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Impact of Anthropogenic Activities on the Physicochemical Quality of Oke-Bola Stream, Oyo State, Nigeria

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ABSTRACT

The study aimed to determine the impact of anthropogenic activities on the physicochemical quality of the Oke-Bola Stream, Oyo State, Nigeria. Five (5) composite water samples were collected from five (5) stations of the stream. Temperature and pH were tested *in situ*, then samples were transported to the chemistry laboratory for further analysis using standard methods. The results showed the highest mean temperature in station A (25.1 ^{O}C), pH in stations C and E (6.73), total acidity in station B (73.0 mg/L), electrical conductivity (EC) (854 µS/cm), total dissolved solid (TDS), salinity, total alkalinity, chloride ion (Cl^-) and dissolved oxygen (DO) in station C (427, 425, 225, 2600 and 15.4 mg/L) respectively. The EC and TDS across the stations were within the WHO (2011) standards (1000 µS/cm, and <600 mg/L). Temperature in station E (24.6 ^{O}C), pH in stations A (6.26) and B (6.11), total alkalinity in station C (225 mg/L), salinity and Cl^- concentration across the stations and DO in four of the stations (A, B, C and E) are not in compliance with the WHO (2011) standards (25-29^{o}C, 6.5-8.5, 200, 100, 250 and 13-14 mg/L respectively). Pearson correlation revealed a significantly strong association between pH and T. alkalinity (r=0.915). TDS with EC (r= 0.988) and salinity (r=0.992). EC with salinity (r=0.978). T. acidity with DO (r=0.917) p<0.01. The study revealed an unacceptable level of the studied physicochemical parameters in some and across the stations linking to the anthropogenic activities around the stream.

Keywords: Anthropogenic Activities, Ibadan, Physicochemical, Stream

INTRODUCTION

Water resources are essentially known to man and its environment for survival, it is utilized for food production, bodily sustenance, and economic growth (Idah, 2017). Thus, maintaining the availability of a sufficient supply of water of a suitable quality is a crucial social and technological issue that needs to be resolved (Famuyiwa *et al.,* 2023). Surface water is one of the many sources of water, these sources are essential to human development because they provide water for the various socioeconomic activities taking place in human settlements; however, human activities have also led to a decline in the quality of the water (García-Ávila *et al.,* 2022).

Water contamination usually results from effluent discharges, agricultural runoff and sewage disposal. One of the two major concerns regarding waste disposal on land includes surface and groundwater contamination by leachate. According to WHO (2011) (2011), the supply of safe water is crucial to human life, and safe drinking and domestic water should not impose a significant risk to humans. Although few elements are essential for human health, an excess amount of these elements can have negative effects (USEPA, 2015).

Surface waters are most exposed to pollution due to their accessibility for disposal of wastewater (Rashid and Romshoo, 2013). Anthropogenic activities on surface water sources have resulted in a serious issue of concern among scholars globally due to their negative impact on humans, and the environment. Compared to the influence of natural occurrence, surface water is a major recipient of pollutants and materials resulting from human activities in the environment (Idah, 2017). The continued population growth and urbanization increase have resulted in the release of various inorganic and organic chemical substances (Bakure *et al.,* 2020; Famuyiwa *et al.,* 2023).

Domestic garbage, oil, grease, and chemicals are carried to the streams by runoff (Bakure *et al.,* 2020). Owing to the large and excessive amounts of organic garbage, many streams are in danger. Nigeria has a large number of streams and rivers that are contaminated by untreated or inadequately treated wastewater, effluents, discharges and other organic wastes that are indiscriminately dumped into them (Inah *et al.,* 2022).

Water management in Nigeria is facing significant difficulty due to an array of contamination (Inah *et al.,* 2022). Reconnaissance visits to the Oke Bola stream in Ibadan, Oyo State, Nigeria revealed a lot of anthropogenic activities which include discharge from domestic wastes, washing of automobiles, direct defecation and urination and dumping of solid domestic and E-wastes), discharge from lead battery smelting workshops. Therefore, there is a need to ascertain the impact of these activities on the physicochemical quality of the stream.

