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Impact of Human Activities on the Physiochemical Quality of Streams Around Ijeun-Titun and Kuto Community in Abeokuta, Ogun State, Nigeria

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ABSTRACT
The study aimed to determine the impact of human activities on the physicochemical quality of the streams in the Ijeun- Titun and Kuto communities in Abeokuta, Ogun State, Nigeria. Ten (10) composite water samples were collected from upstream and downstream of five (5) streams (Lafaru, Ijeun- Titun, Isale - Oja, Isabo, and Stadium). Temperature and pH were tested *in situ*, then samples were transported to the chemistry laboratory of Pure Science Institute for further analysis. The analyzed physicochemical parameters were carried out using standard methods. Results showed that pH (6.70-7.42), temperature (except the upstream of stream D (36.3 ^{0}C), electrical conductivity (EC) (265 - 547 µS/cm), total dissolved solid (TDS) (132 - 458 mg/L) and total alkalinity (85.5 - 134 mg/L) across the streams were within the WHO standards (6.5 - 8.5, 25 - 9.0^{o}C, 1000 µS/cm, <600 and 200 mg/L). Total acidity ranged from 11.0-28.0 mg/L across the streams. Salinity (135 - 276 mg/L) across the streams was higher than the WHO standard (100 mg/L), chloride ion (Cl^-) was higher at the upstream and downstream of stream B (284 and 266 mg/L) and C (1232 and 308.85 mg/L) respectively than the WHO standard (250 mg/L) while dissolved oxygen (DO) was low in the upstream and downstream of the streams compared to the WHO standard (13.0 - 14.0 mg/L). The study revealed an unacceptable concentration of salinity and DO across the streams, chloride ions in stream B (Ijeun –Titun) and C (Isale- Oja) and temperature upstream of stream D (Isabo) in the community.

Keywords*:* Physicochemical; Stream; Community; Kuto; Ijeun-Titun; Abeokuta

INTRODUCTION
Water is the most basic natural resource needed for the survival of all living organisms in the biosphere and the supply of water available is limited by nature even though there is about 70% of water on earth (Omer, 2019). The availability of good quality freshwater for various domestic, agricultural and industrial purposes in most developing countries of the world, especially Nigeria, is one of the most problematic issues facing the populace (Famuyiwa *et al.*, 2023; Umoren *et al.*, 2024). In most urban-rural communities in developing countries especially Sub-Saharan Africa, surface waters (rivers, streams, and lakes among others) have been the most readily available sources of water used for domestic purposes and the water from these sources is contaminated with domestic, agricultural, industrial wastes and accidental spillage and are potential sources of diseases (Dimowo, 2013; Umoren *et al.*, 2024). Waste generation by industries and households has continued to increase and is impacting surface water quality (Zhai *et al.*, 2014). In Nigeria, pollution of surface water bodies is aggravated by the high level of pollution emanating from various human activities which have further led to destruction or degradation of the aquatic ecosystems (Hillel *et al.*, 2015; Adu *et al.*, 2016).

Water is considered contaminated or polluted if it is no longer suitable for the purpose for which it was originally intended. Consequently, they are known to be very sensitive to specific changes, such as nutrient enrichment or metal pollution (Adu *et al.*, 2016). Surface water pollution results in the reduction of water quality which in turn poses a human health risk (Varol and Sen, 2018; Famuyiwa *et al.*, 2023), various reconnaissance visits to streams around Ijeun-Titun and Kuto communities have revealed a lot of human activities (discharge of domestic wastes, and washing of automobiles, practicing of religious rites, direct defecation and urination, bathing of rams, sheep and dumping of solid wastes), taking place around the streams.

Water supply in Ijeun-Titun and Kuto communities is not enough leading to the residents' dependence on alternative sources of water such as boreholes, largely hand-dug wells and streams within the community. Since water is of necessity to biological life, Hence, there is a need to assess the water quality of the streams in order to provide guidelines for their sustainable usage and/or implement corrective measures to ensure their quality. This study aims to assess the physicochemical parameters of the streams in Ijeun-Titun and Kuto Communities.

MATERIALS AND METHODS

Study Area

The study was carried out across streams in the vicinity of Ijeun Titun and Kuto communities of Abeokuta, Ogun State, Nigeria. Abeokuta is a city located between latitude 7^{o} 20'' north of the equator and between longitude 3^{o} 20'' east of the Greenwich Meridian. The city experiences the wet and dry seasons. The wet season runs from April through October while the dry season runs from November through March. The main rock type found in the study area is older granite rock which has undergone intense weathering into a reddish to dark brown medium-grained lateritic layer of considerable thickness. The streams in the city are used by some of its residents for domestic activities. The streams, human activities and their coordinates are presented in Table 1.

