

IMPACT OF ABATTOIR EFFLUENTS ON THE PHYSICOCHEMICAL PARAMETERS OF THE MIDDLE REACHES OF THE NEW CALABAR RIVER, NIGER DELTA

¹AKANKALI J. A., *¹I. C. DAVIES AND ¹O. L. OLALEYE

¹Department of Fisheries, Faculty of Agriculture, University of Port Harcourt, P.M.B. 5323, Choba, Port Harcourt, Nigeria.

*Corresponding author: Email: davies.chris@uniport.edu.ng, +234 703 882 5990

ABSTRACT

Analysis of the impact of abattoir effluents on the physicochemical parameters of the New Calabar River was carried out from February 2020 to July 2020. All parameters were determined using APHA 2340C standards. From the results, the pH ranged from 6.92 to 7.20, while the temperature was from 18.69 to 29.10° C. Salinity ranged from 3.83 to 6.73ppt while chloride was between 5.19 and 9.72mg/l. The Dissolved Oxygen (DO) was between 3.03mg/l to 5.44mg/l while the biological oxygen demand (BOD) values varied from 0.19mg/l to 4.7mg/l, Nitrate was between 2.4 to 3.9mg/L, Phosphate (PO_4^{3-}) values varied from 8.72mg/l to 13.93mg/l and total alkalinity was from 41.37mg/l to 46.80mg/l. pH was at the highest value in July and the lowest in May. The temperature, BOD, alkalinity turbidity, DO, nitrate, salinity, and total hardness values varied across stations and seasons. Conductivity values were lowest in station 1 and greatest at station 3. The highest conductivity was observed in February and the lowest was in July. Generally, the results were within acceptable levels for WHO (2006) and FEPA (2011). However, continuous discharge of this untreated abattoir and other wastes into this river could eventually render the water unsuitable for human use.

Keywords: Slaughter-houses, Variations, Pollution, Regulations, Compliance

INTRODUCTION

Water bodies are considered to be a vital resource with numerous applications and their importance for life on earth because of their unique properties, and as important as water is in all these sectors, water is the most poorly utilized resource in the world (David, 2014). Water being very indispensable played an important role in the determination of the quality of life (Walaqira and Okot-Okumu, 2011). The discharge of untreated water effluents such as agricultural or industrial effluents into major water bodies is a major problem globally which is being experienced by both developing and developed countries of the world. Otokunefor and Obiukwu (2005) posited that most of the water bodies in the world especially developing countries like Nigeria are known as the endpoints of effluents discharged from industries.

Abattoirs, also known as slaughterhouses, are defined as places, buildings, avenues, or premises approved by a controlling authority for the hygienic slaughter of animals and the inspection of meat products for human consumption (Nouri *et al.*, 2008). Wastes from slaughterhouses also known as abattoirs could come in various ways, ranging from solid, liquid and fats which could be highly organic. The solid part of the waste consists of condensed meat, undigested feed, bones, hairs, and aborted fetuses. The liquid aspect on the other hand consists of dissolved solids, blood, gut contents, urine, and water, while fat waste consists of fat and oil

(Magaji and Vhup, 2012). Effluents from abattoirs/slaughterhouses often result in the destruction of primary producers in water; the holoplankton, which subsequently has adverse impacts, on fish yields, because of the disruptions within the food chain.

Blood, hair, and most organs of animals slaughtered at abattoirs/slaughterhouses have been reported to contain toxic metals and could have adverse effects on rivers (Jukna *et al.*, 2006). Osemwota (2010) also reported that abattoir wastes can modify the physicochemical properties of water. This modification generally portends adverse consequences.

The New Calabar River is subject to effluent discharges from industries sited along its banks coupled with surface run-off resulting from soil erosion, anthropogenic operations, dredging activities, and domestic sewage inputs which may lead to wide-scale contamination of the river (Ogan and Nwiika, 1993). Tuckfield and McArthur, 2000) reported that rivers contaminated with effluent and agricultural run-offs are detrimental to aquatic life as they lead to a high presence of elements that could lead to the destruction of aquatic organisms and harbour pathogens. Oxygen availability is an essential water indicator of water quality and it is known that a high oxygen demand will lead to low amounts of dissolved oxygen required to sustain aquatic life (Yakub *et al.*, 2009; Adeogun *et al.*, 2011). Koech *et al.* (2012) reported the presence of high oxygen in animal effluents, especially animal

blood which could have adverse effects on aquatic organisms when discharged into a water body. This leads to a possible phenomenon of accelerated putrefaction of the organic wastes in water through the rapid multiplication of aerobic bacteria, which in turn leads to a heightened biological oxygen demand on such water bodies. Water-borne pathogens have also been associated with abattoir effluents which could influence the physicochemical parameters of water (Nafarnda *et al.*, 2012; Atuanya *et al.*, 2012).

Dienye and Woke (2015) reported that the New Calabar River section that flows through the Choba community, River State, has Abattoirs/Slaughter houses located along its bank that are known for the discharges of their wastes directly into the river. These abattoir effluents being discharged into this river have adverse impacts on the people who majorly depend on the water body as a source of livelihood. Apart from this aforementioned reason, most of these effluents are known to be hazardous to humans and aquatic life as they could lead to the transmission of pathogens subsequently resulting in different diseases (Inyinbor *et al.*, 2018). Therefore, this study is undertaken to assess the impacts of abattoirs and other anthropogenic effluent wastes on the physicochemical parameters of the New Calabar River. It is also projected that findings from this study would further help to enhance the existing empirical data on the water quality status of the New Calabar River.

MATERIALS AND METHODS

Study Area

The study area covered the middle reaches of the New Calabar River which is located within the Niger Delta. This section is a major Abattoir owned by the Choba Community, situated about 15km from Port Harcourt city. The area also has other activities such as a major weekly market and households/commercial ventures, including manufacturing concerns that collectively discharge untreated effluents and solid wastes into the water of the river perennially. The study area is located in the Obio-Akpor Local Government Area of Rivers State, between longitude 06 °89'85" E and latitude 04 ° 88'88" N of the Greenwich Meridian (Figure 1). The Choba abattoir, situated at the bank of the

receiving watercourse and close to the Choba Market, has existed for several decades with an average daily slaughter of 15-20 cows (Tekenah *et al.*, 2014). Among the facilities within the premises is a feedlot, where farm animals are housed before they are slaughtered and a slaughter slab with water taps. All these activities and facilities discharge most of their effluents and solid wastes directly or indirectly into this section of the New Calabar River. It is also important to note that the New Calabar River has been a very important source of socio-economic activities for those living in the area. It serves as a very important source of supply of freshwater fish for consumption, sand dredging for construction purposes and water transportation using both motorized and non-motorized boats amongst others.

