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Microplastics Pollution Assessment in the Surface Water and Sediment of River Niger, Lokoja, Nigeria

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ABSTRACT: Pollution from microplastics (MP) is now considered to be a major global environmental concern, and Nigeria is not an exception. In Nigeria, the River Niger is an essential resource that is used for agriculture, transportation, and fishing. The purpose of this study was to evaluate MPs contamination in Nigeria's Niger River, Lokoja, Kogi State: The sampling was carried out in 2024 between March and June. Following digestion with 10% KOH, density flotation with NaCl, and filtration, the water and sediment were examined. Fourier Transform Infrared (FTIR) spectroscopy was used to identify the MPs, and Openspecy was used to quantify them. One-way ANOVA was used to assess significance in the statistical analysis, which was carried out using SPSS. Fourteen MPs polymers were found. During the four months under study, the most common substances found in water samples were cellulose acetate (CA) and polyvinyl chloride (PVC), with mean values of 5.67 ± 1.56 and 3.92 ± 1.16 (MP/10 mL), respectively. The two substances with the highest mean levels in the sediment samples were polystyrene (PS) at 4.58 ± 1.42 (MP/10 g) and CA at 6.34 ± 1.15 (MP/10 g). According to these findings, the aquatic life and communities that depend on the water and sediment surrounding the River Niger in Lokoja for survival are at serious risk, posing long-term threats to the ecosystem.

Keywords: Microplastics; Water, Sediment, River Niger

Introduction

Microplastics (MPs) are plastics fragments broken down into smaller pieces, and measure less than 5 mm. Particles less than 100 nm are referred to as "nanoplastics" (NP) (Usman *et al.*, 2023). Microplastics pollution has become a crucial environmental issue worldwide, and Nigeria is not left out of this problem (Bashir *et al.*, 2020). According to Mahu *et al.* (2023), inland rivers and their inhabiting organisms in Nigeria should be examined for macro and micro plastic pollution for a better understanding of the distribution and prevalence in Nigeria's water bodies. The problem of MPs in Nigeria's water has given rise to other multitude of other challenges with potential consequences for both the environment and human health (Dada *et al.*, 2023).

According to Li *et al.* (2023), environmental matrices, including sediments and water samples, offer representative samples of the ecosystem and aid in precisely determining the existence, distribution, and abundance of MPs in various aquatic settings. Many lower invertebrate and vertebrate species are at risk from the food chain's exposure pathway to microplastics because they may unintentionally consume these

microscopic plastics found in sand and water. According to Usman *et al.* (2023), there is a significant risk of entanglement, harm, and ingestion to biodiversity. MPs eventually bio-magnify throughout the food chain once the organisms serve as a reservoir for them (Munyaneza *et al.*, 2022). When MPs-contaminated food is devoured by fish and other edible aquatic species in the food chain, the contaminants are eventually passed on to humans, endangering their health. The Krueng Aceh River in Banda Aceh City, Indonesia, was the subject of a study by Maulana *et al.* (2023). Two fish species that are typically caught for food—mullet (*Mugil cephalus*) and bagok catfish (*Hexanematichthys sago*)—were caught and their MP counts were evaluated. The bagok catfish samples from the river estuary and residential areas showed seven to eight MPs per fish, while agricultural areas had lower MPs counts. Fish captured in the river estuary had the highest concentration of MP particles (16 particles/fish on average) among mullet, followed by the sample from residential areas (10 particles/fish on average). In the agricultural region, testing showed five particles per fish. Polyethylene and polypropylene were the most common fiber MPs in their sample, according to the peak values. Ogbomida *et al.* (2023) evaluated MPs in water, sediment, and fish species (*Clarias gariepinus* and *Oreochromis niloticus*) from the Ikpoba River in Edo, South Eastern Nigeria. They found that the surface water had high levels of polypropylene (PP), polystyrene (PS), and polyethylene (PE). In sediment samples, polyvinyl chloride (PVC) and polyethylene terephthalate (PET) was common, whereas in fish, fiber, film, and foam—all of which were present in all sample types—the concentration of MPs was higher in *C. gariepinus* than in *O. niloticus* fish. The size of MPs in water, sediment, and fish samples varied from 50 µm to 5 mm, 100 µm to 5 mm, and 124 µm to 1.53 mm, respectively, with the highest concentration linked to primary consumers.

