PRINT ISSN 1119-8362
Electronic ISSN 2659-1502

Full-text Available Online at
https://www.ajol.info/index.php/jasem
http://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 27 (3) 503-508 March 2023

# Physico-chemical and Heavy Metals Analysis of Different Brands of Sachet Water Sold in Benin City, Nigeria

**IGBINEVBO, ID; *AKIRI-OBAROAKPO, TM; EBUN-IGBEARE, OE**

*Department of Environmental Management and Toxicology, Faculty of Life Science, University of Benin, Benin City, Nigeria*

**Corresponding Author Email: mercy.akiri-obaroakpo@uniben.edu*
*Co-Authors Email: iwinosadesire@gmail.com; ernest.ebun-igbeare@uniben.edu*

**ABSTRACT**: Water of good quality is essential for environmental and public health. In Nigeria, majority of the population rely on sachet/packed water for drinking purpose. This study was carried out to assess physico-chemical characteristics and levels of Fe, Zn, Cu, Pb and Mn in ten brands of sachet water sold in Benin City, Nigeria using standard methods. The lowest and highest values of the physico-chemical parameters were: pH (5.20 - 7.00), EC (10 - 170)µS/cm, turbidity (0.00 - 10.00)NTU TDS (5.30 - 90.10)mg/l, hardness (6.00 - 30.00)mg/l, chloride (7.06 - 21.18)mg/l, alkalinity (4.00 – 16.00)mg/l, nitrate (0.64 - 1.22)mg/l and phosphate (0.01 - 1.15)mg/l. They were all within the WHO permissible limits for drinking water except pH and turbidity that revealed a slight increase in concentrations in two brands, which could be indicative of high level of suspended solids and the presence of cations in the groundwater and could pose serious health threat to consumers. Therefore, proper treatment of water in the water packaging facilities and improved sanitary practices of workers and facilities in general are recommended. UNI data from heavy metals (Fe, Zn, Cu, Pb and Mn) analysis showed no evidence of contamination as they were all within their respective permissible limits of drinking water. It is therefore concluded that the sachet water brands sold in the study area are of good physical and chemical quality.

**DOI**: https://dx.doi.org/10.4314/jasem.v27i3.13



**Cite this paper as:** IGBINEVBO, I. D; AKIRI-OBAROAKPO, T. M; EBUN-IGBEARE, O. (2023). Physiochemical and Heavy Metals Analysis of Different Brands of Sachet Water Sold in Benin City, Nigeria. *J. Appl. Sci. Environ. Manage.* 27 (3) 503-508

**Dates**: Received: 22 February 2023; Revised: 20 March 2023; Accepted: 23 March 2023
Published: 31 March 2023

**Keywords**: sachet water; pH; turbidity; heavy metal; water quality.

The provision of safe drinking water is a human right with international acceptance (Halilu *et al.*, 2011). Availability of safe drinking water is among the top priorities for public health considerations. This is because water is used in various biochemical and metabolic processes which take place in the human body. In addition, clean water is an important component in sanitation of the environment (Bolawa and Adelusi, 2017). It is necessary that the properties of water used for these purposes should be in line with the standards set by the World Health Organization. The problem of poor water supply is a common condition in developing countries around the world. In these countries, small parts of the population have access to pipe-borne water supply and this is only in the high-income urban area. In rural communities in Nigeria, the common sources of potable water are rivers, springs, ponds and lakes, and in urban/peri-urban areas borehole and tap water are more common. Unless people are in the middle or upper classes of the society, they are often unable to afford these sources of water. In bridging the gap, the production of packaged water in sachets has grown to become a large business with many individuals investing in it. The Nigerian government view the industry as a way to eradicate poverty as it creates jobs for a portion of the Nigerian population (Orisakwe *et al.*, 2006). In many parts of Nigeria, however, the process of production of sachet water is characterized by improper methods of purification and packaging, and this leads to contamination of the water by