Table 1: Streams, location coordination and human activities

Streams	Locations	Geographical coordination	Human Activities
A	Lafaru	7°08'15.4"N 3°21'19.8"E	Religious rites, direct defecation and urination, dumping of solid wastes.
B	Ijeun-Titun	7°08'47.2"N 3°21'24.1"E	Automobile wash, discharge of domestic wastes
C	Isale- Oja	7°08'38.0"N 3°21'13.1"E	Discharge of domestic wastes, washing of automobiles, direct defecation and urination, bathing of rams, sheep and dumping of solid wastes.
D	Isabo	7°08'36.9"N 3°20'55.4"E	Washing of automobiles and direct defecation and urination, discharge of domestic wastes
E	M.K.O. Stadium	7°08'00.9"N 3°21'25.1"E	Religious rites, direct defecation and urination, bathing.

Field survey and renaissance visits, 2022

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Water Sampling

The study was carried out from October - November 2022, a total of ten (10) composite water samples were collected using 1L plastic bottle pre-treated with 5% nitric acid (HNO_3) overnight each from upstream and downstream of five (5) streams around Ijeun Titun and Kuto community. When sampling, all necessary precautions were taken to prevent contamination. Temperature and pH samples were determined *in situ*, which were labelled appropriately and transported in an ice pack to the Chemistry unit of Pure Sciences, Abeokuta, Ogun State, Nigeria for further analysis.

Quality Control and Reagents Assurance

All chemicals used were of AnalaR grade and reagent blanks were made following the specifications to evaluate the reagents' purity. To ensure the highest level of instrument accuracy, all field meters and equipment were checked and calibrated according to the manufacturer's specifications and instructions (Ma *et al.*, 2020, Famuyiwa *et al.*, 2023).

Physicochemical Qualities

The physicochemical quality of the water samples namely; pH, Temperature, Total dissolved solids, Electrical conductivity, Salinity, Total Acidity, Total Alkalinity, Chloride ion and Dissolved Oxygen, were carried out using standard methods (AOAC, 2019; Famuyiwa *et al.*, 2023).

Physicochemical Analysis

The pH of the samples was determined using a pH meter (electrometric method). Temperature and pH were measured *in situ*. After standardizing the apparatus with known buffer solutions of pH 4, 7, and 10, the pH content of the water samples was immediately taken. Total dissolved solids, salinity and electrical conductivity were determined using a digital water quality meter (Model: EZ-9909SP). Total acidity, total alkalinity, chloride ion and dissolved oxygen, were determined using Titrimetric Methods (Umoren *et al.*, 2024).

Determination of Total Acidity

The titrant (Dil. NaOH) was titrated against 100 ml of water sample in a conical flask using 2 drops of phenolphthalein as an indicator a pink coloration indicated the endpoint, then the titre value was recorded.

$$\text{Titre value} = (\text{Final} - \text{Initial}) \times 10$$

Determination of Total Alkalinity

The titrant (Dil. HCl) was titrated against 100 ml of water sample in a conical flask using 2 drops of methyl orange as an indicator. A peach coloration was obtained indicating the endpoint then the titre value was recorded.

$$\text{Titre value} = (\text{Final} - \text{Initial}) \times 10$$

Determination of Chloride ion (Cl^-):

One hundred (100) ml of the water sample was measured into the conical flask using Potassium Chromate as the indicator. The solution was then titrated against a dilute silver nitrate solution. A brick red coloration indicated the endpoint.

$$\text{Titre value} = (\text{Final titre} - \text{Initial titre}) \times 10$$

Determination of Dissolved Oxygen (DO):

Dissolved oxygen was carried out using Winkler's method (Biswas, 2015; Famuyiwa *et al.*, 2023), 200 cm^3 of the water samples were cautiously transferred into a 300 cm^3 BOD bottle, then fixed with Winkler A and B reagents *in situ* and determined using titrimetric method. Two (2) ml of concentrated sulphuric acid (H_2SO_4) was added to a volume of 100 ml sample, inverted several times to dissolve the flocs. It was then titrated using a standard sodium thiosulphate solution (0.1N $Na_2S_2O_3$) as titrant and 1ml of starch solution as indicator. The reaction turns from blue-black to colourless. The values of dissolved oxygen were expressed in mass concentration (mg/L) and content expressed using the formula:

$$\text{Dissolved Oxygen (DO)} = \frac{Titre\ value\ x\ 0.1N}{0.025}$$

Statistical Analysis

Data obtained was subjected to analysis using Microsoft Excel 2013 Version for descriptive analysis and visualization.

RESULTS

Physical Quality

The physical quality of the streams is presented in Figures 1-5. The pH of the streams ranged between 6.75 - 7.42, the highest pH was recorded in downstream of stream B, although all the streams had a pH within the WHO standard of 6.5-8.5 (Figure 1). The temperature of the streams ranged from 24.4 - 36.3 °C, highest temperature was recorded in upstream of stream D. The upstream and downstream of the streams (excluding the upstream of stream D (36.3 °C) had a temperature within the WHO standard of 25 – 29 °C (Figure 2). Electrical conductivity of the streams ranged from 265-547 µS/cm, the highest EC was recorded in upstream of stream D, although all streams recorded an EC within the WHO standard (1000 µS/cm) (Figure 3). The total dissolved solid (TDS) in the streams ranged from 132- 458 mg/L and the highest was recorded in the upstream of stream B. Total dissolved solids across the streams were within the WHO standard of <600 mg/L (Figure 4). The salinity of the streams ranged from 135-276 mg/L with the highest recorded upstream of stream D, salinity across the streams was higher than the WHO standard of 100 mg/L (Figure 5).