Information on MPs in sediments and river water from Nigerian inland rivers is scarce. Previous research on microplastics in fish, rivers, and sediments has mostly focused on coastal waters along Nigeria's external borders (Dada *et al.*, 2023, and Mahu *et al.*, 2023). In Nigeria, fish, sediment, lake water, and the marine environment were the subjects of the second study on microplastics in water and sediment. Only a few water bodies in southern Nigeria were the subject of the scant research on inland waters. Other than the study on the river Niger at Idah Local Government in Kogi State on water and sediment, there are no studies on MPs in inland water from northern Nigeria or on MPs pollution in the River Niger Lokoja (Usman *et al.*, 2023).

Because of inadequate management techniques, plastic garbage is being released into Nigeria's aquatic systems. The amount of plastics in the inland freshwater system has increased to an estimated 283,293.47 hectares, of which 70% has degraded as a result of pollution, with plastic production and consumption reaching 436 kilotons and 1,090 kilotons in 2018 respectively (Amana *et al.*, 2025). Hence this study evaluated the trajectory of MPs contamination in the River Niger's surface waters and sediments in Lokoja, Nigeria.

Materials and methods

Sample site: Microplastics in water and sediment from the River Niger Lokoja were evaluated at Kogi State's capital, Lokoja. The map in Figure 1 shows that it is situated in the central belt of Nigeria. Lokoja is situated on the western bank of the Niger River at latitude 7°49'N of the equator and longitude 6°44'E of the Greenwich meridian. The dry season starts around October or November, while the annual rainfall averages about 1150 mm. Rainfall starts in March and lasts until September. Temperatures in Lokoja often range between 30 and 37 degrees Celsius. The high sensible temperature, which is encouraged by high humidity, makes the weather consistently moist. Flash floods are a feature of the Niger and its principal tributaries, occurring on top of permanent flow. In July, the Niger floods at Lokoja start, peak in October, and end in December. Alternatively, flash flow only occurs during and shortly after storms that produce runoff, or it is overlaid on rainy season flow in smaller streams. It is projected that Lokoja has a population of around 886,000. Since the Niger River runs through the region, Lokoja is well-known for its various agricultural pursuits, especially fishing and rice cultivation, as well as its industrial operations, which include mining, the production of plastic, and a number of other manufacturing businesses (Amana *et al.*, 2025). The sampling locations are shown in Figure 1.