**Corresponding Author Email: mercy.akiri-obaroakpo@uniben.edu*

various agents. Contamination of sachet water may also come from piping materials (Ukibe *et al.,* 2016). The presence of contaminants in drinking water is a threat to human health. Common contaminants in drinking water are in form of excess elemental nutrients, heavy metals and microbial entities. The presence of excess sulphates and nitrates/nitrite in water cause decreases in transit time, and gastric cancer mortality and methemoglobinemia (Orisakwe *et al.,* 2006). Heavy metals are sometimes found in contaminated drinking water and could include lead, copper and cadmium. Each of these has adverse impacts on human health: lead causes decreases in intellectual development of children along with Attention Deficiency Disorder (ADD). Copper is recommended as an essential nutrient but at high doses, it imparts taste to water. Cadmium accumulates in the liver and kidneys and it is a known carcinogen (Kantoma *et al.,* 2018). The presence of microbial communities in water especially faecal organisms is a threat to health as they cause adverse effects in humans that range from mild to severe/fatal (Khayan *et al.,* 2019). Due to how heavily the Nigerian population depends on sachet water, the regulatory bodies set up by the government such as the National Agency for Food and Drug Administration Control (NAFDAC) have attempted to put measures in place to ensure the protection of consumers from products of poor quality while ensuring the safety of these products. It is nearly impossible to find safety data for common water sources used in Nigeria and most times, if found, these data are hardly updated (Bolawa and Adelusi, 2017). The objective of this study is to assess the physico-chemical and heavy metal contents of sachet water brands in Benin City, Nigeria.

## MATERIALS AND METHODS

*Study area:* The study was carried out in Ugbowo District which is located in Egor Local Government Area of Benin City in the southern part of Nigeria. Benin City is the capital of Edo State and is located within the tropical rainforest zone at an elevation of 77.8m above sea level.

*Sample collection:* Samples of sachet water were purchased from a total of five shops within Ugbowo District in Benin City. Two brands each were collected from the shops for a total of ten (10) samples. The purchased sachet water samples were stored under ice and transported to the laboratory for analysis. The sampling locations are indicated in Figure 1.