A total of three sampling stations that were at least 1000 meters apart from each other were chosen along the river. Based on the peculiarities and features observed around the study area of this river in terms of various pollution-generating activities, the three sampling stations were selected along the river bank to reflect different activities in the areas. The most important consideration in selecting the sampling locations was to ensure that the sampling stations were distributed in a way to ensure the elimination of bias. This was achieved by locating one station at the upstream (Station 1), midstream (Station 11), and downstream (station 111). The midstream is the core area where the Abattoir is located. A basic description of the particular activities associated with each of the sampling stations is contained in Table 1.

Water samples were collected from these stations to analyze critical Physicochemical parameters of the water. All sites were geo-referenced using a handheld global positioning system (GPS) receiver unit (Magellan GPS 315) to generate geographic coordinates (longitudes and latitudes) of the sampling points. Sampling was carried out once a month between February to July 2020. All the samples were collected within the first week of each sampling month. Figure 1 shows a map of the study area and the various sampling stations along the middle reaches of the New Calabar River course.

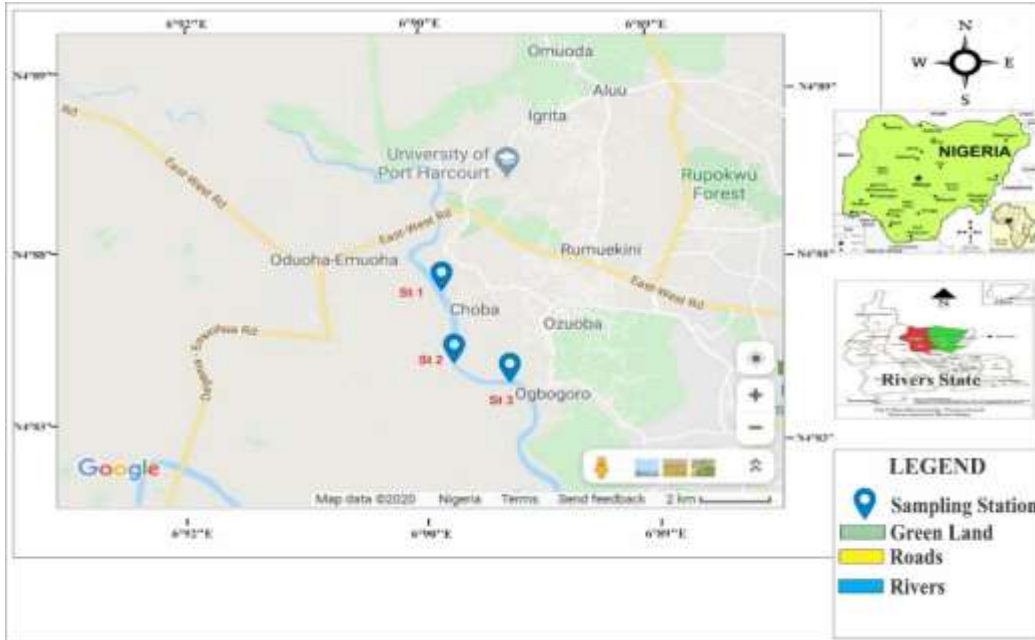


Figure 1: Map of Rivers State showing New Calabar River

Table 1: Sampling Stations Descriptions

Sampling point	Description	Coordinates
Upstream (Station 1)	A dredging zone full of anthropogenic activities	N4°53' 3.78 and E6°54' 32.33)
Midstream (Station 2)	Slaughterhouse (abattoir), fishing activities, marketing.	N4°53' 18.99 and E6°53' 53.46)
Downstream (Station 3)	Abandoned rig, dredging, human waste, and oil spillage	N4°50' 5.85 and E6°54' 32.33).



Station 1



Station 2



Station 3

Plates 1-3: Pictures showing typical effluent and waste generating activities within each station

Station 1: A dredging zone full of anthropogenic activities

Station 2: Slaughter house (abattoir), fishing activities, and market.

Station 3: Abandoned rig, dredging, human waste and oil spillage.

Sampling Procedure**Water Samples Collection**

Surface water samples were collected in pre-cleaned high-density Schott glass bottles. The sampling bottles were cleaned using detergent rinsed with tap water and soaked in 50% hydrochloric acid (HCl) for 24 hours before sampling. The bottles were then washed with tap water and rinsed with distilled water before sampling. The bottles were cleaned to ensure that they were not contaminated with metal residue before sampling and to prevent the adhering of metals to glass surfaces since acidification of the glass enhances metal dissolution. Samples after collection were properly sealed and transported to the laboratory for analysis.

Physicochemical Parameters Analysis

Schott glass bottles were used to collect surface water samples. The temperature, pH, salinity and conductivity of the water were measured using an in-situ Handheld Multimeter (Milwaukee Model pH600 and Laboratory Benchtop meter 860033-model). The dissolved oxygen (DO) was measured using Winkler's method. A 5-day BOD test was used to evaluate the biochemical oxygen demand (BOD) (APHA, 2005). A Secchi disc with a diameter of 20 cm was used to measure turbidity. Total alkalinity was measured using the American Society for Testing and Materials guidelines (ASTM D 1067B). Nitrate, Chloride, Phosphate, Hardness and Sulphate were determined using the method recommended by APHA 2340C (APHA, 2005) standards.

Statistical Analysis

Descriptive statistics and analysis of variance (ANOVA) were conducted using SPSS version 16. The Duncan Multiple Range Test at 0.05 was employed to distinguish significant means. Mean and standard error of the mean was the statistical measures utilized to handle the dataset.

RESULTS

The variations in the physicochemical parameters of the stations sampled across the months (February to July) are shown in Table 2. The temperature recorded its highest value in June (29.10°C) and it is lowest in May (18.69°C). There were no significant differences ($P > 0.05$) across the months for temperature. The pH from February to July also showed no significant differences across the months with its highest value recorded in July (7.20) and its lowest in May (6.73). The table further shows that conductivity ranged from 1940 μ S/cm in February to 1346 μ S/cm in July, no significant differences ($P > 0.05$) were observed. In the same way, the salinity measurements for

February, March, and April did not show any significant variance among them. However, the salinity levels observed in May, June, and July were not significantly different from each other but were significantly different ($P < 0.05$) from those in February, March, and April. The highest salinity value was recorded in July (6.67 ppt) and the lowest in May (3.83 ppt). The dissolved oxygen in the months of April to July was significantly different ($P < 0.05$) from February and March, and the highest value was recorded in March (5.44mg/l) and the lowest in July (3.03mg/l). Furthermore, biochemical oxygen demand (BOD) showed the highest values in July (4.17mg/l) and the lowest in March (0.17mg/l). In terms of BOD, there was no significant difference ($P > 0.05$) between February and March, but a significant difference ($P < 0.05$) between April and July.