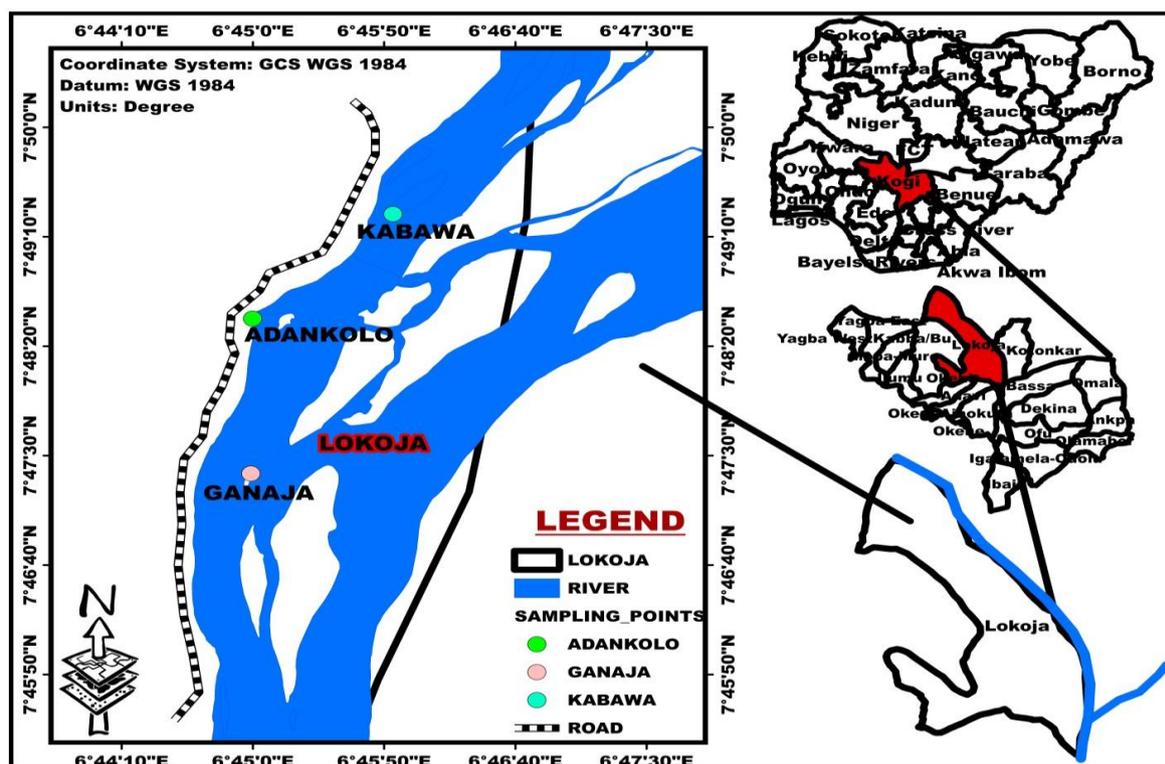


Figure 1: Map of sampling locations, Lokoja (Amana *et al.*, 2025)

Sample collection

Surface water sample collection: Twenty liters of surface water were collected in three (3) replicates at five-minute intervals and labeled as W1, W2, and W3 using a water collector that had been cleaned and deionized with 70% ethanol. The sample was collected for four months at a depth of 0.5 to 1 m. Filtered and sub-sampled into 400 mL glass bottles, each of the three replicates of the 20 liters of collected water was kept at 4 °C until laboratory analysis (Thompson *et al.*, 2022).

Sediment sample collection: Three (3) replicates of the sediment samples were taken from the riverbed at the sampling locations. Using a Van Veen grabber, 2 kg of wet weight sediment was collected from the sampling point, stored in glass jars, and then transported to the laboratory where they were oven dried at 40 °C until laboratory analysis, as advised by Amana *et al.* (2025). The sediment sample was represented as S series, and each replicate is labeled as S1, S2, and S3.

Digestion of water sample and extraction of microplastics: Surface water was prepared for MP analysis using the procedure described by Di and Wang (2018) and Wang *et al.* (2017). Following a thorough shake of each water sample kept in a glass bottle that had been previously cleaned, replicates of 10 mL sub-samples were taken. After that, 10% potassium hydroxide (KOH) was used to digest each 10 mL subsample for 24 hours at 60 °C. Sand and minerals were removed by density separation using a sodium chloride solution (1.5 g/cm³). The supernatants were gathered in the density separator and filtered using a vacuum pump through a GF/C filter with a pore size of 0.45 µm (Membrane Solutions LLC., Kent, WA, USA). The residues were then dried at 60 °C for 24 h prior to FTIR analysis.

Digestion of sediment and extraction of microplastics: As described by Ogbomida *et al.* (2023), the sediment samples were prepared for MP observation. They were homogenized using a wooden pestle and mortar after being oven-dried, and roughly 10 g of each sample were weighed into a glass beaker and combined with a 1.5 g/cm³ NaCl solution that included a drop of olive oil to allow microplastics to collect rather than adhere to the glass walls. After agitating each mixture for 10 minutes and letting it sit for 30 minutes, the supernatant was gradually transferred into glass tubes and digested for 24 hours at 60 °C using 10% potassium hydroxide (KOH) before to FTIR measurement.