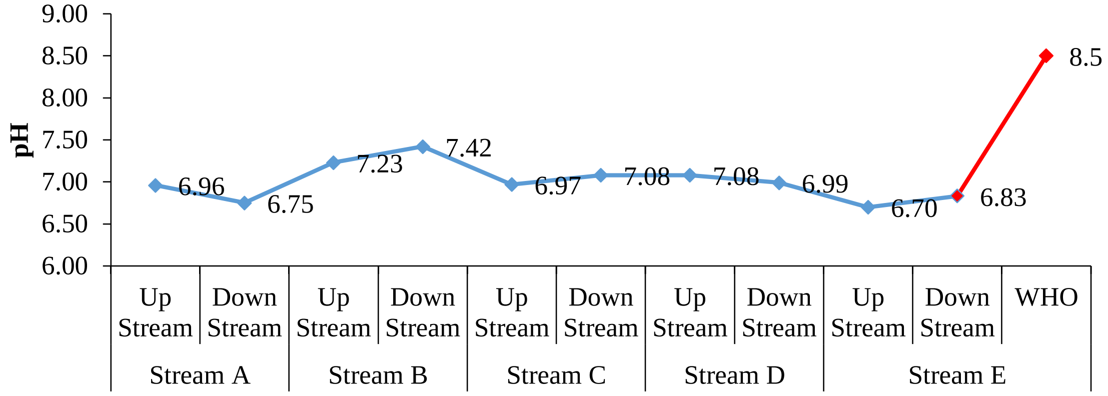

Figure 1: pH content across streams

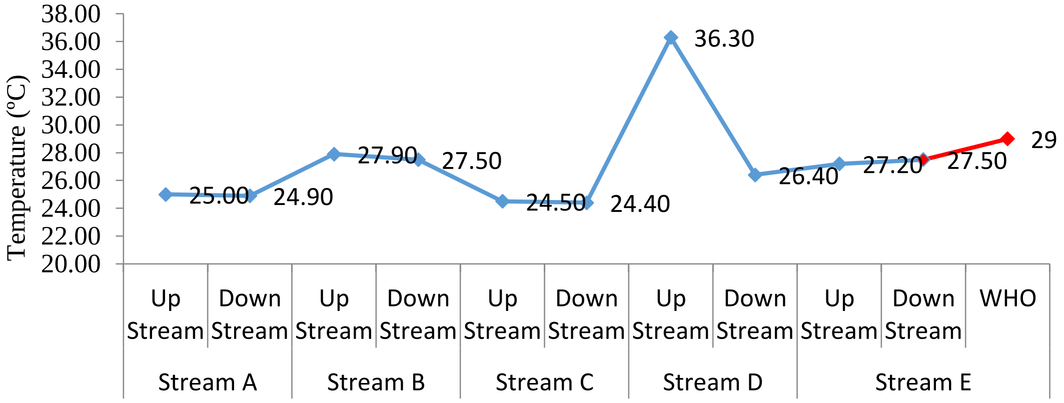

Figure 2: Temperature across streams

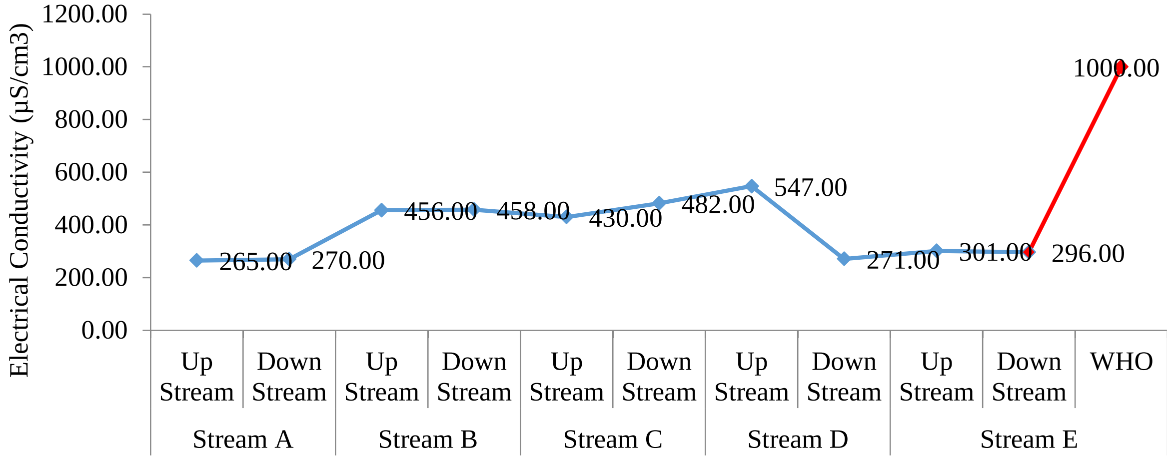

Figure 3: Electrical Conductivity across streams

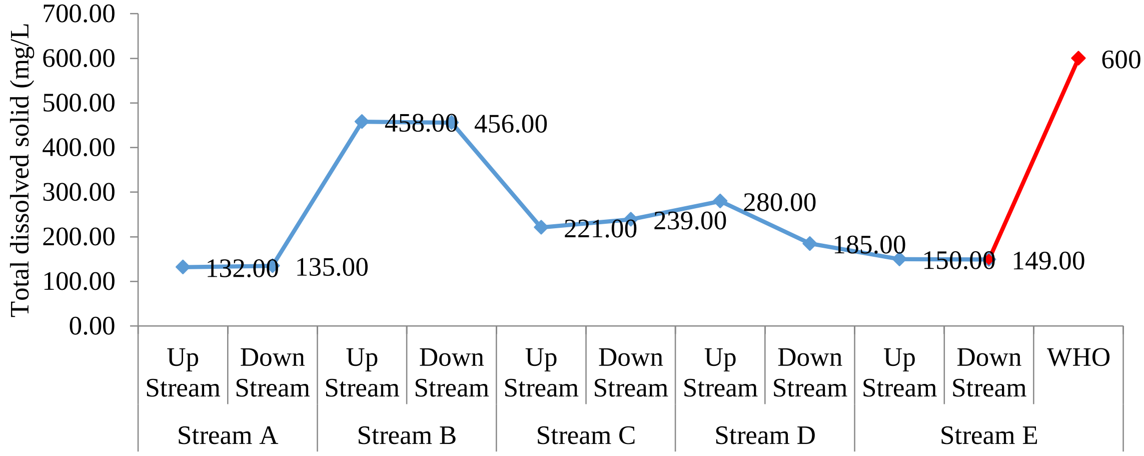

Figure. 4: Total Dissolved Solid across streams

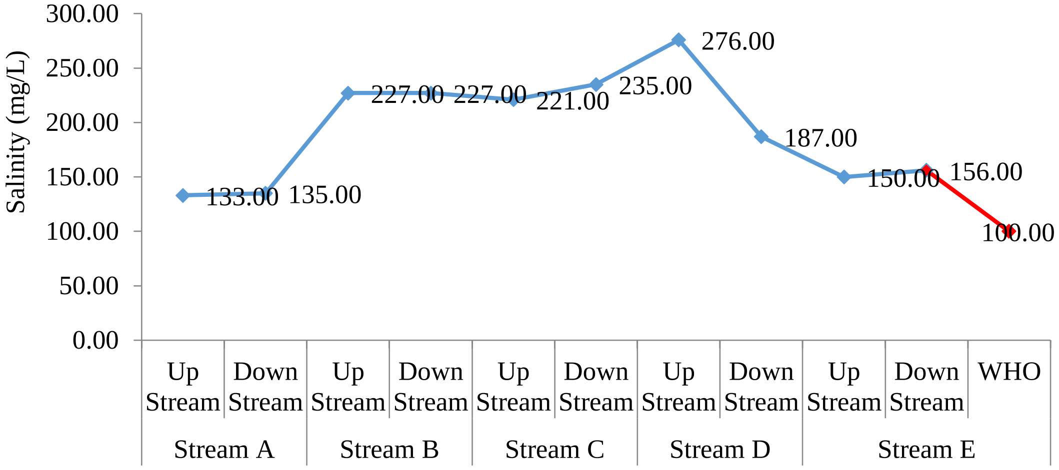

Figure 5: Salinity across streams

Chemical Quality

The chemical quality of the streams is presented in Figures 6-9. The total alkalinity (TA) ranged from 85.5-134 mg/L with the highest recorded downstream of stream B. Total alkalinity across the streams was within the WHO standard of 200 mg/L (Figure 6). The total acidity of the streams ranged from 11.0-28.0 mg/L with the highest recorded in the downstream of stream E (Figure 7). The concentration of chloride ion (Cl^-) ranged from 71.0- 1230 mg/L with the highest recorded upstream of stream C. Chloride ion (Cl^-) concentration in the upstream and downstream of streams A, D and E are within the WHO standard (250 mg/L) while stream B (284 and 266 mg/L) and C (1232 and 308.85 mg/L) are higher respectively (Figure 8). The concentration of dissolved oxygen (DO) ranged from 4.00 - 9.60 mg/L with the highest recorded downstream of stream C. The DO across the streams were lower than the WHO standard (13.0-14.0 mg/L) presented in Figure 9.