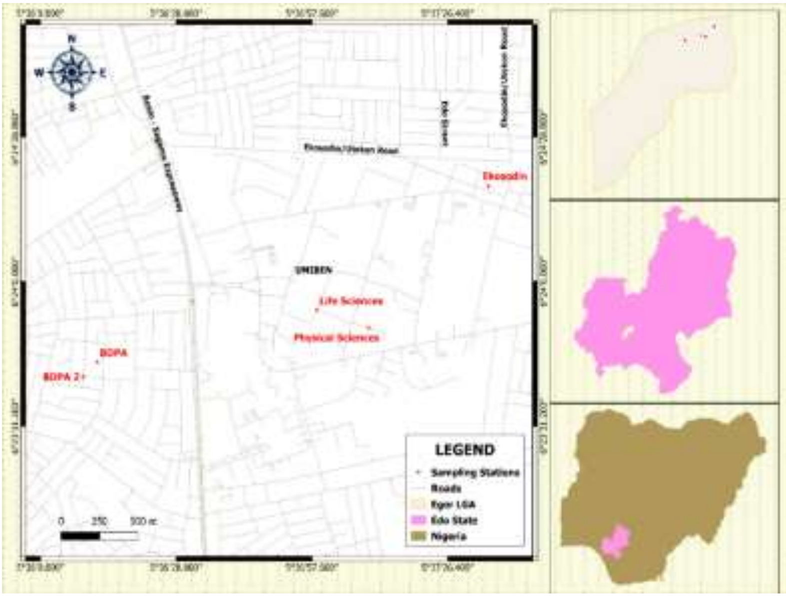


**Fig 1:** A map of the study area indicating the sampling location

*Analytical procedures:* The pH was determined using a pH meter. Conductivity was determined using a conductivity meter, (APHA, 2005). Turbidity was determined using a nephelometer while Total dissolved solids (TDS) was determined using the weight difference method. Alkalinity was determined by acid-base titration with $H_2SO_4$ using phenolphthalein as indicator. The concentrations of nitrate in the samples were determined by analysis using ultraviolet visible spectrometry. Total hardness was determined by titration with EDTA using Eriochrome Black-T as indicator. The concentration of chlorides was determined using a spectrofluorometer. Phosphate concentration was determined via spectrometry. All physico-chemical analyses were done in triplicates and the mean results were recorded.

Heavy metal analysis was done using Atomic Absorption Spectrophotometer (AAS). APHA, (2005).

*Statistical Analysis:* All calculations and statistical tests were carried out using Microsoft Office Suite 2016 Excel sheets and IBM SPSS Statistics 2021.

## RESULTS AND DISCUSSION

Water of good quality is a vital resource that cannot be compromised where the health and safety of man is concerned. Results for the physico-chemical analyses of sachet water showed that the pH of sachet water samples ranged from 5.20 - 7.00 for all samples analysed. The least pH value was 5.20 recorded in NE water, a value which was much lower than WHO least acceptable limit of 6.5. The sources of water for the water packaging facilities are mainly boreholes and the low pH values are an indication of the presence of cations in the water showing that the groundwater in these places is slightly acidic (Daniel and Daodu, 2016; Isikwue, and Chikezie, 2014). Acidity of groundwater may be due to the discharge of domestic wastewater from the surrounding areas which seeps into the ground and contaminated groundwater. The weathering of soil particles also releases cations that may reduce the pH of water (Akinsola *et al.,* 2020). The highest pH value of sampled water, 7.00 was recorded for FM water.

**Table 1**: Physico-chemical properties of water samples

| Parameter | UNIT | UNI | OJ | NE | OL | FL | EJ | FM | SB | NO | IB | *p*-value ($p < 0.05$) | WHO LIMIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | - | 5.30 | 5.40 | 5.20 | 6.20 | 6.50 | 6.50 | 7.00 | 6.50 | 6.30 | 6.10 | 0.00 | 6.5 -8.5 |
| Conductivity | µS/cm | 170.00 | 20.00 | 10.00 | 10.00 | 30.00 | 80.00 | 110.00 | 20.00 | 10.00 | 10.00 | 0.00 | 1000 |
| TDS | mg/L | 90.10 | 10.60 | 5.30 | 5.30 | 15.90 | 42.40 | 58.30 | 10.60 | 5.30 | 5.30 | 0.00 | 500 |
| Turbidity | NTU | 5.00 | 3.00 | 0.00 | 10.00 | 4.00 | 5.00 | 4.00 | 3.00 | 3.00 | 5.00 | 0.343 | 5 |
| Hardness | mg/L | 30.00 | 6.00 | 16.00 | 14.00 | 6.00 | 18.00 | 18.00 | 14.00 | 10.00 | 12.00 | 0.00 | 150 |
| Chloride | mg/L | 21.18 | 7.06 | 14.12 | 14.12 | 14.12 | 7.06 | 14.12 | 7.06 | 7.06 | 14.12 | 0.00 | 250 |
| Alkalinity | mg/L | 16.00 | 8.00 | 6.00 | 6.00 | 14.00 | 16.00 | 46.00 | 12.00 | 4.00 | 20.00 | 0.00 | 100 |
| Nitrate | mg/L | 1.22 | 0.75 | 0.69 | 0.73 | 0.66 | 0.64 | 0.73 | 0.65 | 0.74 | 0.62 | 0.00 | 50 |
| Phosphate | mg/L | 0.04 | 0.03 | 0.02 | 0.03 | 0.03 | 1.15 | 0.03 | 0.01 | 0.02 | 0.03 | 0.00 | 1 |
| Calcium | mg/L | 0.30 | 0.50 | 1.80 | 1.50 | 1.20 | 0.04 | 1.20 | 1.40 | 1.30 | 0.20 | 0.00 | 75 |
| Magnesium | mg/L | 0.14 | 0.13 | 0.20 | 0.22 | 0.24 | 0.11 | 0.18 | 0.16 | 0.15 | 0.17 | 0.00 | 30 |

