

Chemical Analysis of Microplastics in Sachet Water Samples in Katsina Metropolis: Improving Health and Safety Standards

Nuhu Usman¹ & Usman Ibrahim², ^{1*}Auwalu Jalo

¹ Biology Department, School of Secondary Education Sciences, Federal College of Education Katsina, Nigeria

² Integrated Science Department, School of Secondary Education Sciences, Federal College of Education Katsina, Nigeria

*Corresponding Author

DOI: <https://doi.org/10.51584/IJRIAS.2025.100900092>

Received: 20 September 2025; Accepted: 27 September 2025; Published: 25 October 2025

ABSTRACT

The assessment of microplastics (MPs) in sachet water samples sold in Katsina metropolis was investigated. The absorption peak of the infrared spectroscopy (IR) obtained were 1640, 2117 and 3265 cm^{-1} for sample S_A ; 1192, 1640, 2124, 3265 cm^{-1} for S_B ; for sample S_C : 2035, 2146, 2236, 2333, 3227, 3667, 3734, 3816 cm^{-1} , S_D : 1640, 2117, 3265 cm^{-1} , sample S_E : 1640, 2124, 3265 cm^{-1} and S_F : 1640, 2117, 3265 cm^{-1} . The absorption peak of samples S_A to S_F that correspond to functional groups were C=C, C=O, O-H, except S_C that have additional C-O. Comparatively, all the studied samples were absorbed at 1640 cm^{-1} while other absorption peaks varied. The particle size of the sample ranged from 32.0 particle/0.75L sample S_A to 64.1 particle/0.75L sample S_F . The microplastic detected were generally polyethylene terephthalate (PET), polyethylene (PE), and polyvinyl chloride (PVC) and granules in shape. Microplastic pollution load index (MPPLI), micro-plastic contamination factor (MPCF), and the estimated daily intake (EDI) for both adults and children were determined. The MPCF values obtained ranged from 1.00 for sample S_A to 2.00 for sample S_C with a series of profile as $S_A < S_B < S_F < S_E < S_D < S_C$. The result for EDI for adults was slightly greater than 1 except in all the samples except sample S_C which was 2.01 depicting moderate and high daily intake in adults respectively. The EDI for children ranged from 3.84 in sample S_A to 7.69 in sample S_C . The EDI result showed that children consume more microplastics than adults. The MPPLI obtained was 1.28. Microplastic in sachet water require significant attention to reduce the menace it may cause in the health status of humans due to high daily intake studied.

Keywords: Microplastic, Sachet water, Health risk, Polymer, Contamination

INTRODUCTION

Microplastics are classified as synthetic plastic fragments that are often invisible to the naked eye but have significant environmental and health implications. Their presence in drinking water stems from various sources, including the degradation of plastic packaging, industrial emissions, and atmospheric deposition [11]. These particles can harbor toxic chemicals and microorganisms, increasing health risks when consumed [4]. Microplastic contamination has become a global environmental and health concern due to the widespread use of plastic materials in modern society. Andrady, [3] see microplastics as plastic particles smaller than 5 mm, that originate from the breakdown of larger plastic debris (secondary microplastics) or are directly manufactured as microbeads or pellets (primary microplastics). These particles find their way into terrestrial and aquatic environments through improper waste management and industrial activities, eventually infiltrating drinking water sources.

Globally, the issue of microplastic contamination in drinking water has gained significant attention due to its potential health risks. Mason *et al.*, [8] identified synthetic polymer contamination in bottled water, attributing it to mechanical stress and the leaching of microplastics from packaging materials. Terefe *et al.* [12] documented microplastic particles in table salts, emphasizing the widespread nature of plastic pollution and its infiltration into everyday consumables.