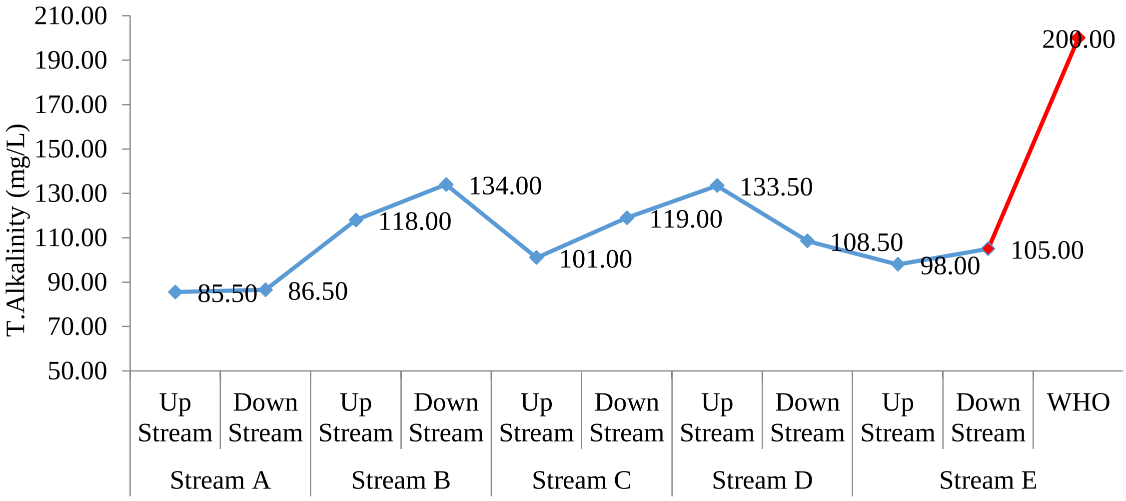

Figure 6: Total Alkalinity across streams

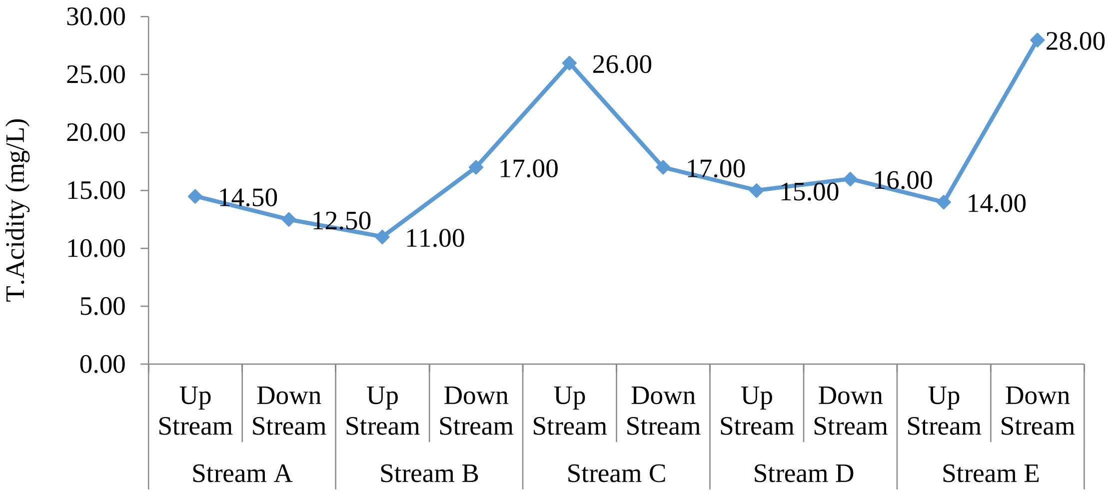

Figure 7: Total Acidity across streams

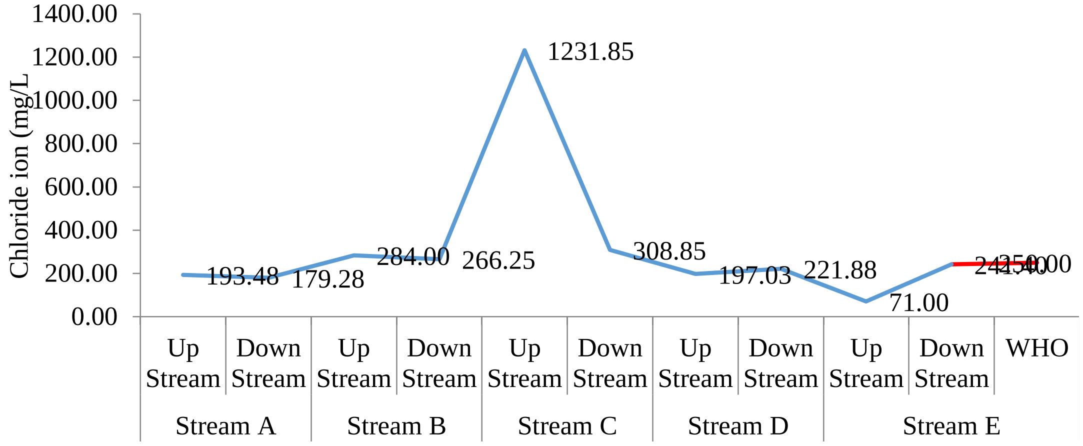

Figure 8: Chloride ion content across streams

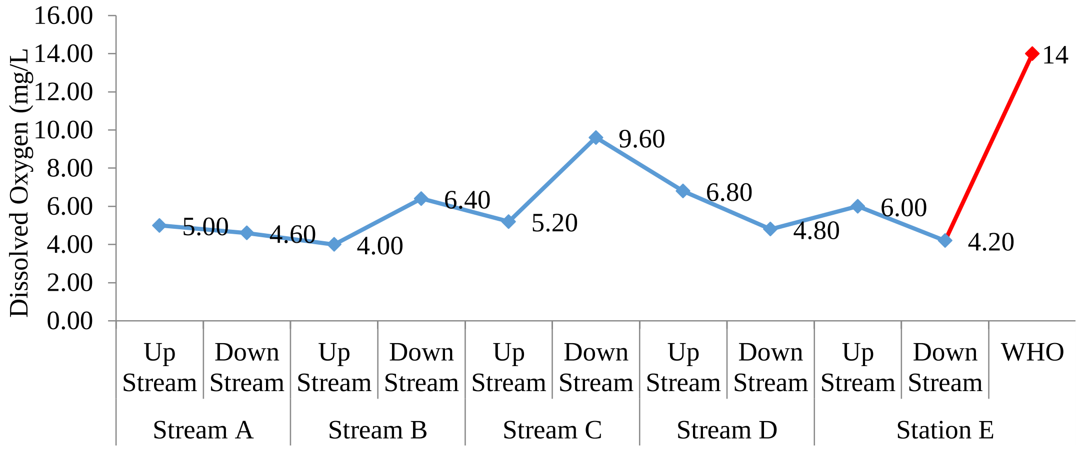

Figure 9: Dissolved Oxygen across streams

DISCUSSION

Generally, the physicochemical parameters of the streams in the studied community are unacceptable for salinity and DO (low) across the streams with high Cl^- (Ijeun – Titun and Isale-Oja) and temperature at the upstream of Isabo. All other parameters are within the acceptable threshold (WHO, 2011). The pH of a stream is the measure of the acidity and alkalinity of the stream, although pH has no significant hazardous implication on the health of humans its impact on the physiology cannot be neglected (Famuyiwa *et al.*, 2023). The pH range of the streams was higher than the reports from surface water in Ogbomosho, Nigeria 5.7–6.7 (Adelowo *et al.*, 2012) but similar to that of the upstream and downstream of River Iju, Ogun State (6.65 – 8.56) impacted by effluents (Famuyiwa *et al.*, 2023).

The temperature of a stream is the degree of coldness and hotness of the stream, the report from the study was similar to the report of an abattoir impacted wells in Omu – Aran, Nigeria with 26.90 – 26.70 °C (Elemile *et al.*, 2019) except high-temperature peak at the upstream of station D which can be attributed to exothermic reaction taking place between the ionic species discharged from the effluents discharged from soap and detergent and domestic wastes (Tadesse *et al.*, 2018) which was similar to the report from palm oil mill effluents in Rivers State Nigeria (45–70°C) (Kanu and Achi, 2011; Famuyiwa *et al.*, 2023).

Electrical conductivity of the stream is the ability of the stream to conduct electricity due to the presence of ions, The EC concentration from the streams is slightly similar to that of River Iju, Ogun State, Nigeria 436 – 1100 µs/cm (Alabi *et al.,* 2013) but largely lower than the report from industrial effluent in Imo State, Nigeria 10460 µS/ cm (Ogemdi and Gold, 2018), Omu – Aran, Nigeria 432 – 547µs/cm (Elemile *et al.,* 2019).