Observation and identification using Fourier Transform Infrared Spectroscopy (FTIR): Fourier Transform Infrared Spectroscopy (FTIR), was employed to make additional identifications. The FTIR spectra were between 50 and 3500 cm⁻¹, and the incident laser was set to 532 nm. The MP was detected and measured by analyzing the sample's FTIR pictures. For this analysis, materials other than the topic under investigation had to be removed. The process was tailored to the various kinds of samples (sediment and water). The concentration

was represented as a number of particles per gram and the abundance in each sample—water and sediment—was ascertained.

Identification and quantification of microplastics using OpenSpecy: Use of the OpenSpecy application was used to identify and quantify the MPs. Microplastic was defined as having an $R^2 \geq 0.05$ when the FTIR image was submitted into the OpenSpecy program.

Statistical analysis: The acquired data was shown as tables, figures, and graphs and stated as means and standard deviations. Prior to analysis, all data underwent a preliminary homogeneity and normality test. One-way analysis of variance was used to determine the variance in the means. A Duncan multiple range post hoc test was applied to the significant means. The threshold for statistical significance was set at $p < 0.05$. Version 20.0 of the Statistical Package for Social Sciences (SPSS) will be used for all statistical analyses.

Results

Monthly variation of microplastics in water (MP/10 ML) from River Niger, Lokoja, Kogi State: The monthly variation of microplastics in the water from River Niger, Lokoja is shown in Table 1. There was no significant difference ($p > 0.05$) in the microplastic concentration across the four months studied but polyvinyl chlorides, PS, PVA increased from March to June, while PC increased from March to May. Cellulose acetate decreased from March to May.

Table 1: Monthly variation of microplastics in water (MP/10 ML) from River Niger, Lokoja, Kogi State

Microplastics (MP/10 ML)	March	April	May	June
PVC	4.00±1.00 ^a	3.33±1.15 ^a	4.00±1.00 ^a	4.33±1.53 ^a
CA	6.00±1.00 ^a	6.00±1.00 ^a	5.00±1.73 ^a	5.67±2.52 ^a
PP	ND	0.67±1.15 ^a	1.00±1.00 ^a	0.67±0.58 ^a
PA	2.33±0.58 ^a	2.33±0.58 ^a	1.33±0.58 ^a	1.33±0.58 ^a
LDPE	3.33±1.53 ^a	2.33±1.53 ^a	1.33±0.58 ^a	1.33±0.58 ^a
PE	1.00±1.00 ^a	1.67±1.53 ^a	1.33±1.53 ^a	1.00±1.00 ^a
PS	3.00±1.00 ^a	2.67±1.15 ^a	3.67±2.08 ^a	4.33±2.08 ^a
PD	1.00±1.00 ^a	1.33±0.58 ^a	1.67±1.53 ^a	1.67±1.53 ^a
OP	1.00±1.00 ^a	2.33±1.15 ^a	2.33±1.53 ^a	1.67±2.08 ^a
PET	0.67±1.15 ^a	1.67±2.08 ^a	1.33±1.53 ^a	0.33±0.58 ^a
PVA	0.33±0.58 ^a	1.33±1.53 ^a	1.67±1.15 ^a	2.33±1.15 ^a
NL	1.33±1.15 ^a	2.33±0.58 ^a	1.00±1.00 ^a	0.67±1.15 ^a
PC	0.67±1.15 ^a	2.33±1.15 ^a	2.67±0.58 ^a	1.33±1.53 ^a
PU	1.67±0.58 ^a	1.33±1.53 ^a	1.00±1.00 ^a	2.00±1.00 ^a