The ubiquitous presence of plastics in ecosystems has led to microplastics infiltrating water systems, food chains, and human bodies. In regions like Katsina Metropolis, where sachet water is a primary source of drinking water, concerns about microplastic contamination are exacerbated by poor waste disposal practices, substandard

packaging, and harsh storage conditions such as prolonged exposure to ultraviolet (UV) radiation Okpashi *et al.*, [10]. Despite the known risks of microplastics, ranging from their potential to act as vectors for toxic pollutants to causing cellular damage when ingested, there is limited empirical data on their prevalence in sachet water in Katsina. The absence of such data undermines efforts to establish effective regulations, improve packaging standards, and educate the public on safe water handling practices. Without intervention, the health risks associated with microplastic ingestion may become an unaddressed public health crisis in the region. While existing studies have focused on neighboring regions, this research will provide localized insights into Katsina Metropolis.

Sachet water, a widely consumed and affordable drinking water option in Katsina particularly and Nigeria at large, is not exempt from this issue. Studies suggest that sachet water is particularly prone to contamination due to poor storage conditions, leaching of packaging materials, and environmental exposure (Aliyu *et al.*, [1].

Similarly, Udoh *et al.*, [13] explore the issue of water inequality in Chiapas, Mexico, where despite abundant water resources, over half of the population, particularly in rural and indigenous areas, lacks access to basic water services. This disparity contributes to health issues, including waterborne diseases. The study calls for a transdisciplinary approach to water management that addresses social inequalities and promotes sustainable, community-based solutions to improve water access and public health.

In Africa, Bazaanah and Mothapo (2023) conducted a comprehensive analysis of water and sanitation systems in the rural communities of Lepelle Nkumpi Local Municipality, South Africa. Utilizing a mixed-methods approach, they gathered data from 657 household and institutional respondents. The study revealed that households use water for various purposes, including consumption, domestic chores, and productive activities.

In Nigeria, sachet water serves as an affordable and widely consumed alternative to other drinking water sources. However, it is not exempt from contamination risks. Aliyu *et al.*, [1] reported significant microplastic pollution in sachet water from Kaduna Metropolis, identifying poor packaging standards, environmental degradation, and improper storage conditions as major contributors. Okpashi *et al.*, [10] revealed that exposure to ultraviolet (UV) rays during storage accelerates the degradation of plastic packaging, releasing microplastics into the water. These studies highlight a systemic challenge, pointing to inadequate regulations and monitoring in the sachet water industry across Nigeria. Kusa & Joshua [7] study assessed the physicochemical and biological properties of various sachet water brands in Nigeria. Findings indicated that while most parameters met standard guidelines, certain brands exhibited elevated levels of lead and iron. Notably, all sampled brands were contaminated with *Escherichia coli*, posing significant health risks. The study underscores the necessity for stringent quality control measures and regular monitoring to ensure the safety of sachet water consumed by the public. Udoh *et al.*, [13] highlighted concerns regarding the microbial quality of packaged drinking water, including sachet water, in Nigeria. The study revealed that some products did not comply with World Health Organization (WHO) and Nigerian Industrial Standards (NIS) for drinking water quality, detecting pathogens such as *Escherichia coli* and *Salmonella* species. These findings emphasize the critical need for improved regulatory oversight and adherence to safety standards to protect public health.

However, Imam *et al.*, [5] assesses the state of drinking water quality monitoring in Northern Nigeria, revealing that only 13.11% of the population has access to clean water. Additionally, 31.14% of water sources were deemed 'fair,' necessitating further treatment to prevent health issues due to contamination levels not meeting WHO standards. The study emphasizes the urgent need for comprehensive monitoring and intervention to meet Sustainable Development Goal 6 by 2030. Adesakin *et al.*, [2] evaluates the physicochemical and microbial quality of sachet water brands in the Samaru community, Zaria. Findings indicated that while most physicochemical parameters met WHO [15] standards, there were concerns regarding microbial contamination due to prolonged storage and inadequate handling practices. The study

analyzed the different types of Microplastic in sachet water samples and assessed the risk exposure of humans to the existing Microplastic based on daily intake in both adults and children of the sampled sachet water of Katsina metropolis.

Materials and Methods

Study Area

The study was carried out in the Katsina metropolis, Katsina State. It is located in the North-Western part of Nigeria at: 12° 59'7.9116 N and 7° 37'1.7184''E.