The salinity of the stream is a measure of dissolved salts in the stream (Tadesse *et al.,* 2018), the high salinity of the streams was likely due to presence of soaps and detergents in the form of ions. Chemically, soap is a salt of fatty acids, or a combination of salts, composed of Na^+ or K^+, and a negative ion, usually the anions of long-chained carboxylic acids (Tadesse *et al.,* 2018). Furthermore, cleaning supplies made of synthetic organic compounds are called detergents, they are grouped into cationic, anionic, non-anionic, and amphoteric (Ataman, 2021). The most commonly utilized are the anionic detergents i.e. Linear Alkylbenzene Sulfonates (LAS) linked to the human activities around the streams such as the discharge of domestic wastes, bathing and washing of automobiles.

Total dissolved solid (TDS) is an important parameter in evaluating the suitability of water for irrigation since it might clog both pores and components of the irrigation water distribution system (Tadesse *et al.,* 2018). TDS recorded from the streams comply with the WHO standard and is similar to the report from effluents in Nkoho River, Abia State, Nigeria 246.7 mg/l, (Chidozie and Nwakanma, 2017) and Imo State, Nigeria 485 mg/l (Ogemdi and Gold, 2018).

According to Müller *et al.* (2016) and Sandborn *et al.* (2023), alkalinity in natural waterways is crucial for controlling pH and CO_2 flux as well as biogeochemical reactions to disturbances and phytoplankton blooms. Alkalinity moderates' acidification as a concentration of buffering species; hence, it has been observed that aquatic ecosystems with relatively low alkalinity are more susceptible to anthropogenic acidification (Sandborn *et al.,* 2023). The total alkalinity (TA) across the streams is aligned with the recommended WHO standard. The TA recorded across the streams was higher than the report across the sampling stations in the dry season in River Sokoto 11- 71 mg/L (Raji *et al.,* 2015) and surface water in Owerri 8.89 - 20.88 mg/L Umedum *et al.,* 2013).