Value as mean ±SD. Different superscripts in the same row for months and column for mean indicate significant difference at $p < 0.05$. **Polymers abbreviations:** Polyethylene (PE), Polystyrene (PS), Polypropylene (PP), Low-Density Polyethylene (LDPE), Polyvinyl Chloride (PVC), Cellulose Acetate (CA), Polyethylene Terephthalate (PET), Polyamides (PA), Polydienes (PD) and Other Plastics (OP), Polyvinyl Alcohol (PVA), Nylon (NL), Polycarbonate (PC), and Polyurethane (PU); ND = Not detected

Monthly variation of microplastics in sediment (MP/10 g) from River Niger Lokoja, Kogi State: The monthly variation of microplastics in the sediment from River Niger, Lokoja is shown in Table 2. There was no significant difference ($p > 0.05$) in the microplastic concentration during the four months of the study.

Table 2: Monthly variation of microplastics in sediment (MP/10 g) from River Niger Lokoja, Kogi State

Microplastics (MP/10 g)	March	April	May	June
PVC	1.67±0.58 ^a	3.00±2.00 ^a	3.00±2.00 ^a	3.00±1.00 ^a
CA	7.33±0.58 ^a	5.67±2.08 ^a	5.67±1.53 ^a	6.67±0.58 ^a
PP	0.67±1.15 ^a	1.33±1.15 ^a	1.33±1.15 ^a	0.67±0.58 ^a
PA	1.67±0.58 ^a	1.33±1.15 ^a	1.33±0.58 ^a	2.33±1.53 ^a
LDPE	1.67±1.15 ^a	1.33±0.58 ^a	1.67±1.15 ^a	2.00±1.00 ^a
PE	1.00±1.73 ^a	1.00±1.73 ^a	1.00±1.00 ^a	1.67±1.15 ^a
PS	4.67±2.31 ^a	4.00±1.73 ^a	4.33±1.15 ^a	5.33±0.58 ^a
PD	0.67±0.58 ^a	1.33±1.53 ^a	1.33±0.58 ^a	0.67±1.15 ^a
OP	1.00±1.00 ^a	0.67±0.58 ^a	1.00±1.00 ^a	ND
PET	1.00±1.73 ^a	1.00±1.73 ^a	0.33±0.58 ^a	1.00±1.00 ^a
PVA	1.33±2.31 ^a	2.33±3.21 ^a	2.00±1.00 ^a	1.33±1.53 ^a
NL	1.33±1.15 ^a	1.67±1.53 ^a	1.67±1.53 ^a	1.00±1.00 ^a
PC	1.00±1.00 ^a	0.67±1.15 ^a	1.67±1.53 ^a	2.00±1.00 ^a
PU	0.00±0.00 ^a	0.33±0.58 ^a	1.33±1.53 ^a	1.00±1.73 ^a

Value as mean ±SD. Different superscripts in the same row for months and column for mean indicate significant difference at $p < 0.05$.

Microplastics variation in the water (MP/10g) from River Niger, Lokoja, Kogi State: The variation in microplastics composition and concentration in River Niger water is shown in Figure 2. There was no significant difference among most of the microplastics encountered except the CA was significantly the highest ($p < 0.05$), followed by PVC and PS.

