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Detection of Microplastic Pollutants and the Wellbeing of *Clarias gariepinus* (African Catfish) in Jama'are River, Bauchi State, Nigeria

[1]Dahiru Aliyu, [1]Timothy Auta and [1,2]Armaya'u Hamsiu Bichi

[1]Department of Biological Sciences, Faculty of Life Sciences, Federal University of Dutsin-Ma, Katsina, Nigeria

[2]Department of Fisheries and Aquaculture, Faculty of Renewable Natural Resources, Federal University of Dutsin-Ma, Katsina, Nigeria

ABSTRACT

Background and Objective: The contamination of freshwater ecosystems with microplastics is becoming a serious concern for its negative consequences on the ecosystem. This study aimed to evaluate the presence of microplastic pollutants and their potential impact on *Clarias gariepinus* (African catfish) in Jama'are River, Bauchi State. **Materials and Methods:** Sampling was conducted fortnightly over 4 months (April to July, 2023) at three stations (A, B and C). Water and fish samples were analyzed for microplastics using light microscopy (stereo microscope Micromed (MC2) with a digital camera and top view 3.7.6273 software) and FTIR. Additionally, physicochemical parameters, histopathological examination of fish tissues and haematological indices of fish blood were assessed. Physicochemical parameters of the water samples were generally within WHO permissible limits. **Results:** However, turbidity levels exceeded the recommended value of 5 NTU. The mean temperature ranged from (30.23±3.1°C) to (33.15±3.7°C), electric conductivity from (150.85±7.0 μs/cm) to (158.33±6.1 μs/cm), dissolved oxygen concentration from (5.55±0.1 mg/L) to (5.15±0.2 mg/L), pH from (6.23±1.2) to (6.99±1.1), turbidity from (308.23±4.2 NTU) to (314.15±4.2 NTU), total dissolved solids from (322.30±36 mg/L) to (397.15±23 mg/L) and total suspended solids from (244.73±37 mg/L) to (291.45±39 mg/L). Microplastic analysis revealed the presence of various contaminants, including acrylonitrile butadiene, polyamides, poly butylene succinate adipate, poly (3-hydroxybutyrate-co-3-hydroxyvalerate), polyethylene (PE), polyvinyl chloride (PVC), poly carbonate (PC), polypropylene (PP), polystyrene (PS), polyether ether ketone and polyethylene (PE). **Conclusion:** These findings indicate water contamination, emphasizing the need for effective measures to control microplastic levels in the surface water of the studied area.

KEYWORDS

Water pollution, physicochemical parameters, histopathological examination, haematological indices, environmental contamination, FTIR analysis, stereomicroscope contaminants

INTRODUCTION

The earth's surface is predominantly covered by water, with approximately 70% comprising freshwater and oceans. However, a substantial portion of this water is unavailable to terrestrial or freshwater ecosystems, with less than 3% being freshwater and, in many cases, not suitable for drinking

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purposes. Notably, more than two-thirds of freshwater is trapped in ice caps and glaciers, leaving a limited portion accessible for various uses[1].

Globally, freshwater lakes and rivers collectively account for around 100,000 km^3, representing a minuscule fraction of the Earth's total water volume[2]. Rivers play a crucial ecological role, fulfilling diverse human needs and contributing significantly to our quality of life by offering numerous opportunities. This reality is reflected in the high population density residing in proximity to bodies of water, including lakes, rivers, marshes, coastal lagoons and reservoirs in Nigeria. Numerous communities extremely rely on these water materials as their primary sources of animal protein and household income[3]. The pervasive issue of plastic waste emerges as a significant contributor to the generation of microplastics, primarily stemming from single-use plastic items and packaging materials. Despite accounting for only half of the plastic products, these disposable items play a substantial role in the microplastics' prevalence[2,3].

The increasing prevalence of microplastic pollutants in aquatic ecosystems poses a significant environmental concern. The presence of microplastics in water bodies, such as the Jama'are River, raises questions about their potential impact on the aquatic biota, particularly the African Catfish (*Clarias gariepinus*)[4,5]. Understanding the extent of microplastic contamination, its sources and the potential consequences on fish health is essential for environmental management and sustainable aquatic ecosystems[6]. The study is justified by its potential to provide essential insights into the ecological and human health implications of microplastic contamination in the Jama'are River, contributing to both scientific knowledge and practical environmental conservation efforts.