Sample Collection

Six different brands of sachet water samples from different sampling sites were purchased in triplicate in Katsina Metropolis, Katsina State, Nigeria and labeled S_A, S_B, S_C, S_D, S_E, and S_F. They were stored in an ice chest and transported to the laboratory for analysis.

Sample Processing

The water samples were filtered using Whatman 1823-047 grade GF/D glass fibre filter paper with a pore size of 2.7 µm in order to separate the MNPs from the bulk water. The MNPs obtained from filtration were thoroughly washed with distilled water and oven-dried at 65°C. The mass of the MNPs was then determined by weighing the dried solid MNPs using an analytical balance to the nearest 0.1 mg.

MPs Characterization

Visual Sorting –This identifies MNP numbers, sizes, shapes and colours. MNPs were identified using a Nikon SMZ 745T stereomicroscope at 20–40× magnification [9].

Procedure for FTIR

Buck scientific M530 USA FTIR was used for the analysis. This instrument was equipped with a detector of deuterated triglycinesulphate and beam splitter of potassium bromide. The software of Gram S_A was used to obtain the spectra and to manipulate them. An approximately of 1.0g of samples, 0.5ml of nujol was added, they were 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 transmittance values.

Health Risk Assessment of Microplastics: Microplastics contamination factors and pollution load index

The microplastics contamination factors (MPCfs) and pollution load index (MPPLI) in the sachet water were measured as described in previous studies Verla *et al.*, [13]. The MPCf refers to the contamination of MPs in the studied drinking water (Sachet water) compared to the background values. The MPCf and MPPLI were mathematically computed using equations (1) and (2). Where MP_i is the quantity of MPs in sample i while MP_b is the minimum baseline concentration taken from the lowest MPs abundance recorded in the study of Mason *et al.*, [8] as it shares similar environments and analytical context as this study.

$$MPCF = MP_i / MP_b \dots\dots\dots(1)$$

MP_i = quantity of MPs in ith sample; MP_b = the minimum baseline concentration taken from the lowest MPs abundance recorded in the study of Verla *et al.*, (2019) which has similar environment and analytical context as this study.

$$MPPLI = (MPCF_1 \times MPCF_2 \times MPCF_3 \dots MPCF_n)^{1/n} \dots\dots\dots(2)$$

The MPCfs were 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.

Estimated Daily Intake:

An individual risk pathway as a result of human exposure to microplastic contamination of drinking water could be through oral ingestion Aliyu *et al.*, [1]. Therefore, the estimated daily intake (EDI) due to exposure to overall MPs resulting from ingestion of contaminated water is determined using equation 3.

$$EDI = MPI \times RI / Bw \dots \dots \dots (3)$$

EDI = estimated daily intake of MPs based on quantity through ingestion of the drinking water (particle/L/Bw-day)

MPI = average quantity of the MPs in drinking water (MP particle/L)

RI = ingestion rate (2.2 L/day for adults; 1.8 L/day for children)

Bw = average body weight (70 kg for adults; 15 kg for children)