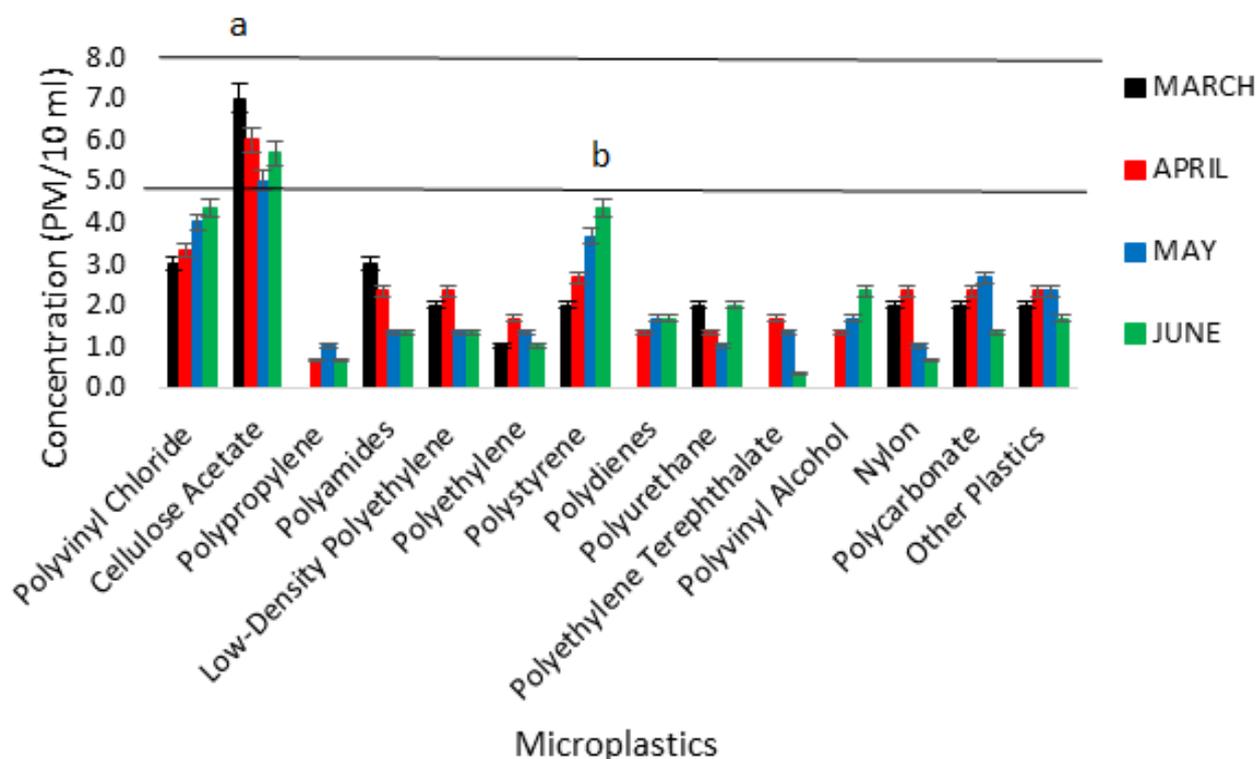


Figure 2: Microplastics variation in the water (MP/10 mL)

Microplastics variation in the sediment (MP/10g) from River Niger Lokoja, Kogi State: The variation in MPs composition and concentration in River Niger water is shown in Figure 3. Cellulose acetate was significantly highest ($p < 0.05$) followed by PS and PVC.