Turbidity recorded its highest values in May (6.50NTU) and it is lowest in March (5.10NTU) and there were no significant differences across the months. Nitrate also showed no significant differences across the months with its highest value recorded in July (3.93mg/l) and the least in February (2.40mg/l). Alkalinity, however, recorded its highest value in April (46.8mg/l) and lowest value in February (41.37mg/l), there were no significant differences across the months. Furthermore, Chloride from February to March was not significantly different ($P > 0.05$), while the value for April was significantly different in comparison with the rest months. The highest value for chloride was recorded in February (9.72 mg/l) and the lowest in July (5.19 mg/l).

The result for phosphate showed significant differences ($P < 0.05$) across the months, with April being the most significantly different across the months. Phosphate's highest value was recorded in February (13.93mg/l) and the least was in July (8.72mg/l). The result of sulphate was highest for the month of March (7.57mg/l) and its lowest figure in July (3.90mg/l), while sulphate pollution across the six months showed that February and March were not significantly different ($P > 0.05$). However, the other four months were significantly different ($P < 0.05$), with April being the most significantly different ($P < 0.05$) across the months for the seasonal variations of the analyzed parameters in the sampled waters of the New Calabar River.

Table 2: Mean Monthly Variation of the Physicochemical Parameters of the Surface Water

Parameters	February	March	April	May	June	July	WHO (2006)	FEPA (2011)
Temperature °C	26.87±0.03 ^b	26.80±0.03 ^b	27.30±0.03 ^a	28.69±0.03 ^a	29.10±0.7 ^a	27.77±0.4 ^a	24 - 28	<40
pH	7.03±0.42 ^a	7.03±0.37 ^a	6.90±0.20 ^a	6.73±0.15 ^a	6.76±0.35 ^a	7.20±0.10 ^a	6.8-8.5	6 - 9
Conductivity (µS/cm)	194.7±0.05 ^a	185±0.08 ^a	169.2±0.04 ^b	155.4±0.03 ^b	136.6±0.08 ^c	134.6±0.03 ^c	1000	1000
Salinity (ppt)	3.83±0.45 ^b	4.05±0.05 ^b	4.63±0.04 ^b	5.77±0.51 ^a	6.73±0.21 ^a	6.67±0.15 ^a	-	10000
DO (mg/L)	5.02±0.40 ^a	5.44±0.47 ^a	3.38±0.05 ^b	3.23±0.06 ^b	3.17±0.02 ^b	3.03±0.02 ^b	3 -7	7.5
BOD (mg/L)	0.19±0.02 ^c	0.17±0.03 ^c	2.42±0.31 ^b	4.20±0.10 ^a	4.03±0.12 ^a	4.17±0.25 ^a	4	5-7
Turbidity (NTU)	5.20±0.34 ^b	5.10±0.50 ^b	6.37±0.50 ^a	6.50±0.96 ^a	6.40±0.26 ^a	6.47±0.15 ^a	5	-
Nitrate (mg/L)	2.40±0.54 ^a	2.75±0.86 ^a	2.58±0.82 ^a	3.17±0.70 ^a	3.34±0.12 ^a	3.93±0.17 ^a	10	10
Alkalinity (mg/L)	41.37±0.61 ^a	42.63±0.59 ^a	46.80±0.46 ^a	46.63±3.2 ^a	43.97±2.3 ^a	41.97±1.7 ^a	-	-
Hardness (mg/L)	37.60±4.1 ^a	38.70±4.5 ^a	33.38±1.54 ^a	36.50±2.1 ^a	33.83±1.42 ^a	31.63±1.6 ^a	500	200
Chloride (mg/L)	9.72±1.46 ^a	9.71±1.30 ^a	7.75±1.42 ^{ab}	6.20±0.93 ^b	5.42±0.80 ^b	5.19±0.84 ^b	250	250
Phosphate (mg/L)	13.93±2.1 ^a	13.58±2.0 ^a	11.32±0.96 ^b	9.92±1.13 ^c	9.45±1.42 ^c	8.72±1.20 ^c	5	2
Sulphate	7.57±1.08 ^a	7.71±0.94 ^a	6.12±0.80 ^{ab}	4.34±0.83 ^b	4.06±0.71 ^b	3.90±0.77 ^b	250	500

Note: Means of values with different superscripts on the same row are significantly different from each other

The intra-monthly variations for all twelve analysed physicochemical parameters (Temperature, DO, Nitrate, Chloride, pH, Total Alkalinity, Phosphate, Salinity, Turbidity, Total Hardness, and Sulphate) from February to July 2020 are illustrated graphically with bar charts as shown in figures 2 to 7. Figure 2 shows that total alkalinity and hardness had the highest values in February. The highest value (47.62mg/l) was recorded in Station 2. The highest value of hardness (37.71mg/l) was recorded in station 3 in February while the lowest values were recorded in station 3 (33.24mg/l) and station 2 (35.28mg/l). The BOD (2.39mg/l) and nitrate (2.57mg/l) in station 1 recorded the lowest values.

Figure 3 showed that Total alkalinity had the highest value for the physicochemical parameters in March, with a value of 49.5mg/l recorded for station 2 while stations 1 and 3 recorded the same value (39.2mg/l). The total hardness had the highest value while the alkalinity in March ranged between 43.91mg/l to 36.22mg/l. Station 3 recorded the highest value (figure 2) while station 1 had the least (36.22mg/l). The lowest physicochemical parameters were recorded in March. However, BOD values ranged between 0.15mg/l to 0.20mg/l. The lowest value of BOD was observed in station 1 while station 3 recorded the highest value.

Figure 4 showed total alkalinity had the highest value with a range of between 54.2mg/l to 43.9mg/l with station 2 having the highest value for April. Total hardness had the highest values in station 3 (35.12mg/l) and station 2 (32.81mg/l)

with slight variation from station 1 (32.2mg/l). The BOD values ranged between 2.11mg/l to 2.73mg/l for April.

The alkalinity value of 49.5mg/l recorded in station 3 was the highest physicochemical parameter in the May station. The lowest dissolved oxygen (DO) ranged between 3.3 mg/l to 3.21 mg/l. The value differs from all the previous months with BOD for May recording the lowest values. DO was lowest at station 2 (3.21mg/l) and was slightly different from station 3 with a value of 3.20 mg/l while station 1 recorded the highest DO value of 3.3mg/l.