RESULTS AND DISCUSSION

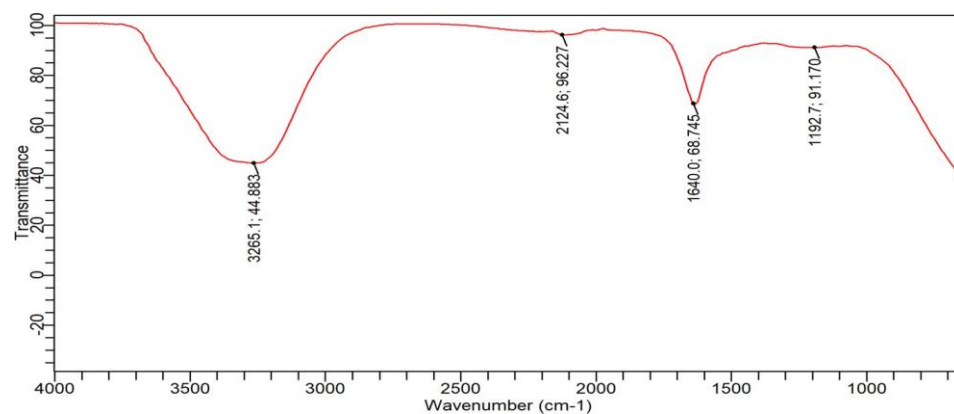
The Fourier Transform Infrared (FTIR) spectroscopy was conducted to ascertain the functional groups present in the sample under investigation [9]. The FTIR works on the principle that the molecule vibrates at specified frequencies and ranges from 200 cm^{-1} to 4000 cm^{-1} which falls within the IR portion of the electromagnetic spectrum. When an IR is incident on a sample, it absorbs radiation at a frequency similar to its molecular vibration frequency and transmits other frequencies. The infrared spectrometer detects the frequencies of absorbed vibrations, and a plot of absorbed energy against the infrared spectrum is obtained. The table below shows the results obtained from the infrared spectrum of the studied samples. From the FTIR results of the analysis carried out on the bottled water samples, the absorption peak of sample S_A were 1640, 2117 and 3265 cm^{-1} ; S_B: 1192, 1640, 2124, 3265; S_C: 2035, 2146, 2236, 2333, 3227, 3667, 3734, 3816; S_D: 1640, 2117, 3265; S_E: 1640, 2124, 3265 cm^{-1} and S_F: 1640, 2117, 3265 cm^{-1} . There were three absorption peaks each of samples S_A, S_E and S_F with corresponding functional group C=C, C=O, O-H while sample S_C which had eight absorption peaks with a functional group C-O, C=C, $C \equiv C$, O-H.

Samples	Polymer Type	Absorbance Peak (cm^{-1})	Functional Group
S _A	PE, PET	1640, 2117, 3265	C=C, C=O, O-H
S _B	PE, PET	1192, 1640, 2124, 3265	C=C, C=O, O-H
S _C	PE, PET, PVC	2035, 2146, 2236, 2333, 3227, 3667, 3734, 3816	C-O, C=C, $C \equiv C$, O-H
S _D	PE, PET	1640, 2117, 3265	C=C, C=O, O-H
S _E	PE, PET	1640, 2124, 3265	C=C, C=O, O-H
S _F	PE, PET	1640, 2117, 3265	C=C, C=O, O-H

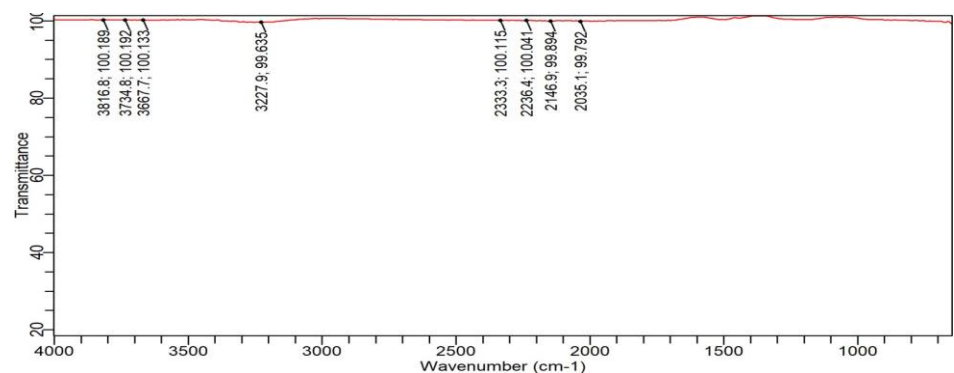
Table. 1 FTIR Results of the Samples S_A to S_F

Fig 1. FTIR Spectra in Sachet water samples of S_A , S_B , S_C , S_D , S_E and S_F .