For electrical conductivity, 10µS/cm was the minimum value and was recorded from four samples (NE, OL, NO and IB), while the maximum value was 170µS/cm in UNI water. Electrical conductivity (EC) indicates the quantity of dissolved ions in water. The acceptable limit for EC in drinking water is 1000 µS/cm (WHO, 2017). According to Omalu *et al.*, 2012, low EC values is a result of the removal of a number of dissolved salts (mineral elements such as calcium, magnesium and fluoride) during the treatment of water via flocculation, reverse osmosis (RO) or distillation. Studies have shown that the continuous drinking of packaged water of EC less than 40 µscm-1 could lead to a number of health risks such as higher probability of fracture in children, pregnancy disorder (preeclampsia), diuresis, premature or low baby weight at birth and increased tooth decay (Ndinwa *et al.*, 2012). The lowest TDS concentration recorded was 5.30mg/L in four samples (NE, OL, NO and IB) with UNI water having the maximum value of 90.1mg/L. Total dissolved solids (TDS) concentrations in the samples all fell below the recommended maximum limit (500mg/L). These results agree with those obtained in a study undertaken by Akintelu *et al.* (2021) who assessed sachet water quality in parts of Ondo State, Nigeria with EC and TDS being 77.2 - 142.3 µS/cm and 47.7 - 99.5 mg/l, respectively.

The value for turbidity was least in NE water (0 NTU) and highest in OL water (10 NTU). The maximum recommended turbidity value is 5NTU (WHO, 2017). All values obtained were within this range, with the exception of OL water which had a turbidity value of 10NTU. Similarly, high turbidity was reported by Yusuf *et al.* (2015) who recorded turbidity of a slightly higher value (5.58) than recommended by WHO (2017). High turbidity in water is a major factor in suspended solids content.. According to Airaodion *et al.* (2019), high turbidity values in sachet water is a result of inefficiency of the filtrations system used to purify water before packaging. This view is also presented by Danso-Boateng and Frimpong (2013).

The lowest and highest values recorded for hardness was 6.00mg/L in OJ and FL waters, and 30.00mg/L in UNI water while lowest and highest values for chloride ranged from 7.06mg/L in four samples (OJ, EJ, SB and NO) to 21.18mg/L in UNI water. The lowest value for alkalinity value was 4mg/L recorded in NO while the highest was 46mg/L recorded in FM. Nitrate concentrations also ranged from 0.62mg/L in IB water to 1.22mg/L in UNI water. All values obtained for hardness, chloride, alkalinity and nitrate concentrations in the sampled waters were within the range of recommended limits (150mg/L, 250mg/L, 150mg/L and 10mg/L, respectively) (WHO, 2017). These findings are in concurrence with previous studies (Sheshe and Magashi, 2014; Mosi *et al.*, 2018). The least value of 0.01mg/L phosphate was recorded in SB water while highest values of 1.15mg/L was recorded in EJ water (a value is slightly higher than the WHO recommended limit of 1.0mg/L), An increase in phosphate is indicative of the presence, of seepages from septic tank and run-offs. Although that is not always the case as some water utilities treat drinking water by adding phosphate to prevent metal dissolution from water pipe work systems and particularly lead poisoning (Rosales *et al.*, 2020). Also, the lowest and highest obtained for calcium was 0.20mg/L and 1.80mg/L for IB and NE waters respectively while the ranges for magnesium was 0.11mg/L and 0.24mg/L in EJ and FL waters respectively. All these values were within **WHO** permissible limits and were in concurrence with work done by Solano *et al.* (2020). From the analysis of Pearson's correlation, at significance levels ($p < 0.05$), positive correlations were observed between the following: electrical conductivity and nitrate; total dissolved solids and nitrate; and hardness and nitrate.