MATERIALS AND METHODS

Description of Study Area

The study was carried out in Oke Bola Stream (coordination: 7°22'39.9"N 3°52'58.9"E), Ibadan, Oyo State, South-West Nigeria (plate 1). Ibadan is a significant metropolis in southwest Nigeria. It is the seat of the Oyo State government and, after Lagos and Kano, is the third most populous city in Nigeria. Ibadan is a diversified and prosperous city known for its rich cultural legacy, historical sites, and bustling markets. It was a key hub of commercial and political activity in the pre-colonial era and contributed significantly to the Yoruba kingdom's growth. People from various ethnic backgrounds and cultural traditions cohabit peacefully in the city, which has a diversified population (Encyclopedia Britannica, 2023). Oke Bola stream is vulnerable to a wide range of anthropogenic activities most especially electronic and domestic waste discharge including discharge from battery smelting workshops.

Plate 1: Pictorial view of Oke-Bola stream

Sampling Procedure

Five (5) composite water samples were collected using a 1L plastic bottle pre-treated with 5% nitric acid (HNO_3) overnight each from five (5) stations, 100 meters apart in the stream. During sampling, all necessary precautions were taken into consideration to avoid contamination. The temperature and pH of the samples were determined *in situ*. labelled appropriately and transported in an ice pack to the Chemistry/Biochemistry Unit of Pure Sciences, Abeokuta, Ogun State, Nigeria for further analysis.

Quality Control

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

Physicochemical Quality

The physicochemical quality of the water samples was carried out using standard methods (AOAC, 2019; Famuyiwa *et al.*, 2023). The pH of each sample was determined using a handheld pH meter. Temperature and pH were measured *in situ*. After standardizing the apparatus with standard buffer solutions of varying pH, the sample pH was immediately taken. Total dissolved solids, salinity and electrical conductivity were determined using a handheld digital water quality meter (Model: EZ-9909SP). Total acidity, total alkalinity, chloride ion and dissolved oxygen, were determined using Titrimetric Methods.

Total Acidity: The titrant (0.025 M NaOH) was titrated against 100 cm^3 of water sample in an Erlenmeyer flask using 2 drops of phenolphthalein as an indicator. A pink coloration indicated the endpoint then the titre value was recorded.

$$Total\ Acidity = \frac{Titre\ value \times 0.2 \times 1000}{100}$$

Total Alkalinity: The titrant (0.025 M HCl) was titrated against 100 cm^3 of water sample in an Erlenmeyer flask using 2 drops of methyl orange as an indicator. A peach coloration was obtained indicating the endpoint, then the titre value was recorded.

$$Total\ Alkalinity = \frac{Titre\ value \times 0.2 \times 1000}{100}$$

Chloride ion (Cl^-): 100 cm^3 of the water sample was measured into the Erlenmeyer flask using Potassium Chromate (K_2CrO_4) as the indicator. The solution was then titrated against 1M $AgNO_3$ solution. A brick red colouration indicates the endpoint.

$$Chloride\ ion = \frac{Titre\ value \times 1000}{100}$$

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

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

Statistical Analysis

Data was subjected to Microsoft Excel 2013 for descriptive statistics and data visualization. Tukey Post hoc test was employed to determine the significance between the stations. P-value was set at 0.05. Pearson correlation was employed to reveal the association between parameters.