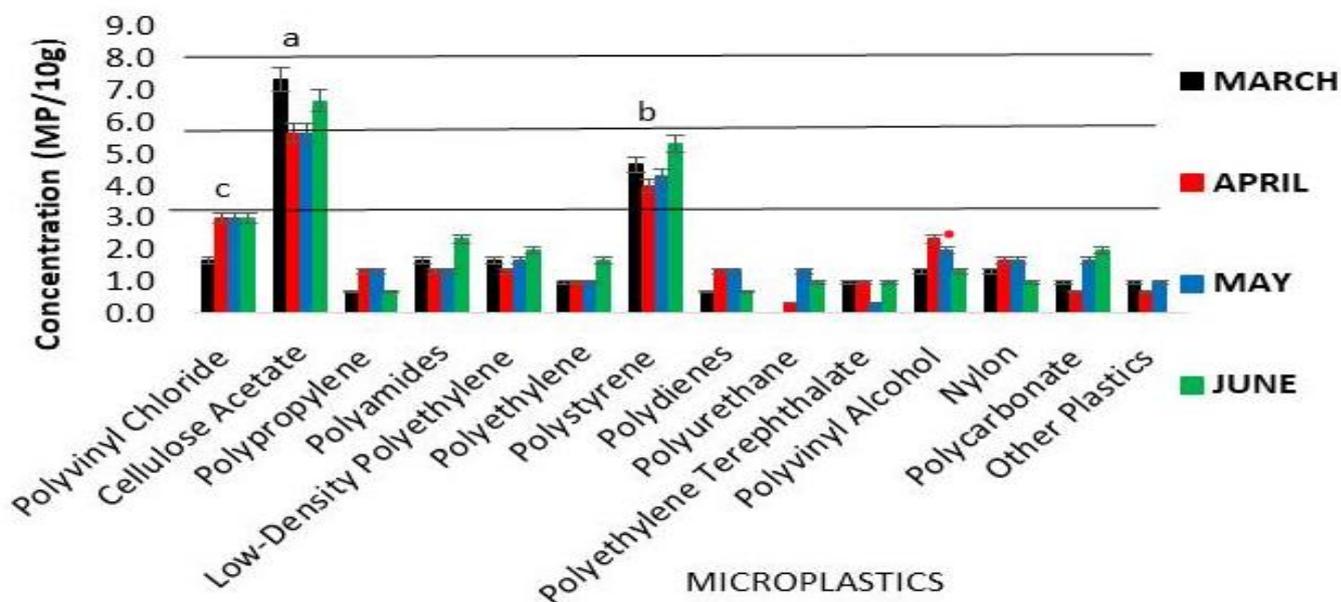


Figure 3: Microplastics variation in the sediment (MP/10 g)

Differences in microplastics concentration between the water and sediment from River Niger Lokoja, Kogi State: The comparison in MPs concentration between the water and sediment from River Niger, Lokoja is shown in Figure 4. The PVC and OP were significant ($p < 0.05$) higher in water as compared to the sediment. There was no significant difference ($p > 0.05$) in the remaining MPS but CA, PP, PS, PVA and nylon were higher in sediment.