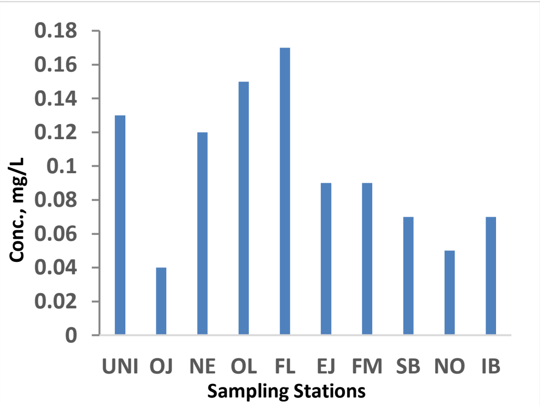


**Fig 2:** Concentrations of iron (Fe) in the samples

Additionally, at significance level ($p < 0.01$), positive correlations were observed between: electrical conductivity and total dissolved solids; hardness and electrical conductivity; and hardness and total dissolved solids. The concentrations of iron (Fe) in the samples was least in OJ water (0.04mg/L) and highest in FL water (0.17mg/L). For zinc (Zn), concentrations ranged between 0.04mg/L (IB) to 0.16mg/L (SB). The lowest recorded value of copper (Cu) was 0.01mg/L in SB water, while the highest value was 0.17mg/L in FL water. The concentrations of the heavy metals, namely, Iron (Fe), Copper (Cu) and Zinc (Zn) were all within regulatory limits prescribed by WHO (2017). This is in agreement with a study carried out by Dada *et al.* (2018) in a work on assessing sachet and bottled water quality. A study by Ndubuisi and Ibe (2019) reported similar results in Anambra State, Nigeria.

The concentrations of lead (Pb) in all the samples were below the limits of detection of the AAS instrument (0.01mg/L).