The result for total alkalinity was highest at station 3 (46.2mg/l) in June, while dissolved oxygen (3.17mg/l) was lowest at station 2 in June (Figure 6). The total alkalinity and total hardness were highest in July compared to other parameters. Total alkalinity recorded ranged between 40.1mg/l to 43.5mg/l with Station 3 recording the highest value and lowest (40.1mg/l) in Station 1. Total hardness was highest in station 2 (33.5mg/l) and the least (30.2mg/l) in station 1. The dissolved oxygen ranged from 3.01mg/l to 3.04mg/l in July (figure 7).

The values for the inter-monthly variations for conductivity readings from February to July are shown exclusively in Figure 8. The Conductivity value was highest in February (1940µS/cm) while July recorded the lowest value (1346µS/cm) across the months. Station 3 had the highest conductivity value (1959.57µS/cm) across the stations while station 1 recorded the lowest value (1417.1µS/cm).

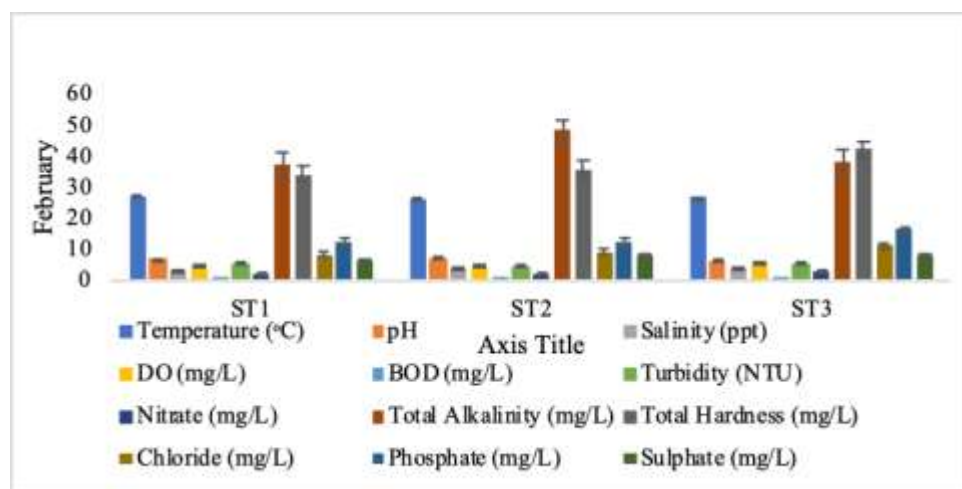


Figure 2: Physicochemical variations for February

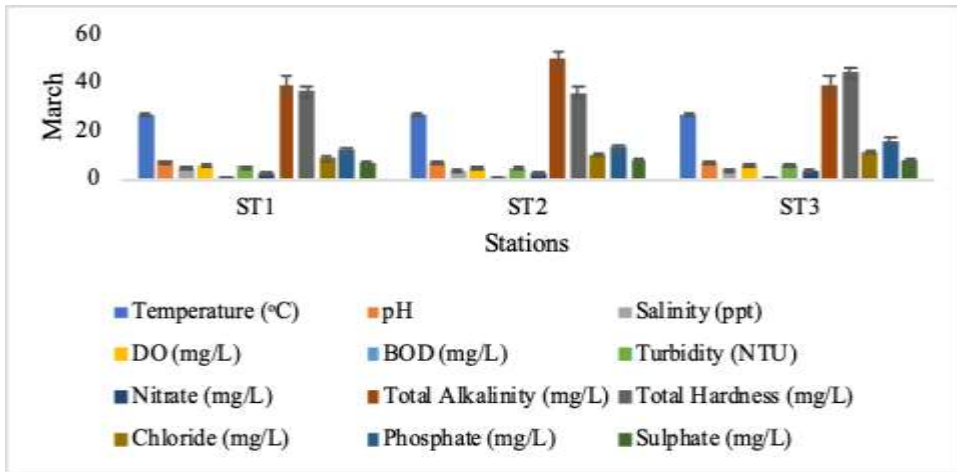


Figure 3: Physicochemical variations for March

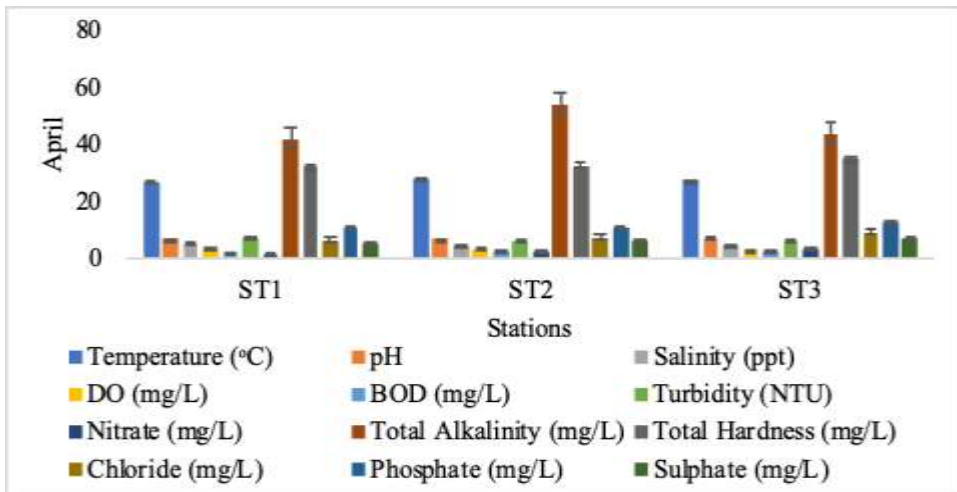


Figure 4: Physicochemical variations for April

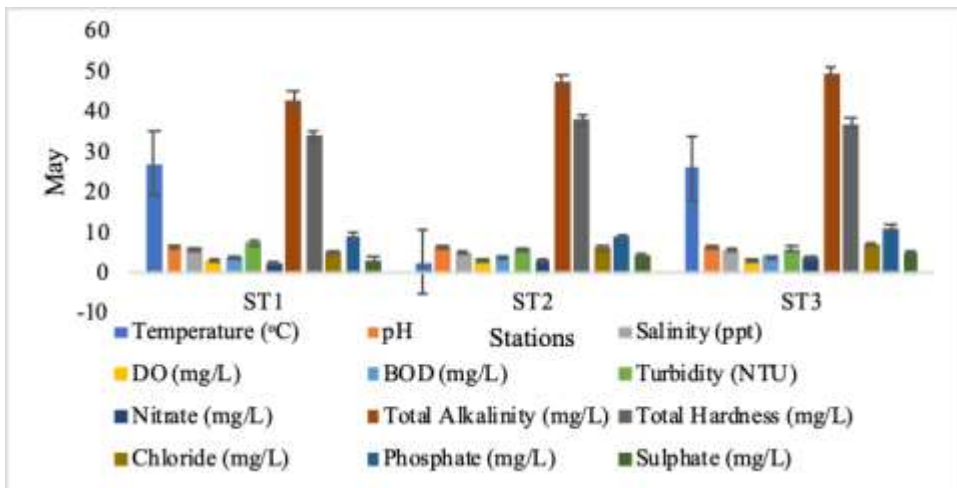


Figure 5: Physicochemical variations for May

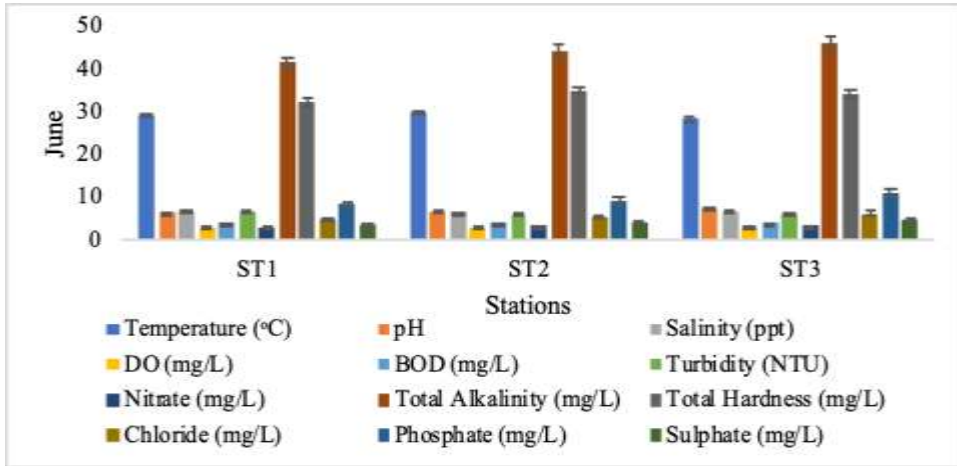


Figure 6: Physicochemical variations for June

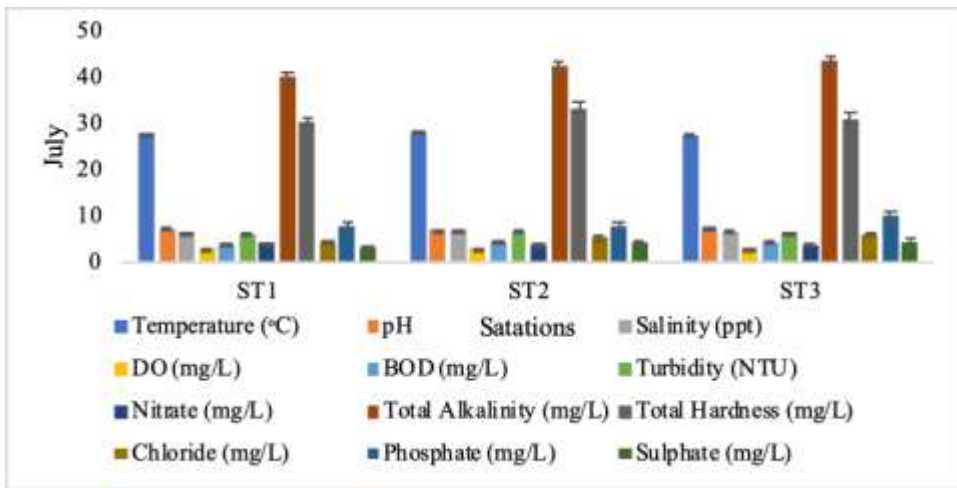


Figure 7: Physicochemical variations for July