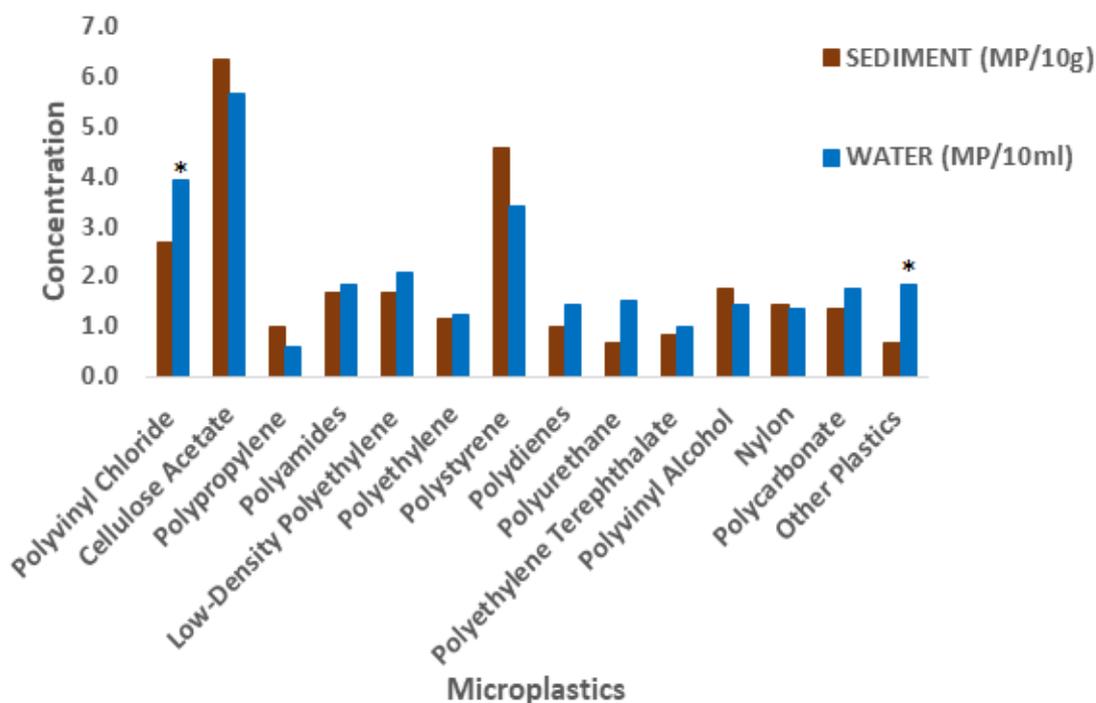


Figure 4: Differences in microplastics concentration between the water and sediment from River Niger, Lokoja, Kogi State.

Discussion

In Lokoja, Kogi State, microplastic pollution of the River Niger is a serious environmental problem. The results of this investigation show that several kinds of MPs were present in sediment and water samples taken from the River Niger during a four-month period (March to June). There were 14 distinct microplastics identified in this study: PE, PS, PP, LDPE, PVC, CA, PET, PA, PD and OP, PVA, NL, PC, and PU. The fourteen (14) MPs identified in this study was more than the eight (8) MPs found in the study on the assessment of MPs in water, sediments, and fish that was carried out in Edo State's Ikpoba River (Ogbomida *et al.*, 2023).

According to Ndibe *et al.* (2023), MPs can originate from a variety of sources, including synthetic fibers, microbeads, and plastic waste. The findings show some variations in the abundance of some microplastics across the months. For instance, in sediment and water samples, the levels of CA, PVC, and PS microplastics increased from March to June. This trend is consistent with findings by Oni *et al.* (2021), who reported an increase in the prevalence of microplastics in freshwater environments. Similarly, water samples showed a notable rise in CA, PVC, and PS microplastics between March and June. Because of their lower water density, these polymers are more common in surface waters (Ogbomida *et al.*, 2023).

Lighter materials such as PVC and C also float on the surface due to their buoyancy, making them susceptible to ingestion by aquatic organisms throughout various food chains. This upward trend in C, PVC, and PS MP also corresponds with the findings done by Munira *et al.* (2021), who reported elevated levels of MP contamination in a large, isolated mountain lake. The analysis also revealed that CA MPs were the most abundant type of MP found in both sediment and water samples across the four months examined. According to Sarijan *et al.* (2021), CA MPs can stem from various origins, including plastic bags, packaging materials, and synthetic fibers. Furthermore, PVC, PS and PET MPs were consistently detected throughout all months, albeit with varying abundance levels. Notably, OP MPs in sediments and water decreased during the course of the months under observation; this decrease is consistent with Tongo *et al.* (2022) study, which found a decrease in the quantity of microplastics in marine settings. Because microplastics can enter the food chain and jeopardize both aquatic life and human consumers, their presence in the River Niger Lokoja poses serious hazards to environmental health.

MPs may also act as transporters of contaminants including pesticides and heavy metals, which can have a negative impact on aquatic life (Oni *et al.*, 2021). In the end, the information in this study emphasizes how important it is to continue monitoring and controlling MP contamination in the River Niger. According to this research, MP pollution is a persistent problem with varying abundance and composition throughout the year. To clarify the origins, destiny, and effects of MPs in the River Niger and to develop practical solutions for reducing this pollution problem, more research is necessary.

Conclusion

The evaluation of MP in sediments and water from the River Niger, Lokoja, showed that MPs contamination was present in both samples. The contamination of the River Niger in Lokoja, Kogi State, by MPs is a serious environmental problem that has a big impact on food security and ecological health. Significant contamination in sediments and water samples from the River Niger Lokoja, as well as a lack of change in MP quantity and distribution throughout months, suggest that species exposed to MPs directly and indirectly are at risk for bioaccumulation. According to these findings, the ecosystem of the River Niger is at long-term risk from ongoing plastic pollution, endangering aquatic species as well as human populations that rely on these resources for livelihood and survival.

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