RESULTS AND DISCUSSION

Results

Physicochemical Qualities

The physicochemical qualities across the stations are represented in Table 1. The study revealed that the highest water temperature was recorded in station A (25.1ºC) while the lowest was recorded in station E (24.6 ºC) $p<0.05$. The temperature across the stations except for station E complies with the WHO (2011) standard (25 – 29ºC). The highest pH was equally recorded in stations C and E (6.73) respectively, while the lowest was recorded in station B (6.11) $p<0.05$. The pH in only three of the stations (C, D and E) complies with the WHO (2011) standard (6.5-8.5). The highest TDS was recorded in station B (427 mg/L) while the lowest was recorded in both stations D and E (365 mg/L) $p<0.05$. The TDS across the stations comply with the WHO (2011) standard (<600 mg/L). The highest EC concentration was recorded in station C (854 µS/cm) while the lowest was recorded in station E (720 µS/cm) $p<0.05$. The EC concentration across the stations complies with the WHO (2011) standard (1000 µS/cm). The highest salinity was recorded in station C (425 mg/L) while the lowest was recorded in both stations D and E (364 mg/L) $p<0.05$. The salinity across the stations is not in compliance with the WHO (2011) standard (100 mg/L).

The highest total alkalinity was recorded in station C (225 mg/L) while the lowest was recorded in both stations B (151 mg/L) $p<0.05$. Total alkalinity across the stations except for station C complies with the WHO (2011) standard (200 mg/L). The highest total acidity was recorded in station E (146 mg/L) while the lowest was recorded in station A (51.0 mg/L) $p<0.05$. The highest Cl^- concentration was recorded in station C (2600 mg/L) while the lowest was recorded in both stations B (1060 mg/L) $p<0.05$. The Cl^- concentration across the stations is not in compliance with the WHO (2011) standard (250 mg/L). The highest DO concertation was recorded in station C (15.4 mg/L) while the lowest was recorded in station A (8.0 mg/L) $p<0.05$. The DO across the stations except for station C are not in compliance with the WHO (2011) standard (13.0-14.0 mg/L).

Table 1: Physicochemical qualities of the sampling stations

Parameter	Stations	Mean	Std. Deviation	Minimum	Maximum
Temperature (^oC)	St A	25.1^b	0.12	25.0	25.2
	St B	25.0^{ab}	0.15	24.8	25.1
	St C	25.0^{ab}	0.21	24.8	25.2
	St D	25.0^{ab}	0.06	24.9	25.0
	St E	24.6^a	0.20	24.4	24.8
	WHO (2011)	**25 - 29**			
pH	St A	6.26^b	0.03	6.22	6.28
	St B	6.11^a	0.02	6.10	6.13
	St C	6.73^c	0.03	6.70	6.75
	St D	6.65^c	0.09	6.55	6.71
	St E	6.73^c	0.01	6.72	6.74
TDS (mg/L)	St A	390^b	14.2	381	406
	St B	385^b	3.61	382	389
	St C	427^c	5.86	420	431
	St D	365^a	1.15	364	366
	St E	365^a	1.00	364	366
	WHO (2011)	**<600**			
EC (µS/cm)	St A	780^c	28.0	762	812
	St B	769^{bc}	4.58	764	773
	St C	854^d	11.9	840	862
	St D	730^{ab}	2.08	728	732
	St E	720^a	16.2	701	729
	WHO (2011)	**1000**			
Salinity (mg/L)	St A	390^b	15.0	381	407
	St B	380^{ab}	7.77	371	386
	St C	425^c	6.03	419	431
	St D	364^a	2.08	362	366
	St E	364^b	2.00	362	366
	WHO (2011)	**100**			
Total Alkalinity (Mg/L)	St A	154^a	5.66	150	158
	St B	151^a	1.41	150	152
	St C	225^c	4.24	222	228
	St D	197^b	4.24	194	200
	St E	196^b	5.66	192	200
	WHO (2011)	**200**			
Total Acidity (Mg/L)	St A	51.0^a	7.07	46.0	56.0
	St B	73.0^a	1.41	72.0	74.0
	St C	72.0^a	2.83	70.0	74.0
	St D	58.0^a	19.8	44.0	72.0
	St E	146^b	33.9	122	170
	WHO (2011)	**-**			
Chloride ion (Mg/L)	St A	1060^a	114	980	1140
	St B	2420^b	39.60	2390	2450
	St C	2600^b	327	2370	2840
	St D	1260^a	124	1180	1350
	St E	1480^a	238	131	1650
	WHO (2011)	**250**			
Dissolved Oxygen (Mg/L)	St A	8.00^a	1.13	7.20	8.80
	St B	8.60^a	1.98	7.20	10.0
	St C	15.4^a	3.11	13.2	17.6
	St D	11.0^a	2.55	9.20	12.8
	St E	8.90^b	0.28	9.60	10.0
	WHO (2011)	**13-14**			

