all months, Station A consistently recorded the

highest pH, followed by Station B, while Station C had the lowest. This spatial variation may indicate differences in pollution load, chemical inputs, or biological activity. The overall alkaline nature of the water could be attributed to high levels of dissolved salts, anthropogenic activities, or runoff containing alkaline substances. And as stated by WHO, 2022 the standard pH for drinking water ranges from 6.5-8.5. This deviation shows that the reservoir water is not within acceptable drinking standards, as highly alkaline water can affect taste, reduce disinfection efficiency, and may cause irritation in consumers (WHO, 2022).

From April to August, the temperature gradually drops, then slightly rises in September. April had the greatest temperatures (A: 34°C, B: 33°C, and C: 33°C), which is consistent with the dry season's peak. Due to increased rainfall and cloud cover throughout the rainy season, temperatures fell to their lowest points by August (A: 28°C, B: 27°C, and C: 26°C). September's minor temperature increase points to a period of transition between the highest rainfall and the beginning of dry weather. As with pH, Station A's temperatures were consistently marginally higher than those of Stations B and C. This may be due to differences in exposure to sunlight, water depth, or flow rate. These values are generally above the desirable range, particularly during the dry season. Elevated temperatures may accelerate biological activity, reduce dissolved oxygen, and promote microbial proliferation, thereby compromising water quality (WHO, 2022).

There is a noticeable upward trend in turbidity readings from April to July, after which they start to fall in September. Turbidity levels were lowest in April (A: 250.0 NTU, B: 183.3 NTU, C: 163.3 NTU), but they rose sharply and peaked in July (A: 416.7 NTU, B: 380.7 NTU, C: 343.3 NTU). The rainy season, which brings suspended particles, organic matter, and sediments into the water bodies through surface runoff, is correlated with this increase in turbidity. The following decrease in runoff strength from August to September is indicative of a slow settling of suspended particles. Station C regularly recorded the lowest turbidity values, indicating comparatively less disturbance, whereas Station A consistently recorded the highest values, indicating it may be more subject to erosion, human activity, or sediment influx (Nanyanzi *et al*., 2021).The findings from this study reveal a clear seasonal variation in microplastic polymer composition within the Ajiwa Reservoir, with distinct differences between the dry and rainy seasons. During the dry season (April–June), the reservoir was predominantly characterized by Rayon/Cellulose fibers, which are commonly associated with textile materials originating from domestic laundry, wastewater discharge, and municipal activities. This observation aligns with earlier studies that identified synthetic and semi-synthetic fibers as dominant microplastics in freshwater systems, largely due to their continuous release from washing processes and inadequate wastewater treatment facilities (Browne *et al.,* 2011; Dris *et al.,* 2016).

Fiber contamination appears to be the most common and reliable kind of microplastic pollution in the reservoir, as evidenced by the continuous detection of Rayon/Cellulose in all months and sample locations. Dris *et al*. (2015) and Hernandez *et al*. (2017) revealed similar results, pointing out that microfibers predominate in aquatic habitats because to their great mobility, low weight, and constant input from human sources. Moreover, excessive amounts of cellulosic fibers have been connected to low filtering effectiveness in treatment systems and urban wastewater discharge, especially in developing areas (Napper and Thompson, 2016).

In contrast, more complex polymers like polyethylene (PE) and polystyrene (PS) emerged during the rainy season, especially in August, indicating an increase in polymer variety, or "polymer richness." The prevalence of these polymers during the rainy season indicates increased input from surface runoff and stormwater conveyance, and they are frequently employed in consumer goods and plastic packaging materials. The idea that floods and rainfall events are the main ways that land-based plastic debris enters aquatic systems is supported by this seasonal change. Similar findings have been published in research by Hurley *et al*. (2018) and Lebreton *et al*. (2017), Both studies underscore the critical role of seasonal hydrology in mobilizing and transporting microplastics from terrestrial sources into freshwater systems, which directly supports the findings of the present study. Hurley *et al*. (2018) conducted a catchment-wide investigation in northwest England and demonstrated that severe flooding events exported approximately 70% of stored microplastic loads from river beds, equating to 0.85 ± 0.27 tonnes or 43 ± 14 billion particles, thereby proving that flood events efficiently flush plastics from catchments into downstream water bodies. Similarly, Lebreton *et al*. (2017) developed the first global model quantifying riverine plastic inputs into the world's oceans and estimated that between 1.15 and 2.41 million metric tons of plastic waste enter the ocean from rivers

annually, with the 20 most polluting rivers contributing approximately 67% of this total and over 74% of emissions occurring between May and October. The seasonal rainfall patterns and peak rainy season polymer diversity observed in the present study align with these findings, as the appearance of Polyethylene and Polystyrene exclusively during the rainy season corroborates the hypothesis that heavy rainfall and flooding are the primary mechanisms for introducing land-based plastic waste into aquatic systems, thereby validating the research of both Hurley *et al*. (2018) and Lebreton *et al*. (2017).

The observed increase in polymer diversity during the rainy season is also consistent with findings by Free *et al.* (2014), who reported that urban runoff contributes significantly to the influx of polyethylene and polystyrene particles into freshwater bodies. This indicates that seasonal hydrological processes play a critical role in shaping microplastic composition, with the dry season reflecting point-source pollution (e.g., wastewater discharge) and the rainy season reflecting diffuse pollution sources (e.g., runoff and erosion).

In sediment samples, however, a different pattern was observed. The FTIR analysis consistently identified Rayon/Cellulose fibers as the dominant polymer type across all months, indicating long-term accumulation and persistence of fibrous particles in the sediment matrix. This finding agrees with studies such as Woodall *et al*. (2014) and Zhang (2017), which reported that fibers tend to accumulate in sediments due to their interaction with organic matter and gradual settling processes. The higher absorption intensities observed in the fingerprint region further suggest the concentration and compaction of these particles over time.

Unlike the water column, where PE and PS appeared during the rainy season, the sediment remained largely dominated by Rayon fibers, with only minimal detection of other polymers. This shows that heavier or denser particles are more likely to settle and persist, while lighter polymers such as PE may remain suspended or be transported downstream. Similar observations were reported by Claessens *et al.* (2011), who found that sediments act as sinks for specific types of microplastics, particularly fibers. The contrast between water and sediment results highlights the dynamic behavior of microplastics in aquatic environments. While the water column reflects recent and seasonal inputs, the sediment represents a long-term reservoir of accumulated pollutants. The dominance of Rayon/Cellulose across both matrices emphasizes the significant role of textile-related pollution, while the seasonal appearance of PE and PS underscores the impact of urban runoff and rainfall-driven transport mechanisms.

CONCLUSION

The comparison with (WHO) standards reveals that the physico-chemical characteristics of the Ajiwa Reservoir are significantly impacted by environmental and anthropogenic factors, particularly during the rainy season. The water quality falls below international standards for potable water, highlighting the need for adequate treatment, monitoring, and pollution control measures. Microfiber pollution (Rayon/Cellulose) is the dominant and most persistent form of microplastic contamination. Seasonal rainfall significantly increases polymer diversity through runoff-driven inputs. Sediments act as long-term sinks for fibrous microplastics. Water samples reflect short-term, seasonal variations, while sediments reflect long-term accumulation. The findings underscore the combined impact of seasonal variability and human activities on both water quality and microplastic pollution in the Ajiwa Reservoir, and they point to the urgent need for integrated water management strategies, effective waste control measures, and continuous environmental monitoring.

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