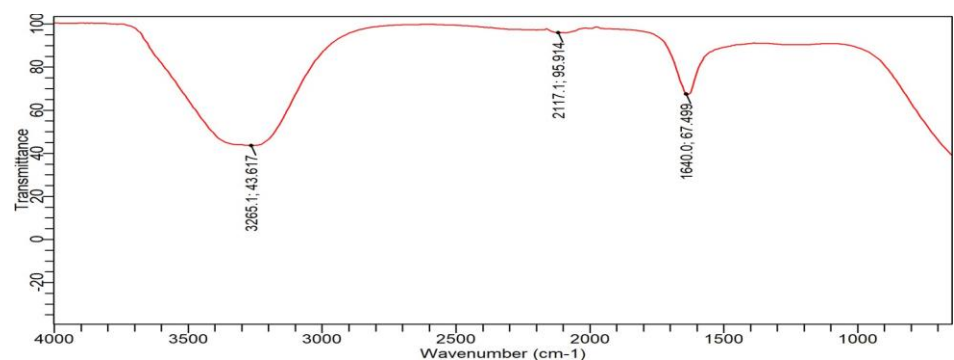
S_A



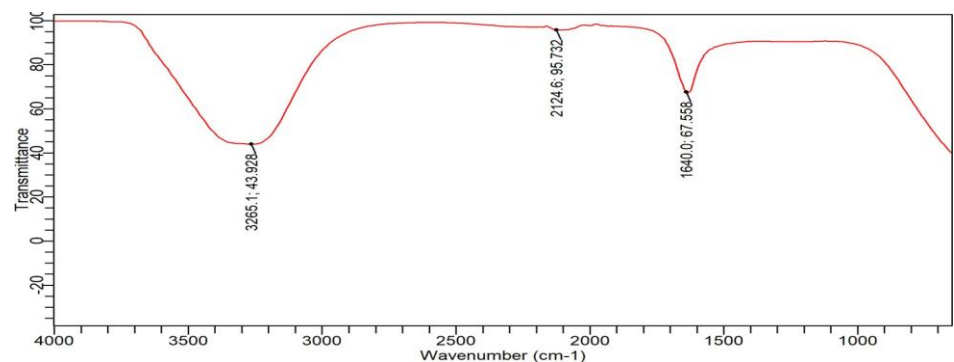
S_B



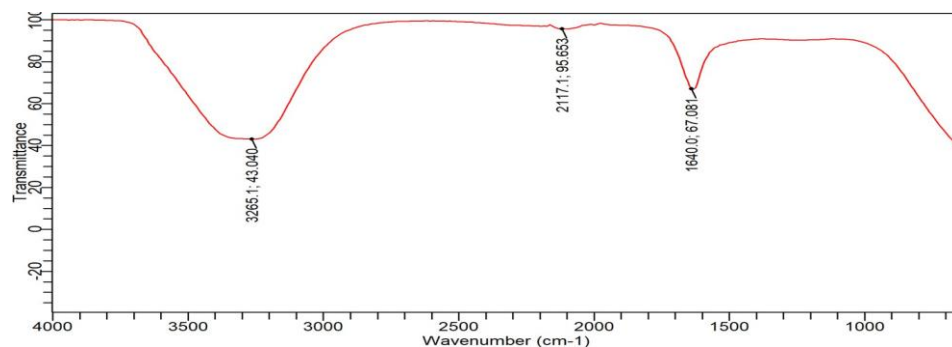
S_C



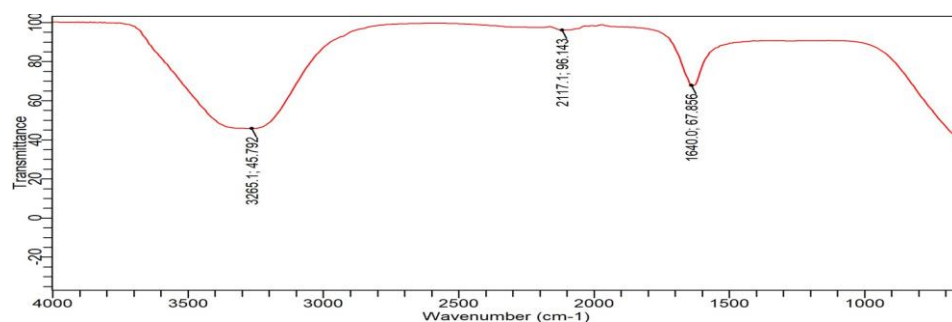
S_D



S_E



S_F



The studied samples were all absorbed at 1640 cm^{-1} while other absorption peaks varied. The IR result obtained by [11] in plastic bottled water showed strong peaks at 2916 cm^{-1} , 2846 cm^{-1} , and 2914 cm^{-1} showing C-H stretch, CH₂ bend at the peak of 1466 cm^{-1} , 1462 cm^{-1} and 1747 cm^{-1} indicating C=O, while 1241 cm^{-1} , 1035 cm^{-1} indicate C-O bond stretching. The results were applicable to what was obtained in sample S_A, S_B, S_C, S_D and S_F of this study. Kusa and Joshua in their study obtained 2920 cm^{-1} , and 2850 cm^{-1} to show C-H bond stretching vibration [10]. The presence of a peak at 2035 , 2146 , 2236 cm^{-1} in sample S_C corresponding to C-O stretching vibration indicates the presence of ester groups. This suggests that the plastic identified in the sample may be composed of polyester materials which are commonly used in the production of various plastic products including packaging materials [11]. Furthermore, the detection of peaks at 2117 cm^{-1} , 2035 cm^{-1} , 2124 cm^{-1} and in all sachet water samples is an indication of the presence of C=O bond stretching vibration pointing toward the presence of carbonyl groups in the polymer and the presence of 1192 cm^{-1} and 1640 cm^{-1} in sample S_A, S_D and S_F and all other samples respectively represent C=C bond of an aromatic. These C-O and C=C arid maybe associated with plastic like polyethylene terephthalate (PET), mostly used materials for the manufacturing of beverage bottles and food containers. More so, the identification of peaks at 3265 cm^{-1} , 3667 cm^{-1} , 3734 cm^{-1} , and 3816 cm^{-1} in all Samples and mostly in S_C correspond to O-H stretching vibration, suggesting the presence of a hydroxyl group in the sample. This O-H can be attributed to the additive or surface modification applied to the plastic materials. In the determination of micro-plastic in water samples in various other studies, the most frequently identified plastics were PE, PET, PP, PS, and PVC[1].This is similar to the PE, PET, and PVC obtained in this study.