The primary cause of acidity in naturally occurring, unpolluted waters is dissolved CO_2. Weak acids like CH_3COOH can make a major contribution to the overall acidity of contaminated waters (Olawale, 2016). Additionally, adding to the acidity of some organic fluids are organic acids. The acidity recorded across the streams was similar to the report across sampling stations in the dry season in River Sokoto 05- 20 mg/L (Raji *et al.,* 2015) and Asa River, Ilorin 26.3 - 50.23 mg/L (Olawale, 2016).

The concentration of Cl^- in two of the streams (B and C) was not in compliance with the water quality standard of WHO. The sources of high chloride ions in the streams can be linked to domestic sewage (Hong *et al.,* 2023). High concentrations of Cl^- in water produce an unpleasant taste and harm to human health. More so, human skin contact can result in a dermal damage. Chloride ions in water have a corrosive effect on reinforced concrete, such as that used for bridges, and accelerate the ageing of buildings (Hong *et al.,* 2023). The concentration of chloride ions across the streams was higher than the reports from Imo State, Nigeria 80 mg/L (Ogemdi and Gold, 2018) except for the upstream of stream E (71 mg/L) and slightly similar to that of Nkoho River, Abia State, Nigeria 367.9 mg/L (Chidozie and Nwakanma, 2017).

The dissolved oxygen concentration across the streams was below the acceptable level and can be harmful to aquatic ecosystem (Puri and Kumar, 2012). The DO concentrations from streams were similar to the report from industrial effluent at 50 meters (4.98 mg/L) and 100 meters (7.56 mg/L) downstream of River Iju (Famuyiwa *et al.,* 2023) and abattoir impacted well in Omu – Aran, Nigeria 5.80 – 7.23 mg/L (Elemile *et al.,* 2019). This can be traced to the dumping of solid waste, direct defecation and the use of soap and detergents. Additionally, detergents contain oxygen-reducing agents that break down biochemically in receiving fluids and use up the dissolved oxygen in the surrounding water during this process (Ataman, 2021).

CONCLUSION AND RECOMMENDATION

The study evaluates the impact of the physicochemical quality of streams around the Ijeun-Titun and Kuto communities in Abeokuta, Ogun State, Nigeria. The study shows that the streams contain high concentrations of salinity (salt content), and chloride ions in Ijeun –Titun and Isale- Oja which can be both linked to the use of soaps and detergents around the streams, making the surface water unsafe for domestic use. The low dissolved oxygen which was attributed to a high content of organic and inorganic matter from direct dumping of wastes and defecation, poses a threat to aquatic habitats of the streams. High temperature in upstream of Isabo could also be attributed to the activities around the stream. It is therefore recommended that the level of soap and detergent used and other human activities around the streams should be regulated and monitored.

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REFERENCES

Adelowo, O. O., Akinlabi, I. A. and Fagade, O. E. (2012). Environmental impact assessment of Attenda abattoir, Ogbomoso southwestern Nigeria on the surface and groundwater quality using geoelectrical imaging and microbiological analysis. *Environmental monitoring and assessment*, *184*(7), 4565 – 4574.

Adu, B. W., Kemabonta, K. A. and Giwa, O. E. (2016). Study of water quality characteristics and benthic macroinvertebrate assemblages of Aahoo stream, Akure, southwestern Nigeria. *Nigeria Journal of Scientific Research*, 15(3), 499–504.

Alabi, M. A., Idowu, G., Osoteku, O. A., Fasuyi, F. H., Adeyemi, Y. A., Adedokun, T. A. and Adelowo A. A. (2013). Water Quality Assessment of Iju River in Ogun State, Nigeria: Effect of Human Activities, *OSR Journal of Environmental Science, Toxicology and Food Technology*, *6*(3), 64 – 68

AOAC (2019). *Official Methods of Analysis* (21st ed.). Washington, DC, USA. Association Official Analysis Chemists (assessed Dec. 2023).

Ataman A. A. (2021) Seasonal changes of some detergent components in surface water of rivers to the Van Lake, Turkey, *Toxicological & Environmental Chemistry*, *103*:1, 37-49, DOI: 10.1080/02772248.2021.1882460

Biswas, J. (2015) Assessment of physicochemical quality of food wastewater of Raipur area. *International Journal of Engineering Research*, vol. 3, no. 1.

Chidozie, K. and Nwakanma, C. (2017) Assessment of Saclux Paint Industrial Effluents on 371 Nkoho River in Abia State, Nigeria. *J Ecosyst Ecography* 7: 240. doi:10.4172/2157 – 372 7625.1000240

Dimowo, B. O. (2013), Assessment of some physicochemical Parameters of River Ogun (Abeokuta, Ogun State, Southwestern Nigeria) in Comparison with National and International Standards, *International Journal of Aquaculture*, 3, (15) 79-84 (doi: 10.5376/ija.2013. 03.0015)

Elemile, O. O., Raphael, D. O., Omole, D. O., Oloruntoba, E. O., Ajayi, E. O. and Ohwavborua, N. A. (2019). Assessment of the impact of abattoir effluent on the quality of groundwater in a residential area of Omu – Aran, Nigeria. *Environmental Sciences Europe*, *31*(1), 1 – 10.