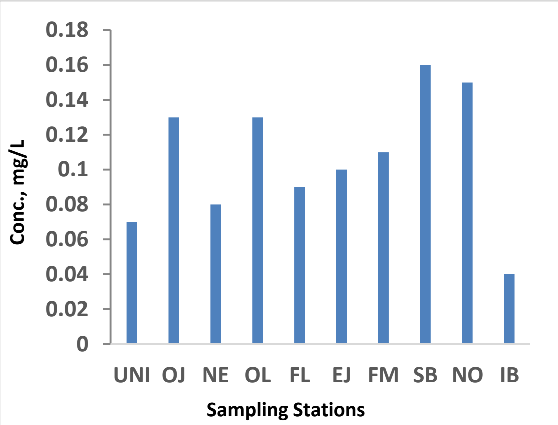


**Fig 3:** Concentrations of zinc (Zn) in the samples

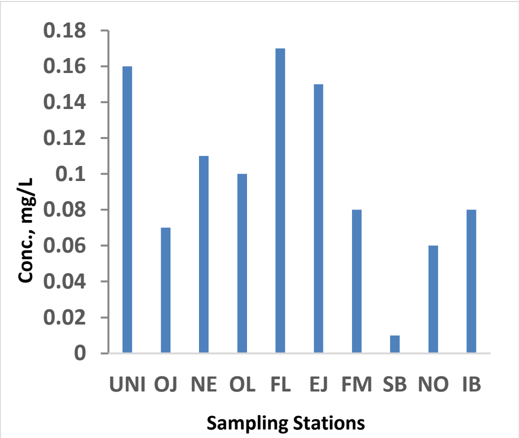


**Fig 4:** Concentrations of copper (Cu) in the samples

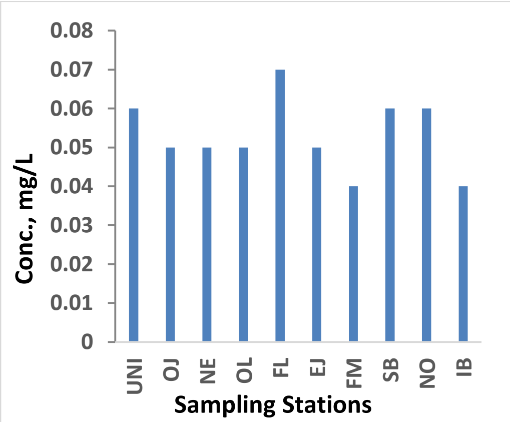


**Fig 5:** Concentrations of manganese (Mn) in the samples

The concentration of Lead (Pb) in all samples was below detection limits. Similar results were reported by Bolawa and Adelusi (2017) who found out that lead was not detected in a majority of sachet water samples obtained in Lagos, Nigeria.

Manganese (Mn) concentrations were least in FM water (0.04mg/L) and highest in FL water (0.07mg/L). Manganese (Mn) concentrations also fell below the maximum allowable limits. This finding is in agreement with those from previous studies (David *et al.*, 2013; Solana *et al.*, 2020). All heavy metal concentrations were compared with the drinking water standards of the World Health Organization (WHO, 2017).

*Conclusion* The presence of contaminants in sachet water sold in various parts of Nigeria has occasioned the need for assessment of these water sources. From the results obtained, it was concluded that most of sachet water brands sold in the study area are of good physical and chemical quality for drinking. However, further treatment of water in the water packaging facilities via chlorination or ozonation coupled with improved sanitary practices of workers and facilities in general is recommended.

## REFERENCES

Airaodion, AI; Ewa, O; Awosanya, OO; Ogbuagu, EO; Ogbuagu, U; Okereke, D (2019). Assessment of sachet and bottled water quality in Ibadan, Nigeria. Available online at https://doi.org/10.33552/GJNFS.2019.01.000519. Accessed December 2nd, 2021.

Akinsola, OA; Oyewumi, TO; Adegola, BA; Okpe, PO (2020). Quality assessment of selected brands of sachet water marketed in Owo, Akure and Ondo areas of Ondo State, Nigeria, *RJPST*, 3(1): 8 - 24.

Akintelu, SA; Folorunsho, FA; Oyebamiji, AK; Akinola, AO; Adetunji, AT; Olugbeko, SC; Folorunsho, AS (2021). Physicochemical and microbiological assessment of some water produced in Irele, Ondo State, Nigeria, *Lett. Appl. NanoBioScience*, 10(4): 2877 - 2886.

APHA (American Public Health Association) (2005). *Standard Methods for the Examination of Water and Wastewater*, 21st Edition. APHA: Washington DC, USA. 182p.

Bolawa, OE; Adelusi, OS (2017). Determination of heavy metal profile in bottled and sachet water samples obtained from various markets in Lagos, Nigeria, *Environ. Pollut. Clim. Chang.*, 1(2): 114 - 118.

Dada, EO; Osidipe, VA; Iyaomolere, KE; Itoje, SO; Akinola, MO (2018). Concentrations of phthalates and metals in commercially packaged sachet and plastic bottled water solid in Lagos, Nigeria, *J. Food Qual.Hazards Control*, 5(1): 134 - 139.

Daniel, EO; Daodu, AA (2016). Bacteriological analysis of sachet water vended in Ugbor, Benin City, Nigeria, *SAU J. Sci. Technol.*, 1(1): 88 - 100.

Danso-Boateng, E; Frimpong, IK (2013). Quality analysis of plastic sachet and bottled water brands produced or sold in Kumasi, Ghana, *Int. J. Dev. Sustain. (IJDS)*, 2(4): 2222 - 2232.