Table 2. Results of SEM characterization of MPs in the Bottled Water Samples

Samples	Brand Location	Microplastics Composition	Particle Size	Shape
S _A		PE, PET, PVC	32.0	Granules
S _B		PE, PET, PVC	36.2	Granules
S _C		PE, PET, PVC	64.1	Granules
S _D		PE, PET, PVC	41.4	Granules

S _E		PE, PET, PVC	39.1	Granules
S _F		PE, PET, PVC	38.5	Granules

Scanning Electron Microscope and Energy Dispersive X-ray Spectroscopy Result

Scanning Electron Microscope (SEM) is a technique used in obtaining the surface morphology of a substance by scanning the surface of the material to create a high-resolution image [9]. The resulting image gives detailed information about the object and its physical characteristics while Energy Dispersive X-ray Spectroscopy (EDS) gives information about the elemental composition of the substance under investigation[8-9]. The table 2 above shows the result of SEM obtained from the studied sachet water samples of S_A to S_F. The table showed the particle size of the sample ranged from 32.0 particle/0.75L sample S_A to 64.1 particle/0.75L sample S_F. The MPs types detected were polyethylene terephthalate (PET), polyethylene (PE), and polyvinyl chloride (PVC) while granules were the predominant shape of MPs obtained.

However, table 3 below shows the result of the health risk assessment of the microplastics in sachet water samples. The micro-plastic pollution load index (MPPLI), micro-plastic contamination factor (MPCF), and estimated of daily intake (EDI) were determined as well. The MPCF values ranged from 1.00 for sample S_A to 2.00 for sample S_C and followed the profile, S_A < S_B < S_F < S_E < S_D < S_C. The EDI values of the samples were evaluated for both adults and children. The EDI values of all samples for adults were slightly greater than 1 which is an indication of a moderate daily intake of MPs suggesting that daily consumption may be moderately risky except for sample S_C showed 2.00 EDI in adults which is high daily intake and may be high risk[11]