Mean values in the same column with different superscripts are significant at $P \leq 0.05$

Relationship between physicochemical parameters

Pearson's correlation coefficient conducted between parameters is presented in Table 2, this reveals that pH had a significantly strong relationship to T. Alkalinity (r=0.915, p<0.01). TDS had a significantly strong relationship with EC (r= 0.988, p<0.01) and salinity (r=0.992, p<0.01). EC had a significantly strong relationship with salinity (r=0.978, p<0.01) while T. Acidity was significantly related to DO (r=0.917, p<0.01).

Table 2: Correlation of Matric between parameters

	Temperature	pH	TDS	EC	Salinity	T. Alkalinity	T. Acidity	Cl^-	DO
Temperature	1								
pH	-0.392	1							
TDS	0.412	0.019	1						
EC	0.456	-0.012	0.988**	1					
Salinity	0.424	0.065	0.992**	0.978**	1				
T. Alkalinity	-0.366	0.915**	0.269	0.229	0.324	1			
T. Acidity	-0.744*	0.460	-0.317	-0.448	-0.296	0.278	1		
Chloride(Cl^-)	-0.176	-0.023	0.559	0.551	0.483	0.262	-0.021	1	
Dissolved Oxygen (DO)	-0.843**	0.499	-0.444	-0.535	-0.414	0.238	0.917**	-0.209	1

*Correlation is significant at the 0.05 level (2-tailed) **Correlation is significant at the 0.01 level (2-tailed)

DISCUSSION

The temperature of the stream is the degree of coldness and hotness of the stream. The slightly low temperature recorded in station E can be linked to the atmospheric temperature at the time of sampling. The report from the study was lower than the report of abattoir effluents in Omu – Aran, Nigeria (26.90 – 26.70 °C) (Elemile *et al.*, 2019) and largely lower to the palm oil mill effluents from Rivers State Nigeria (45–70ºC) (Kanu and Achi, 2011). The pH of a stream in a pure state is neutral, therefore, water is neither acidic nor basic. Although pH has no significant hazardous implication on the health of humans, its impact on physiology cannot be neglected (Famuyiwa *et al.*, 2023). The slightly low pH recorded in stations C, D and E which are downstream is due to the lotic nature of the stream. The pH recorded across the stations is similar to the reports from Iju river, Ogun State (6.65 – 8.56) impacted by industrial effluents (Famuyiwa *et al.*, 2023), and surface water in Ogbomosho, Nigeria (5.7–6.7) (Adelowo *et al.*, 2012). Total dissolved solid is an important parameter in evaluating the suitability of water for irrigation since the solid might clog both pores and components of the water distribution system (Tadesse *et al.*, 2018). TDS recorded from the streams comply with the WHO (2011) 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).

Electrical conductivity is a measure of the capacity of a water sample to conduct electric current as well as the relative level of total dissolved salts in the water (Ebenebe *et al.*, 2020). The EC concentration from the streams is higher than the report in effluents from Omu–Aran, Nigeria (432 – 547µS/cm) (Elemile *et al.*, 2019) but extremely lower than the report from industrial effluent in Imo State, Nigeria (10460 µS/cm) (Ogemdi and Gold, 2018). The salinity of the stream is a measure of dissolved salts in the stream (Tadesse *et al.*, 2018), the high salinity recorded across the stations could be due to the presence of ions derived from soaps and detergents linked to the discharge of domestic waste and washing of automobiles. The salinity recorded from this study is extremely higher than that reported from mini Whuo Stream (24.82±4.97mg/L), Port Harcourt, Rivers State, Nigeria (Edori *et al.*, 2021).