David, TW; Awoh, DK; Essa, GA (2013). Investigation of heavy metals in drinking water (sachet and bottled) in Ago-Iwoye and environs, Ijebu North LGA, Ogun State, Nigeria, *J. Biotechnol.*, 2(1): 1 - 6.

Halilu, M; Modibbo, UU Haziel, H (2011). Determination of heavy metal concentrations in sachet water sold in Gombe metropolis, *BOMJ*, 8(1): 15 - 19.

Isikwue, MO; Chikezie, A (2014). Quality Assessment of Various Sachet Water Brands Marketed in Bauchi Metropolis of Nigeria. *Int. J. Adv. Eng. Technol.*, 6: 2489-2495.

Kantoma, D; Yusuf, J; Bidam, MY; (2018). Assessment of heavy metals concentration in drinking water samples from selected areas of Kauru Local Government Area of Kaduna State, Nigeria, *Bayero J. Pure Appl. Sci.*, 10(1): 509 - 516.

Khayan, K; Husodo, AH; Astuti, I; Sudarmadji, S; Dhojan, TS (2019). Rainwater as a source of drinking water: health impacts and rainwater treatment. Available online at https://doi.org/10.1155/2019/1760950. Accessed December 9th, 2021.

Mosi, L.; Adadey, SM; Sowah, SA; Yeboah, C (2018). Microbiological assessment of sachet water "pure water" from five regions in Ghana. Available online at https://doi.org/10.12688/aasopenres.12837.1. Accessed December 3rd, 2021.

Ndinwa, CCG; Chukwumah, OC; Edafe, EA; Obarakpor, KI; Morka, W; Osubor-Ndinwa., PN (2012). Physico-chemical and bacteriological characteristics of bottled and sachet brands of packaged water in Warri and Abraka, Southern Nigeria. *J. Environ. Manage. Safety*, 3:145-160

Ndubuisi, AC; Ibe, COC (2019). Heavy metal profile of sachet water samples in Anambra State, Nigeria, *IOSR J. Pharm. Biol. Sci.*, 14(6): 42 - 45.

Omalu, IC; Mohammed, AZ; Olamide, PI; Ayanwale, VA; Adeniran, L; Gbise, S (2012). Bacteriological and physicochemical analysis of sachet water in North-Central Nigeria, *J. Pharm. Biomed. Sci.*, 21(21): 1 - 4.

Orisakwe, OE; Igwilo, OI; Afonne, OJ; Maduabuchi, JU; Obi, E; Nduka, JC (2006). Heavy metal hazards of sachet water in Nigeria, Archives of Environmental and Occupational Health, *Front. Microbiol*, 61(5): 209 - 213.

Rosales, E; Del Olmo, G; Calero-Preciado, C; Douterelo, I (2020). Phosphate Dosing in Drinking Water Distribution Systems Promotes Changes in Biofilm Structure and Functional Genetic Diversity, *Front. Microbial.* 11:1-14.

Sheshe, MU; Magashi, AM (2014). Assessment of physicochemical quality of sachet water produced in selected local government areas of Kano Metropolis, Kano State - Nigeria, *Bayero J. Pure Appl. Sci.*, 7(2): 31 - 35.

Ukibe, SN; Ukibe, NR; Ikeako, LC; Okpogba, AN; Obi-Okaro, AC; Nwaankwo, PC (2016). Heavy metals contamination of drinking water in Anambra State, South-east Nigeria, *Eur. J. Sci. Res.*, 139(2): 104 - 108.

World Health Organization (WHO) (2017). *Guideline for Drinking Water Quality*, 4th Edition. WHO: Geneva, Switzerland. 541p.

Yusuf, YO; Jimoh, AI; Onaolapo, EO; Dabo, Y (2015). An assessment of sachet water quality in Zaria Area of Kaduna State, Nigeria, *J. Geogr. Reg. Plan.*, 8(7): 174 - 180