Health Risk Assessment of MPs in Sachet Water Samples

Table 3. Estimated Daily Intake of Microplastics in Sampled Sachet Water

Samples	MPCF	Estimated Daily Intake	
		Adult	Child
S _A	1.00	1.13	3.84
S _B	1.13	1.14	4.34
S _C	2.00	2.01	7.69
S _D	1.29	1.30	4.97
S _E	1.22	1.23	4.69
S _F	1.20	1.21	4.62
	MPPLI = 1.28		

However, the EDIs for children ranged from 3.84 in sample S_A to 7.69 in sample S_C. This is an indication that children consume more MPs than adults. This result is in agreement with the study of Kusa and Joshua [7], that the EDI for children is always higher compared to that of adults. From the results, it is obvious that children are more likely to consume MPs beyond the threshold level than adults. However, there is no backing evidence of the danger of MP consumption to human health. The MPPLI was calculated to be 1.27 which is lower than what was obtained by Aliyu *et al.*, [1]. Also, Figure 2 below showed that micro-plastic are more abundant in the sachet water samples in S_C and exposure is more significant among the consumers of the samples compared to other samples investigated. The lowest levels of MP in the sachet water samples was found in samples S_A.

Fig. 2. Daily Intake of Microplastics particles in Adult and Child

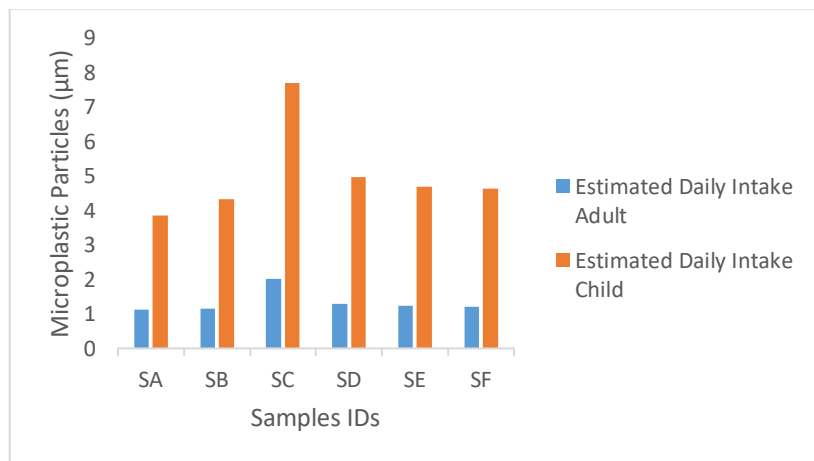


Table 4. Microplastic Contamination Factors and Pollution Load Index in Sachet Water

Samples	MPCF	Risk Category
S _A	1.00	Moderately Contaminated
S _B	1.13	Moderately Contaminated
S _C	2.00	Moderately Contaminated
S _D	1.29	Moderately Contaminated
S _E	1.22	Moderately Contaminated
S _F	1.20	Moderately Contaminated

CONCLUSION

The result obtained showed the presence of polymers. The IR result from the analysis of the Sachet samples showed the presence of polymers like PE, PET, and PVC. The microplastic shape was granules from the surface morphology of the SEM results conducted. The EDI for Children was higher than the adults. This is an indication that children are more susceptible to Microplastic infiltration than adults. As water is life to both plants and animals it is detrimental and life threatening when polluted form of water is ingested. Regulatory monitoring, stricter packaging standards and penalties for non-compliance and should be adopted, also Public health campaigns could be proposed to educate consumers about safer storage practices, such as avoiding UV exposure. Finally future studies might integrate biological assays to examine the physiological impacts of detected Microplastic levels, strengthening the connection between environmental exposure and human health outcomes.

ACKNOWLEDGEMENT

The researchers wish to acknowledge the effort of Management of Federal College of Education Katsina (FCE, Katsina) in funding this research and immense support through the mother funding body, Tertiary Education Trust Fund, Nigeria (TETFUND).

Conflict Of Interest

There is no conflict of interest during the course of this research.