Total alkalinity is the concentration of titratable bases in water (Boyd *et al.*, 2016). Alkalinity moderate's acidification as a concentration of buffering species, therefore it has been observed that aquatic ecosystems with relatively low alkalinity are more susceptible to anthropogenic acidification (Sandborn *et al.*, 2023). The high total alkalinity recorded in station C can be linked to temperature and increased levels of bicarbonate because of the high rate of photosynthesis (Eze and Chigbu, 2015). The total alkalinity recorded across the stations is higher than the report from surface water in Owerri (8.89 - 20.88 mg/L) (Umedum *et al.*, 2013) and in the dry season from river Sokoto (11- 71 mg/L) (Raji *et al.*, 2015).

The primary cause of acidity in naturally occurring, unpolluted waters is CO_2. Weak acids like CH_3COOH can make a major contribution to the overall acidity of contaminated waters (Olawale, 2016). Acidity levels in water indicate its corrosive properties and can take a leading role in regulating biological processes as well as in chemical reactions coagulation and flocculation

(Prasanthi *et al*., 2012). Additionally, adding to the acidity of some organic fluids are organic acids. The high acidity recorded in the study is traceable to discharges from lead smelting battery workshops around the stream. The acidity recorded across the streams is exponentially higher than the report from Asa River, Ilorin (26.3 - 50.23 mg/L) (Olawale, 2016) and River Sokoto (05- 20 mg/L) (Raji *et al.*, 2015).

The concentration of Cl^- in the study is extremely high across the stations, chlorides may get into surface water from several sources however, the high concentration from this study can be linked to a wide range of activities around the stream especially domestic sewage (Hong *et al.*, 2023). High concentrations of Cl^- ions in water produce an unpleasant taste and harm human health such as skin damage, Additionally, extremely high Cl^- ions in water have a corrosive effect on reinforced concrete (used for bridges) and accelerate the ageing of buildings (Hong *et al.*, 2023). Chlorides can contaminate freshwater streams therefore, Fish and aquatic communities cannot survive in high levels of chlorides (Kumar and Puri, 2012). The concentration of Cl^- ions across the stations is higher than the reports from Imo State, Nigeria in industrial effluents (80 mg/L) (Ogemdi and Gold, 2018) and in Nkoho river, Abia State, Nigeria (367.9 mg/L) (Chidozie and Nwakanma, 2017).

The DO is a measure of the degree of pollution by organic matter, the destruction of organic substances as well as self-purification capacity of the water body (Ojekunle and Lateef, 2017). The DO relationship to bodies of water provides both direct and indirect information about things like photosynthesis, bacterial activity, and nutrient availability. At low-level do can cause rust in boilers, heat exchangers, and water pipelines (Eze and Chigbu, 2015). The DO concentration in four (4) of the stations was below the acceptable level while one of the stations is above. Low or high DO in water can be a potential threat to aquatic life (Puri and Kumar, 2012). Fish in water with low DO would be hypoxic while excessive dissolved gases may suffer from "gas bubble disease" which is however a very rare condition (Kumar and Puri, 2012). Adequate dissolved oxygen is necessary for good water quality. The DO concentration across the station is higher than the report from industrial effluent 100 meters downstream of River Iju (7.56 mg/L) (Famuyiwa *et al.*, 2023) and abattoir effluent 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 impact of anthropogenic activities on the physicochemical quality of the Oke Bola stream in Ibadan, Oyo State, Nigeria was evaluated in the present study. Analytical results revealed an unacceptable temperature in station E, pH in stations A and B, total alkalinity in station C, salinity and Cl^- concentration across the stations and DO across the stations which can be attributed to the anthropogenic activities around the stream. It is therefore recommended that the level of human activities around the streams should be regulated and monitored.

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