Therefore, this study assessed the concentration and types of microplastics present in Jama'are River, identified potential sources of microplastic pollution in the river, such as anthropogenic activities or specific industries, looked into the potential impacts of microplastics on the health additionally well-being of African Catfish in the studied aquatic environment and attempted to understand the broader environmental implications of microplastics contamination in Jama'are River and its potential cascading effects on ecosystem dynamics.

By addressing these aspects, the study aims to contribute valuable insights into the current state of microplastic pollution in the aquatic environment and its repercussions on the African Catfish population, thereby informing future conservation and management strategies.

MATERIALS AND METHODS

Study area: The study was carried out from April to July, 2023. Jama'are is located some 200 kilometres northeast of Bauchi State Capital, Bauchi on Latitude 11°0.40'00"N and Longitude 9°0.55'53"E.

Physicochemical parameters analysis of water sample: The physicochemical parameter analysis inside water sample variables include electrical conductivity (EC), temperature and dissolved oxygen (DO), pH, turbidity (T), Total Dissolved Solid (TDS) and total suspended solid (TSS) were all measured.

Using a standardised mercury-in-glass centigrade thermometer, the temperature was measured *in situ*. A handheld pH meter (HANNA 3100 model) was used to measure the pH:

- Dissolved oxygen (DO) was determined using a portable DO meter (JPB 607 Model)
- Turbidity was determined using a graduated portable turbidity tube
- Electric conductivity (EC) was measured using a conductivity meter (SUNTEX Model)

Sample collection: All water and fish samples were collected fortnightly (bi-weekly, twice a month) for a period of 4 months. Samples were collected between 8:00 am and 12:00 noon.

Water sample collection: Approximately 500 mL of water sample was collected using clean sample containers at each sampling point for physico-chemical parameters analysis

Fish sample collection: A total of 200 fresh matured adult fish African catfish (*Clarias gariepinus*) weighing 100-500 g was collected.

Samples were collected and dissected and work was done according to the method developed by Bellas *et al.*[7] and Claessens *et al.*[8].

Haematological analysis: During haematological analysis, a sample of blood was drawn from twelve specimens of fish, four from every sample station. The blood sample was extracted from the fish's tail vein using a sterile syringe that contained an anticoagulant solution of heparin. These blood specimens were employed for the determination of full blood count using the technique of Akorsu *et al.*[9] for red blood cells (RBCs) and Van Kampen and Zijlstra[10] for the measurement of haemoglobin content (Hb) at Faculty of Medicine, Amino Kano Teaching Hospital Kano.

Histopathological evaluation of fish sample: Histopathological evaluation of fish samples was done at the Laboratory of Histopathology, Teaching Hospital, Aminu Kano, according to the procedure described by Gurina and Lary[11]. The procedure involves the following steps: The biopsies of the gills, liver and kidney of fish were adjusted with 10% formal saline, drained with increasing alcohol concentration, cleaned with toluene and then penetrated by melted paraffin wax. The microtome portion was tarnished with haematoxylin regarding the method of Eosin staining and investigated using Leica DM750 under a microscope and captured on Leica film ICC Fifty High Definition Cameras[11].

Statistical analysis: The ANOVA was used to analyze the data (Analysis of variance). The $p \leq 0.05$ or $p < 0.01$ was the threshold for statistically significant differences.

RESULTS

Physicochemical parameters: Table 1 summarizes the physicochemical parameters recorded during the research period from April to July, 2023. The highest temperature occurred in July (33.43±0.4 OC), contrasting with the lowest temperature in April (28.23±0.7 OC), indicating a significant difference ($p < 0.001$). Electric conductivity (E.C.) ranged from 152.4±5.4 to 158.3±6.1, with the highest in April (158.3±6.1 μs/cm) and the lowest in July (152.4±5.4 μs/cm). Dissolved oxygen concentration showed the highest mean value in April (5.365±0.4 mg/L) and the lowest in July (4.978±0.2 mg/L), with $p < 0.905$ indicating no meaningful difference. As the highest pH mean value occurred in June (6.997±0.1) and the lowest was in July (6.633±0.3). Turbidity mean values peaked in June (305.5±4.9 NTU) and July (314.5±3.2 NTU), significantly differing from April (236.8±10) and May (244.1±4.8) ($p < 0.000$). Total dissolved material recorded its highest average in July (397.3±4.2 mg/L) and the lowest in April (319.3±23 mg/L). Total suspended solid was highest in July (291.1±1.8 mg/L) and lowest in April (287.9±7.7mg/L).