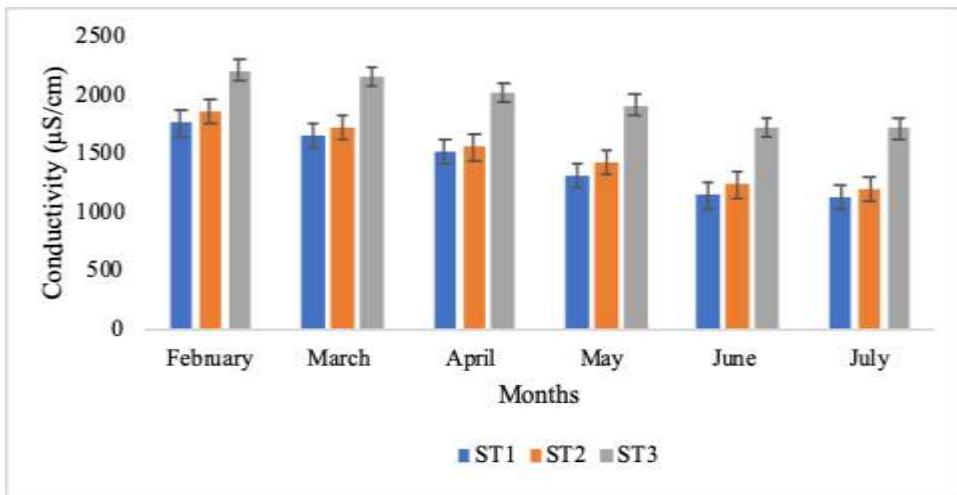


Figure 8: Conductivity across the months

DISCUSSION

Temperature

Temperature is important as the amount of dissolved oxygen is affected by temperature which influences the survival of micro-organisms. The

temperature recorded in this study ranged between 18°C-29°C across the months, which was slightly above the World Health Organization (WHO) upper limit of 28°C, it is however lower than the FEPA standard range value (<40°C) and can be

said to be within the acceptable limits. This observation was in agreement with the findings earlier reported in the Niger Delta waters, as reported by (Dirisu *et al.*, 2016)). This resulting study is also in agreement with what was reported by (Benz *et al.*, 2017). Where it was reported that there is a relationship between ambient temperature, wastewater and groundwater temperature.

pH

pH is the negative logarithm of H⁺ concentration. If the pH of water is too high or too low, the aquatic organisms living within it will die (Edori and Nna, (2018). The seasonal variation of pH values observed in this study ranged from 6.7 to 7.2 across the months and complies with the range of WHO (6.8-8.5) and FEPA (6-9) standard values (2011). Akakuru *et al.* (2022) reported a similar result and stated that a high value of pH observed would likely cause diseases in aquatic organisms such as acidosis and also referred to as an indicator of the presence of microorganisms as it controls their activities.