REFERENCE

- Adesakin, T. A., Oyewale, A. T., Mohammed, N. A., Bayero, U., Adedeji, A. A., Aduwo, I. A., Bolade, A. C., & Adam, M. (2022). Effects of Prolonged Storage Condition on the Physicochemical and Microbiological Quality of Sachet Water and Its Health Implications: A Case Study of Selected Water Brands Sold within Samaru Community, Northwest Nigeria. *Microbiology Research*, 13(4), 706-720. <https://doi.org/10.3390/microbiolres13040051>
- Aliyu, A. O., Okunola, O. J., Awe, F. E., & Musa, A. A. (2023). Assessment of microplastics contamination in river water, bottled water, sachet water, and branded table salt samples in Kaduna Metropolis, Nigeria. *Journal of Applied Sciences and Environmental Management*, 27(6), 1105–1118. <https://doi.org/10.4314/jasem.v27i6.7>
- Andrady, A. L. (2011). Microplastics in the marine environment. *Marine Pollution Bulletin*, 62(8), 1596–1605. <https://doi.org/10.1016/j.marpolbul.2011.05.030>
- Barboza, L. G. A., Vethaak, A. D., Lavorante, B. R. B. O., Lundebye, A. K., & Guilhermino, L. (2018). Marine microplastic debris: An emerging issue for food security, food safety, and human health. *Marine Pollution Bulletin*, 133, 336–348. <https://doi.org/10.1016/j.marpolbul.2018.05.047>
- Imam N., AbdurrahmanN., Lawal Isah A., & S. LawalO. (2023). Progress on Drinking Water Quality Monitoring in the Northern Part of Nigeria: A Catalyst to Achieving Sustainable Development Goals. *Fudma Journal of Sciences*, 7(2), 152 - 158. <https://doi.org/10.33003/fjs-2023-0702-1472>
- Kelly, E., Cronk, R., Fisher, M. (2021). Sanitary inspection, microbial water quality analysis, and water safety in handpumps in rural sub-Saharan Africa. *NPJ Clean Water* 4, 3. <https://doi.org/10.1038/s41545-020-00093-z>
- Kusa R., & Joshua W.K. (2023). Evaluating the potability and human health risk of sachet water in Wukari, Nigeria. *Arch Environ Occup Health*;78(2):71-79. doi: 10.1080/19338244.2022.2063785. Epub 2022 Apr 13. PMID: 35416759.
- Mason, S. A., Welch, V. G., & Neratko, J. (2018). Synthetic polymer contamination in bottled water. *Fredonia State University of New York*.
- Ogbuewu I, Nnaji JC & Otuokere IE. (2025). Spectroscopic Evaluation and Health Risk Assessment of Microplastics (mps) in bottled water samples sold in Abakaliki, Nigeria. *J. Chem. Soc. Nigeria*, 50(1), 065 – 074.
- Okpashi, V. E., Ushie, O. A., & Abeng, F. E. (2019). Analysis of microplastics in sachet water exposed to ultraviolet radiation: A risk of drinking polymer. *Journal of Science, Engineering, and Technology*, 8(2), 121–135.
- Pivokonsky, M., Čermáková, L., Novotná, K., Peer, P., Cajthaml, T., & Janda, V. (2018). Occurrence of Microplastics in raw and treated drinking water. *Science of the Total Environment*, 643, 1644–1651. <https://doi.org/10.1016/j.scitotenv.2018.08.102>
- Terefe, B., Jembere, M.M. & Assimamaw, N.T. (2024). Access to drinking safe water and its associated factors among households in East Africa: a mixed effect analysis using 12 East African countries recent national health survey. *J Health Popul Nutr* 43, 72. <https://doi.org/10.1186/s41043-024-00562-y>
- Udoh A, Lawal BK, Akpan M, Labaran KS, Ndem E, Ohabunwa U.(2021). Microbial contamination of packaged drinking water in Nigeria. *Trop Med Int Health*. 26: 1378–1400. <https://doi.org/10.1111/tmi.13672>
- Verla, A. W., Enyoh, C. E., Verla, E. N. (2019). Macrodebris and microplastics pollution in Nigeria: first report on abundance, distribution and composition. *J. of Analy. Meth. in Env. Chem*. DOI: 10.5620/eaht.e2019012
- World Health Organization. (2019). *Microplastics in drinking water*. Geneva, Switzerland: WHO Press.