Table 2 displays physicochemical parameters across sampling stations (A, B and C). Station B had the highest temperature (30.23±3.1 OC), followed by station C (33.15±3.7), differing from station A (29.14±3.1 OC). Electric conductivity was highest in station C (158.33±6.1 μs/cm) and lowest in station A (150.85±7.0 μs/cm). Dissolved oxygen concentration was highest in station A (5.55±0.1 mg/L) and lowest in station C (5.15±0.2 mg/L). Station B exhibited the highest pH (6.99±1.1), while station A had the lowest (6.23±1.2). Turbidity peaked in station C (314.15±4.2 NTU) and station B (308.23±4.2 NTU) compared to station A (240.33±4.3 mg/L). Total dissolved solids were highest in station C (397.15±23 mg/L) and lowest in station A (322.30±36 mg/L). Total suspended solid was highest in station C (291.45±39 mg/L) and station A had the lowest (244.73±37 mg/L).

Table 1: Monthly Mean±Standard Deviation of the physicochemical parameters recorded in river Jama'are Bauchi State

Parameters	April	May	June	July	p-value
Temp. (°C)	28.23±0.7	30.22±0.9	32.15±0.6	33.43±0.4	0.001
EC (μs/cm)	158.3±6.1	145.6±16	150.8±9.1	152.4±5.4	0.124
DO (mg/L)	5.365±0.4	5.113±6.3	5.345±0.1	4.978±0.2	0.905
pH	6.960±0.3	6.847±0.3	6.997±0.1	6.633±0.3	0.313
TURB. (NTU)	236.8±10	244.1±4.8	305.5±4.9	314.5±3.2	0.000
TDS (mg/L)	319.3±23	326.3±54	350.5±3.2	397.3±4.2	0.630
TSS (mg/L)	287.9±7.7	289.3±1.8	290.5±5.9	291.1±1.8	0.001

Temp.: Temperature, TURB: Turbidity, TDS: Total dissolved oxygen, DO: Dissolved oxygen, TSS: Total suspended solid and EC: Electrical conductivity

Table 2: Mean±Standard Deviation of physical-chemical parameters measured at all sites in Bauchi State Jama'are River

Station	Temp. (°C)	EC (μs/cm)	DO (mg/L)	pH	TURB. (NTU)	TDS (mg/L)	TSS (ppm)
A	29.14±3.1	150.85±7.0	5.55±0.1	6.23±1.2	240.33±4.3	322.30±36	244.73±37
B	30.23±3.1	156.25±7.3	5.23±0.2	6.99±1.1	308.23±4.2	333.25±21	246.73±46
C	33.15±3.7	158.33±6.1	5.15±0.2	6.25±1.3	314.15±4.2	397.15±23	291.45±39

Temp.: Temperature, TURB: Turbidity, TDS: Total dissolved oxygen, DO: Dissolved oxygen, TSS: Total suspended solid and EC: Electrical conductivity

Table 3: Physicochemical parameter correlation coefficient matrix for Jama'are River, Bauchi State

Parameter	Temperature	pH	DO	E.C	TURB.	TDS
pH	-0.065	1.00				
DO (mg/L)	0.218	0.455*	1.00			
EC (μs/cm)	-0.247*	-0.123	-0.233	1.00		
TURB. (NTU)	0.712**	-0.030	-0.121	-0.132	1.00	
TDS (mg/L)	-0.027	-0.721**	-0.111	0.132	-0.111	1.00
TSS (mg/L)	-0.866**	0.121	0.122	0.183	-0.677**	0.177

*Correlation is significant at the one-tailed p-0.05 level, **Significant correlation exists at the 0.01 level (1 tailed), DO: Dissolved oxygen, EC: Electrical conductivity, TURB: Turbidity and TDS: Total dissolved oxygen

Table 3 reveals correlation coefficients between physicochemical parameters. Temperature showed a negative correlation with pH (-0.065), electric conductivity E.C (-0.247), total solid dissolved TD (-0.207) and complete suspended solid TSS (-0.866)**. The pH exhibited a positive correlation with dissolved oxygen concentration DO (0.455) and total suspended solid TSS (0.121), show a negative correlation with E.C (-0.123), turbidity (-0.030) and TDS (-0.721). Dissolved oxygen concentration showed negative correlations with E.C (-0.233), turbidity (-0.121) and TDS (-0.111). Electric conductivity had a negative interaction with turbidity (-0.123) and a positive interaction with TDS (0.111) and TSS (0.122). A strong negative interaction was observed between turbidity and TSS (-0.677)** and a negative correlation with TDS (-0.111). Finally, a positive correlation was observed between TDS and TSS (0.177).