Electrical Conductivity

The electrical conductivity of water is directly related to the concentration of ions and their mobility. Studies showed that electrical conductivity is indicative of dissolved ionizable solids (Davies and Okonkwo, 2021). Electrical conductivity observed in this study was high across the months in comparison to WHO (2006). However, the results were above the permissible limit of the FEPA standard (2011) which is 1000µS/cm, therefore the water is said to be polluted. The result reported by Stanley *et al.* (2017) also agrees with the current result and states that the concentration of salts dissolved in the water is as little as possible and that a high amount of electrical conductivity above permissible limits can defect the endocrine functions. Afolabi *et al.*, 2012 reported a conductivity value of 332.5µS/cm for borehole water exceeding the 1000µS/cm limit as indicative of saline intrusions into the groundwater. This may be due to the continuous discharge of chemicals and salts from industrial effluents (Adewuyi *et al.*, 2010).

Salinity

The salinity recorded in this study ranged from 3.8ppt to 6.7ppt as compared to FEPA, the value obtained in the study was very low. Uedeme-Naa *et al.* (2011) disagreed with the result of this study and the mean value of salinity was reported to be the same in all the sampled stations in the Nta-Wogba stream in Port Harcourt. Dirisu *et al.*, (2016) also agree with the current finding. Stanley *et al.* (2017) whose results compared favourably

stated that the variations may be due to the excessive lowering of the water table along the creek leading to the reversal of hydraulic gradient and saltwater intrusion.

Chloride

Chlorine is present in most disinfected drinking water at safe concentrations. The value for the chloride observed across the months ranged from 5.19mg/l to 9.72mg/l which is not in conformity with that of Elemile *et al.* (2019) who stated that chloride ions are harmless at low levels and water with high concentrations of chloride ions could damage plants if used for gardening or irrigation, and it could also give drinking water an unpleasant taste if consumed. This value falls below the FEPA standard value of 200mg/l and was not within acceptable limits. Govindaradjane *et al.* (2007) reported that a high positive correlation exists between EC and chloride content of water. In unpolluted waters, chloride concentrations are usually lower than 10 mg/L according to Medhi *et al.* (2005), however high amounts of chloride and sulphate may result in the hardness of the water. Sodium chloride, which is used as a dehydrating and antiseptic agent, is also a source of chloride in groundwater.

Total Hardness

Total hardness is a measurement of mineral content in a water sample that is irreversible by boiling. Hardness is the property of water that prevents the lather formation with soap by formation of a complex with calcium, and magnesium present in water. The value obtained from this study ranges from 31.63mg/l to 38.70mg/l and was below FEPA (2011) and WHO (2006) standard values for total hardness (200mg/l) and (500mg/l) respectively. The total hardness is also taken to comprise the calcium and magnesium concentrations expressed as Mg/L CaCO₃ agrees with Dienye and Woke (2015) who reported that hardness depends upon calcium or magnesium or both. Although abattoir wastewater has been reported to contribute to a high impact on the total hardness values and water quality index of an urban water body in Shimoga Town (Yogendra and Puttaiah, 2008).

Dissolved oxygen

DO is important because it is essential for the survival of aquatic organisms and also affects a vast number of other parameters such as odour, clarity, and taste (Davies *et al.*, 2021). Consequently, oxygen is perhaps the most important and established indicator of water quality, and contamination of sewage water and organic waste consumes oxygen (Kanun and Achi, 2011). The Dissolved Oxygen (DO) value of the water sample in this study ranges from 3.03mg/l to

5.44mg/l across the months and falls within the WHO (2006) standard (3-7mg/l) and FEPA (2011) standard value of 7.5mg/l. DO value obtained in this study is not in conformity with Dienye and Woke (2015) who carried out similar research work at the same site. However, Elimile *et al.* (2019) result finding agreed with this present finding.

Biological Oxygen Demand

BOD measures the quantity of oxygen consumption by microorganisms during the decomposition of organic matter (Dasgupta and Yildiz, 2016). As an indicator of water's organic quality, BOD is widely used, although it is not a precise quantitative test (Gholizadeh *et al.*, 2016). According to Lodh *et al.* (2014), the high BOD may indicate faecal and organic waste contamination from human and animal sources and restrict the use of water for drinking and domestic use. Biological oxygen demand (BOD) values obtained ranging from 0.19mg/l to 4.7mg/l did not agree with the result of Uedema-Naa, *et al.* (2011). The BOD value recorded in this study was within the standard value placed by WHO at 4mg/l. Also, in comparison to the FEPA standard at 5-7mg/l, the present study's BOD value falls within the range of their standard limit for BOD.

Turbidity

Turbidity is a measure of the relative clarity of a liquid. It is an optical property of water that determines how much light is scattered by stuff in the water when light is shone on it through the water sample. TU in drinking water may be due to the presence of inorganic particulate matter in some groundwater or the sloughing of biofilm within the distribution system according to Emmanuel and Nurudeen, (2012). The turbidity value obtained in this study ranges from 5.10NTU to 6.47NTU across the months and exceeds the WHO standard limit for turbidity at 5NTU. However, the results obtained from this study did not disagree with an earlier report by Edori and Nna (2018) from the New Calabar River.

Nitrate (NO₃⁻)

Nitrate is a polyatomic ion with the chemical formula NO₃. Nitrates are salts that include this ion. Nitrates are common components of fertilizers and explosives (Singh *et al.*, 2019). Almost all inorganic nitrates are soluble in water. Nitrate levels above a certain level can result in blue eye syndrome in newborns and pregnant women, as well as contribute to eutrophication (Pereira and Desai, 2020). The nitrate value obtained from this study which ranges from 2.4mg/L to 3.9mg/L falls within WHO and FEPA standards set for Nitrate. Edori and Nna (2018) reported a similar finding when they looked at the physicochemical properties of effluents at

discharge stations into the New Calabar River along the Rumuolumeni axis.

Phosphate

Phosphorus originates from the weathering of local rocks and fertilizer use (Aydin *et al.*, 2010). Phosphate may occur in a lake as a result of domestic waste, detergent, and agricultural runoff containing fertilizer (Ayele and Atlabachew, 2021). Phosphate (PO₄³⁻) values recorded in this study which ranged from 8.72mg/l to 13.93mg/l were reported to be higher than the FEPA (2011) standard value of phosphate (2mg/l). The values obtained in this study were above the limit set by WHO (2006) and could pollute the New Calabar River. Edori and Nna (2018) also agreed with this present result. Gopalkrusna, (2011) reported similar results and stated that the high amount of phosphate might be due to the discharge of municipality sewage and dumping of domestic waste into the waterbody.