Famuyiwa, A.O., Umoren, O.D., Ande, S., Eze, R.I., Sowemimo, K.S. and Rafiu, R.B. (2023). Physicochemical quality, potentially toxic elements characterization and toxicological risk assessment of industrial effluents in Iju River, Ogun State, Nigeria. *Journal of Research in Forestry, Wildlife & Environment.* 15(3): 126 – 135

Hillel, N., Geyer, S., Licha, T., Khayat, S., Laronne, J. B. and Siebert, C. (2015). Water quality and discharge of the Lower Jordan River. *Journal of Hydrology*, *527*, 1096-1105.

Hong, Y., Zhu, Z., Liao, W., Yan, Z., Feng, C., & Xu, D. (2023). Freshwater Water-Quality Criteria for Chloride and Guidance for the Revision of the Water-Quality Standard in China. *International Journal of Environmental Research and Public Health*, *20*(4), 2875.

Kanu, I. and Achi, O. K. (2011). Industrial effluents and their impact on water quality of receiving rivers in Nigeria. *Journal of applied technology in environmental* sanitations, 1(1), 75 – 86.

Ma, J., Wu, S., Shekhar, N. V., Biswas, S. and Sahu, A. K. (2020). Determination of physicochemical parameters and levels of heavy metals in food wastewater with environmental effects. *Bioinorganic Chemistry and Applications*, https://doi.org/10.1155/2020/8886093

Müller, B., J. S. Meyer, and R. Gächter. (2016). Alkalinity regulation in calcium carbonate-buffered lakes: Alkalinity regulation in calcium carbonate-buffered lakes. *Limnol. Oceanogr*. 61: 341–352. doi:10.1002/lno.10213

Omer, N. H. (2019). Water quality parameters. *Water quality-science, assessments and policy*, *18*, 1-34.

Ogemdi, I. K. and Gold, E. E. (2018). Physicochemical parameters of industrial effluents from a brewery industry in Imo state, Nigeria. *Advanced Journal of Chemistry 1 (2 Section A)*, 412 66 – 78.

Olawale, S. A. (2016). Physicochemical analysis of water from Asa River, Ilorin, Nigeria. *Imperial Journal of Interdisciplinary Research*, *2*(3), 122-129.

Puri, A. and Kumar, M. (2012). A review of permissible limits of drinking water. *Indian Journal of Occupational and Environmental Medicine, 16*(1), 40. doi:10.4103/0019 – 5278.99696 .

Raji, M.I.O., Ibrahim, Y.K.E., Tytler, B.A. and Ehinmidu, J.O. (2015). Physicochemical Characteristics of Water Samples Collected from River Sokoto, Northwestern Nigeria. *Atmospheric and Climate Sciences*, 5, 194-199. http://dx.doi.org/10.4236/acs.2015.53013

Sandborn, D. E., Minor, E. C. and Hill, C. (2023). Total alkalinity measurement using an open-source platform. *Limnology and Oceanography: Methods*, 21(6), 334-344. https://doi.org/10.1002/lom3.10549

Tadesse, M., Tsegaye, D. and Girma, G. (2018). Assessment of the level of some physico-chemical parameters and heavy metals of Rebu river in oromia region, Ethiopia. *MOJ Biology and Medicine*, *3*(3), 99-118.

Umedum, N. L., Kaka, E. B., Okoye, N. H., Anarado, C. E. and Udeozo, I. P. (2013). Physicochemical analysis of selected surface water in Warri, Nigeria. *International Journal of Scientific & Engineering Research*, *4*(7), 1558-1562.

Umoren, O.D., Adetula, E.E., Benjamin, N.F., Akinbola, S.A., Ibrahim, S.S. and Orefuwa, T.R. (2024). Impact of Anthropogenic Activities On the Physicochemical Quality of Oke-Bola Stream, Oyo State, Nigeria. *ChemSearch Journal (CSJ), 15*(1), xx-xx (Galley Proof/In press). Available at https://www.researchgate.net

Varol, M. and Sen, B. (2018). Assessment of nutrient and heavy metal contamination in surface water and sediments of the upper Tigris River, Turkey. *Catena* 92(1):1 – 10. https://doi.org/10.1016/j.catena.2011.11.0 11

World Health Organization (2011). *Guidelines for Drinking–water Quality, 4th edition.* World Health Organization (WHO). http://whqlibdoc.who.int/publications/2011/9789241548151_eng.pdf?ua=1 (accessed Dec. 12, 2023).

Zhai, X., Xia, J. and Zhang, Y. (2014). Water quality variation in highly disturbed Huai River Basin, China from 1994 – 2005 by multistatistical analyses. *Science of the Total Environment*, 496: 594 – 606.