Microplastic abundance (%): Table 4 illustrates the types of microplastic constituents identified in various sampling points. The study identified a range of microplastic in different body parts of *Clarias gariepinus*, including but not limited to acrylonitrile butadiene, polyamides, polyvinyl chloride (PVC), polyether ketone, polypropylene (PP), polyethylene (PE), polycarbonate (PC), s polystyrene (PS), acrylonitrile butadiene styrene (ABS) and others.

Haematological indices: Table 5 presents the results of haematological indices of *Clarias gariepinus* sampled from Jama'are River during the period from April to July, 2023. The hematocrit value (PCV) exhibited a significant range between 36.11±0.7% in July and 27.28±0.6% in April ($p<0.05$), indicating a notable difference across the months. The highest haemoglobin content was recorded in April (12.23±0.1 g/dL), May (12.11±0.7 g/dL) and July (12.52±0.7 g/dL), with the lowest observed in June (11.22±1.3 g/dL), however, the monthly means had a $P<0.05$ significance level.

The amount of white blood cells (WBC) present showed a monthly mean value range of 77.56±14 10^9/mL in April to 81.3±2.3 10^9/mL in July, indicating statistical differences between the months. Red blood cell (RBC) monthly mean values varied significantly between 2.12±0.1 10^12/mL in

Table 4: Micro plastics Identified from the Body Parts of (*Clarias gariepinus)* across the station of Jama'are River Bauchi State, Nigeria

Sampling station	Fish collected	Microplastics identified	Part of fish collected	Percentage of microplastics (%)
JAMA'ARE	A	Acrylonitrile butadiene	Liver	64.9747
Under bridge		Poly amides		42.9
	B	Acrylonitrile butadiene	Gills	64.9747
	C	Acrylonitrile butadiene	Gills	43.169
		Poly amides		
	D	Acrylonitrile butadiene	Kidney	64.9747
		Poly amides		43.169
	E	Acrylonitrile butadiene	Kidney	89.38133
		Poly amides		66.05832
	F	Poly ether ketone	Liver	89.38133
		Poly amide		66.05832
		Poly butalene succinate		89.38133
		Adipate		95.5666
		Acrylonitrile butadiene		44.33
		5poly (3- hydroxybtyrate-co-3-hydroxyvalerate)	Gills	64.63122
	G	Acrylonitrile butadiene		
	H	Acrylonitrile butadiene	Kidney	64.52769
		Poly amide		64.527
	I	Acrylonitrile butadiene		
		Poly amide	Liver	64.44924
				44.31
	J	Acrylonitrile butadiene	Gills	64.52769
GONGO	A	Polyethylene (PE)	Gills	30.000
		Polyvinyl chloride (PVC)		29.000
		Poly carbonate (PC)		44.31
	B	Poly carbonate (PC)	Kidney	44.31
		Polypropylene (PP)		64.316
		Polystyrene (PS)		69.001
	C	Poly ether ketone	Liver	89.3813
		Poly amide (PA)		66.05832
		Poly butylene-succinate adopate (PBSA)		89.38133
	D	Acrylonitrile butadiene (AB)	Gills	64.63122
		Polyethylene (PE)		32.000
		Poly carbonate (PC)		44.310
	E	Poly propylene (PP)	Gills	64.316
		Poly amide(PA)		66.05832
	F	Acrylonitrile butadiene (AB)	Liver	64.63123
		Polyvinyl chloride (PC)		29.001
		Polyvinyl chloride (PC)	Liver	33.010
	G	Poly propylene (PP)		64.316
		Poly Amide(PA)	Kidney	66.05832
		Acrylonitrile butadiene (AB)		64.63123
	H	Polyvinyl chloride (PC)	Kidney	33.01
		Poly amide (PA)		66.05832
	I	Poly carbonate (PC)	Kidney	44.310
		Poly propylene (PP)		64.310
	J			
YOLA	A	Poly propylene (PP)	Kidney	64.310
		Poly carbonate (PC)		44.310
	B	Polyethylene (PE)	Gills	33.000
		Polyvinyl chloride (PC)		29.000
	C	Acrylonitrile butadiene (AB)	Gills	64.52769
		Poly ether ketone		89.3813
	D	Poly amide (PA)	Liver	64.527
		Acrylonitrile butadiene styrene (ABS)		95.3813
	E	Poly styrene (PS)	Liver	69.000
		Poly butylene-succinate-adopate		89.013
	F	Poly amide (PA)	Liver	66.05832