Sulfate

Sulphate ranks second after bicarbonate as the primary anion in hardwater reservoirs. Sulphates (SO₄⁻) can be naturally occurring or the result of municipal or industrial discharges (Derkho *et al.*, 2021). Sulfates can also be found in water bodies caused by fertilizer runoff, soil containing gypsum, or atmospheric deposition. When naturally occurring, they are often a result of decayed leaves that fall into streams, or decaying soils containing gypsum and other common minerals (Bhateria and Jain, 2016). The value obtained for sulphate concentration in this study ranged from 3.9mg/l to 7.57mg/l was below the approved standard the WHO standard value for sulphate concentration is 250mg/l while FEPA is 500mg/l. Point sources include sewage treatment plants and industrial discharges such as oil spillage. Sulfates are also carried into water bodies by runoff from fertilized agricultural regions. (Singh and Gupta, 2016).

Total alkalinity

Total alkalinity is measured by measuring the amount of acid (e.g. Sulphuric acid) needed to bring the sample to a pH of 4.2 (Boyd *et al.*, 2016). The total alkalinity of water is defined as its ability to neutralize acids, and it is usually the result of calcium, sodium, and potassium bicarbonates and carbonates (Lawson, 2011). The total alkalinity value from this study ranges from 41.37mg/l to 46.80mg/l. However, the values were slightly similar to the values (10.0 to 44.0 mg/L) reported by Afolabi *et al.* (2012). This level of alkalinity may lead to corrosion and influence chemical, and biochemical reactions (George *et al.*, 2010).

CONCLUSION

There were significant variations in the physicochemical parameters of the middle reaches of the New Calabar River across the sampling stations. The variations across the stations and months could be attributed to the different types or magnitudes of water pollutants generated by anthropogenic activities in the study area that directly or indirectly release effluents and other types of wastes into the New Calabar River. Furthermore, it could be inferred that though the analyzed parameters were generally within the acceptable limits as given by WHO (2006) and FEPA (2011), if the present scenario where effluents from abattoirs and other wastes and effluents generating anthropogenic activities are not controlled, the New Calabar River could soon become significantly and adversely impacted by the pollutants from these sources. Such a situation will result in mass mortality of aquatic organisms of the river and trigger other associated health and socio-economic deteriorations for residents of the area and all other stakeholders that harness resources from the New Calabar River for their livelihoods either directly or indirectly.

RECOMMENDATIONS

It is therefore recommended that efforts should be made to enforce existing regulations set by the States and Federal Ministry of Environment that stipulate the minimum treatment standards of wastes, especially effluents before they are discharged into open water bodies such as the New Calabar River. Furthermore, adequate monitoring systems should be put in place to ensure that effluents and associated wastes being discharged in the river by the abattoirs and other activities comply substantially with set standards. Most importantly, relevant public awareness campaign programmes should be mounted for all concerned stakeholders to highlight the adverse consequences of the impacts of pollution from abattoir wastes and other sources to the concerned public by the relevant agencies.

REFERENCES

- Adewuyi, G.O. Oputu, O. U and Opasina, M.A. (2010). Assessment of Groundwater Quality and saline intrusions in Coastal Aquifers of Lagos Metropolis, Nigeria. *Journal of Water Resource and Protection* 2: 849-853.
- Afolabi, T.A., Ogbunike, C.C., Ogunkunle, O.A. and Bamiro, F.O. (2012). *Comparative Assessment of the Potable Quality of Water from Industrial, Urban and Rural Parts of Lagos, Nigeria. Ife Journal of Science*. 14(2): 221-232.
- Adeogun, A., Chukwuka, A. and Ibor, O. (2011). Impact of Abattoir and Saw-Mill Effluents on Water Quality of Upper Ogun River (Abeokuta). *American Journal of Environmental Sciences*, 7 (6).
- Akakuru, O. C., Eze, C. U., Okeke, O. C., Opara, A. I., Usman, A. O., Itheme, O., ... and Iwuoha, P. O. (2022). Hydrogeochemical evolution, water quality indices, irrigation suitability and pollution index of groundwater (PIG) around eastern Niger Delta, Nigeria. *International Journal of Energy and Water Resources*, 1-23.
- APHA, 2005. Standard methods for the examination of water and wastewater (21st ed.), Washington, D.C: American Public Health Association.
- Atuanya, E., Nwogu, N. and Akpor, E. (2012). Effluent Qualities of Government and Private Abattoirs and Their Effects on Ikpoba River, Benin City, Edo State, Nigeria. Pp; 196--201.
- Aydin, I., Aydin, F., Saydut, A., Bakirdere, E. G. and Hamamci, C. (2010). Hazardous metal geochemistry of sedimentary phosphate rock used for fertilizer (Mazıdag, SE Anatolia, Turkey). *Microchemical Journal*, 96(2), 247-251.
- Ayele, H. S. and Atlabachew, M. (2021). Review of characterization, factors, impacts, and solutions of Lake eutrophication: lesson for lake Tana, Ethiopia. *Environmental Science and Pollution Research*, 28(12), 14233-14252.
- Benz, S. A., Bayer, P. and Blum, P. (2017). Identifying anthropogenic anomalies in air, surface and groundwater temperatures in Germany. *Science of The Total Environment*, 584, 145-153.
- Bhateria, R. and Jain, D. (2016). Water quality assessment of lake water: a review. *Sustainable Water Resources Management*, 2(2), 161-173.
- Boyd, C. E., Tucker, C. S. and Somridhivej, B. (2016). Alkalinity and hardness: critical but elusive concepts in aquaculture. *Journal of the World Aquaculture Society*, 47(1), 6-41.
- Davies, I. C. and Okonkwo, S. E. (2021). Analyses of Some Heavy Metal and Nutrients of Water Samples from Ajegunle Creek in Lagos. *International Journal of Environment and Pollution Research*. Vol.9, No.1 pp.7-26.
- Davies, I. C., Agarin, O. J. and Onoja C. R. (2021). Study on Heavy Metals Levels and Some Physicochemical Parameters of a Polluted Creek Along the Tin Can Island in Lagos. *International Journal of Environment and Pollution Research*. 9(2), 25-39.
- David, N.O. (2014). Impact of untreated sewage waste discharge on the physicochemical properties of rivers in Port Harcourt Metropolis. *World Journal of Scientific Research and Reviews*. ;2(1): 1-19.