Table 4: Continued

Sampling station	Fish collected	Microplastics identified	Part of fish collected	Percentage of microplastics (%)
		Acrylonitrile butadiene styrene (ABS)		95.1849
	G	Poly ether ketone	Kidney	89.38133
		Poly propylene (PP)		64.316
	H	Polyethylene (PE)	Kidney	32.0001
		Polyvinyl chloride (PC)		29.001
	I	Poly amide (PA)	Liver	66.05832
		Poly carbonate (PC)		44.301
	J	Acrylonitrile butadiene styrene (ABS)		95.1849
		Poly ether ketone		89.38133

Table 5: Mean±Standard Deviation of the haematological parameters of African catfish (*Clarias gariepinus*) in the Jama'are River during sampling sites in Bauchi State

Month	HCT (%)	Hb (g/dL)	WBC (10^9/mL)	RBC (10^{12}/mL)	MCV (f/L)	MCH (pg)	MCHC
April	36.11±0.7	12.23±0.1	77.56±14	2.51±0.1	140.34±2.0	49.77±6.3	39.91±2.1
May	36.41±1.5	12.11±0.7	79.05±7.1	3.26±0.1	130.23±5.3	47.79±3.8	38.73±2.8
June	26.14±1.5	11.22±1.3	80.12±3.7	2.12±0.1	129.11±3.8	46.61±3.0	36.32±1.7
July	27.28±0.6	12.52±0.7	81.3±2.3	3.27±0.1	126.12±6.1	43.50±6.1	34.61±1.8

HCT: Haematocrit value, Hb: Haemoglobin, WBC: White blood cell, RBC: Red blood cell, MCV: Mean corpuscular volume, MCH: Mean corpuscular haemoglobin and MCHC: Mean corpuscular haemoglobin concentration

June and 2.51±0.1 10^12/mL in April across the study period. The mean corpuscular volume (MCV) exhibited a significant variation in monthly mean values ranging between 126.12±6.1 f/L and 140.34±2.0 f/L in April ($p<0.05$).

Monthly mean values of mean corpuscular haemoglobin (MCH) ranged between 43.50±6.1 in July (the lowest) and 49.77±6.3 in April (the highest). The highest monthly mean value of mean corpuscular haemoglobin concentration (MCHC) was recorded in April, while the lowest was observed in July.

DISCUSSION

Water temperatures recorded during the study period range between (28.23±0.7°C) and (33.43±0.4°C) which indicates a slight difference among the three sampling points and the values fell within the allowed range of WHO. This also agreed with the finding of Ogbe *et al.*[1] in their study of the physicochemical properties of lower river Niger at the stations of Kpata, Adankolo and Gadomo in Kogi State Nigeria. Electric conductivity is an indirect measurement of the saltiness of the water body. The mean value of electric conductivity recorded varied between 152.4±5.4 and 158.3±6.1 µS/cm, these figures are higher than 99.0 µS/cm reported by Onozeyi[12] in River Ogun. The 74.6-510 µS/cm in River Sokoto[13], 113-287 µS/cm reported by Okomoda *et al.*[14] in the flooded areas of lower River Niger in Lokoja. Lower value was observed of 6.0-17.0 µS/cm reported by Sikoki and Anyanwu[15]. The values were as well below the WHO permissible guideline of 200 µS/cm. An increase in temperature and DO are associated with an increase in the growth of *Clarias gariepinus*[16].

Dissolved oxygen concentration was recorded lies between 4.978±0.2 and 5.365±0.4 mg/L. The values were within the permissible limit of FOA and WHO 6 mg/L, these values were lower than the values reported by Ogbe *et al.*[1] in Adankolo and Gadumo stations are 6.34, 6.72 and 7.36 mg/L. The pH mean value recorded ranged between 6.997±0.1 and 6.633±0.3. The value was within WHO's acceptable limit of 6.5-6.9 and NESREA 6.5-8.5. This agreed with the finding of a mean pH of 6.6 reported by Chinyere *et al.*[17] in their study of the Uturu section of Oku River. The turbidity mean value recorded varied between 305.5±4.9 NTU and 314.5±3.2 NTU. The turbidity obtained from all the stations was far higher than the 5 NTU (Nephelometric turbidity unit) value recommended by WHO[18], indicating that the water samples from these sampling stations were more turbid than needed.

This might be attributable to the open structure and nature of the water sources that make it simple for pollutants that might interfere with light transmission to flow into them. The findings of El- Banerjee *et al.*[19] differed from this finding by reporting that the turbidity mean value in surface water containing species of *Clarias gariepinus* and *Oreochromis niloticus* is a bit greater than the WHO recommended limits. Anthropogenic activities can cause water to become more turbid, which can alter fish behaviour by impairing their ability to see, damaging their respiratory systems, slowing down their growth, or stopping them from reproducing[20].

The mean value of the total dissolved solid recorded ranged between 397.3±4.2 mg/L and 319.3±23 mg/L. The TDS gives water an alkaline quality which in turn causes several clinical problems for aquatic organisms[21]. The total dissolved solids (TDS) mean value obtained from the study area was above the WHO minimum recommended limit of 300 mgL. The total suspended solid recorded was 291.1±1.8 and 287.9±7.7mg/L. The TSS's mean values fall below the WHO recommended limits of 450-2000 mg/L[18].

Microplastics pollution has emerged as an ecological disaster as they are increasingly being detected in aquatic environments which serve as routes and sinks for these intractable pollutants[22]. In this present study, the following microplastics were detected in different body parts of *Clarias gariepinus*. Acrylonitrile Butadiene poly amides, Poly ether ketone, Polycarbonate (PC), Polyethylene (P E), Polyvinyl chloride (PVC), Polycarbonate (PC), Polyvinyl Chloride (PVC) and Acrylonitrile Butadiene (AB). These findings agreed with the finding of Attah *et al.*[22] in their study 'Assessment of microplastics pollution in some selected water bodies in Rivers State, Nigeria' microplastics were detected in all water, sediment and fish (*P. elongatus*) samples from Bonny River and New Calabar River, of which Polyethylene terephthalate (PET), Polypropylene (PP), Polystyrene (PS) and Polyethylene (PE), Polyester (PES) and PVC, or polyvinyl chloride were identified in all the samples. The PE, PET, PS and PP are commonly reported microplastics present in sediment samples globally.

CONCLUSION AND RECOMMENDATIONS

The research findings on microplastic pollutants in Jama'are River present a concerning picture of water quality and its potential impacts on *Clarias gariepinus*, an important fish species in the region. The water quality analysis revealed variations in key physicochemical parameters, including temperature, electric conductivity, total dissolved solids, total suspended solids, pH, turbidity and dissolved oxygen. While most parameters were within permissible limits, elevated turbidity levels were observed, exceeding recommended standards. This indicates a potential degradation of water quality, emphasizing the need for targeted interventions to reduce turbidity. Microplastic contaminants were identified in both water and fish samples. The presence of diverse microplastic types, including acrylonitrile butadiene, polyamides, poly butylene succinate adipate, polyethylene, polyvinyl chloride and others, underscores the extent of plastic pollution in the Jama'are River. This poses a threat to aquatic life and raises concerns about potential repercussions for human health through the consumption of contaminated fish. Hematological indices provided insights into the physiological responses of *Clarias gariepinus* to microplastic exposure. Changes in parameters such as hemoglobin content, hematocrit and red blood cell count levels suggest physiological stress in fish exposed to microplastics. These findings underscore the urgent need for environmental management strategies to address microplastic pollution in the Jama'are River. The study's comprehensive approach, encompassing ecological and hematological assessments, contributes valuable data for informed decision-making. Mitigating plastic pollution requires collaborative efforts, involving local communities, policymakers and environmental organizations to ensure the conservation of aquatic ecosystems and maintain public health.

SIGNIFICANCE STATEMENT

The detection of microplastic pollutants in the Jama'are River, Bauchi State and their impact on the wellbeing of *Clarias gariepinus* (African catfish) holds critical significance for environmental conservation and public health. This study sheds light on the pervasive presence of microplastics in freshwater ecosystems and highlights the potential threat posed to aquatic organisms, particularly economically important species like Clarias gariepinus. Understanding the interactions between microplastic pollution and the health of aquatic species not only informs sustainable resource management practices but also underscores the urgent need for effective mitigation strategies to safeguard both ecosystem integrity and human well-being.

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