- Dasgupta, M. and Yildiz, Y. (2016). Assessment of biochemical oxygen demand as indicator of organic load in wastewaters of Morris County, New Jersey, USA. *Journal of Environmental & Analytical Toxicology*, 6(3), 378.
- Derkho, M. A., Mukhamedyarova, L. G., Nokhrin, D. Y., Zhivetina, A. V. and Meshcheryakova, G. V. (2021). Features of cathode-anion composition of water in the reservoir subject to anthropogenic contamination. In *E3S Web of Conferences* (Vol. 282, p. 07003). EDP Sciences.
- Dienye H.E. and Woke G.N. (2015) Physicochemical Parameters of the Upper and Lower Reach of the New Calabar River Niger Delta. *Journal of Fisheries Livestock Production* 3: 154.
- Dirisu, C. G., Mafiana, M. O., Dirisu, G. B. and Amodu, R. (2016). Level of pH in drinking water of an oil and gas producing community and perceived biological and health implications. *European Journal of Basic and Applied Sciences* Vol, 3(3).
- Edori, O. S. and Nna, P. J. (2018). Determination of physicochemical parameters of effluents at discharge points into the New Calabar River along Rumuolumeni axis, Niger Delta, Nigeria. *Journal of Environmental and Analytical Toxicology*, 8(3), 2161-0525.
- Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics*, 11(1), 1-42.
- Elemile, O.O., Raphae, O.R. Omole, D.O., Oloruntoba, E.O. and Ohwavboru, N.A. (2019). Assessment of the impact of abattoir effluent on the quality of groundwater in a residential area of Omu-Aran, Nigeria. *Environmental Science of European journal* .31:16.
- Emmanuel, B. and Nurudeen A., (2012), "Physicochemical Analysis of Ground Water samples of Bichi local government area of kano state of Nigeria, ". *ARPJ Journal of Science and Technology*, pp-325-332
- Edori, O. S., and Nna, P. J. (2018). Determination of physicochemical parameters of effluents at discharge points into the New Calabar River along Rumuolumeni axis, Niger Delta, Nigeria. *Journal of Environmental and Analytical Toxicology*, 8(3), 2161-0525.
- FEPA. (2011). *National Environmental Protection (effluents limitations) regulations - Environmental Physiology of Animal and Pollution*. Lagos, Nigeria: Published by Diversity Resources Limited. pp: 157 – 219.
- George, M., Umadevi, A.G., Dharmalingam, P., Abraham, J. P., Rajago- palan, M. Balakrishnan, D. A., Harridasan, P.P., and Pillai, P.M. (2010). An Investigation of Quality of Under- ground Water at Eloor in Ernakulum District of Kerala, India. *EJournal of Chemistry*. 7(3): 903-914.
- Gholizadeh, M. H., Melesse, A. M., and Reddi, L. (2016). A comprehensive review on water Quality Parameters Estimation using remote sensing techniques. *Sensors*, 16(8), 1298.
- Gopalkrushna, M.H., (2011). Determination of physico-chemical parameters of Surface Water Samples in and around Akot City, *International Journal of Research in Chemistry and Environment*, vol. 1 (2), pp. 183-187.
- Govindaradjane, S., Sundararajan, D., Sivamoorthy Reddy, S. and Sivasankaran, M.A. (2007). Physico-chemical characteristic of wastewater from a pharmaceutical industry. Pp: 131-133.
- Inyinbor Adejumoke, A., Adebessin Babatunde, O., Oluyori Abimbola, P., Adelani A., Tabitha, A., Dada Adewumi, O., and Oreofe Toyin, A. (2018). Water pollution: effects, prevention, and climatic impact. *Water Challenges of an Urbanizing World*, 33, 33-47.
- Jukna C, Jukna V. and Suigzdaite J. (2006). Determination of heavy metals in viscera and muscles of Cattle. *Bulgaria Journal of Veterinary Medicine*.9:35-41.
- 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 sanitation*, 1(1), 75-86
- Koech, H., Ogendi, G. and Kipkemboi, J. (2012). Status of Treated Slaughter-House Effluent and Its Effects on the Physicochemical Characteristics of Surface Water in Kavuthi Stream, Dagoretti-Kenya. *Research Journal of Environmental and Earth Sciences*, 4 (8), pp. 789-796.
- Lawson, E. O. (2011). Physico-chemical parameters and heavy metal contents of water from the Mangrove Swamps of Lagos Lagoon, Lagos, Nigeria. *Advances in biological research*, 5(1), 8-21.
- Lodh, R., Paul, R., Karmakar, B., and Das, M. K. (2014). Physicochemical studies of water quality With special reference to ancient lakes of Udaipur City, Tripura, India. *International Journal of Scientific and Research Publications*, 4(6), 1-9.
- Magaji, J.Y. and Chup, C.D. (2012). The Effects of Abattoir Waste On Water Quality sin Gwagwalada-Abuja, Nigeria. *Ethiopian Journal of Environmental Studies and Management EJESM* 5 (4).
- Mehdi, A. (2005). Effect of wastewater disposal and extent of industrial pollution in and

- around Kanpur, Uttarpradesh, India. pp: 31-35.
- Nafarnda, W., Ajayi, I., Shawulu, J., Kawe, M., Omeiza, G., Sani, N., Tenuche, O. and Dantong, D. (2012). Bacteriological Quality of Abattoir Effluents Discharged into Water Bodies in Abuja, Nigeria. *ISRN veterinary science*.
- Nouri, J., Karbassi, A. R. and Mirkia, S. (2008) Environmental Management of Coastal Regions In the Caspian Sea. *International Journal of Environmental Science and Technology*, 5 (1): 43-52.
- Otokunefor, T.V. and Obiukwu, C. (2005). Impact of refinery effluent on physicochemical properties of Water body in the Niger delta. *Applied Ecology and Environmental Research*. 2005; 3(1):61- 72.
- Osemwota, I.O. (2010). Effect of abattoir effluent on the physical and chemical properties of soils. *Environ Monitoring Assessment*. 167:399-404.
- Ogan, M.T. and Nwiika, D.E. (1993). Studies on the ecology of aquatic bacteria of the lower Niger Delta: Multiple antibiotic resistance among the standard plate count organisms. *Journal of Applied Bacteriology*. 74: 595-602.
- Pereira, F., and Desai, V. (2020). The Impact of Unbalanced Nitrogen Cycling On Human Health. *Global Implications of the Nitrogen Cycle*, 430.
- Singh, P., Singh, M. K., Beg, Y. R. and Nishad, G. R. (2019). A review on spectroscopic methods for the determination of nitrite and nitrate in environmental samples. *Talanta*, 191, 364-381.
- Singh, M. R. and Gupta, A. (2016). Water pollution-sources, effects and control. *Centre for Biodiversity, Department of Botany, Nagaland University*.
- Stanley, H.O., Immanuel, O.M. and Nwagboso, A. (2017). Water Quality Assessment of the New Calabar River. *Journal of Applied Life Sciences International*. 15(2): 1-5.
- Tekenah, W.E., Agi, P.I. and Babatunde, B.B. (2014). Analysis of surface water pollution from abattoirs and the interrelationship between physicochemical properties (A case study of the New Calabar River). *Journal of Environmental Science, Toxicology and Food Technology*.
- Tuckfield R.C. and McArthur J.V. (2000). Spatial and temporal parameters among stream bacterial assemblages. *Journal of the North American Benthological society* 16(2), 347-357.
- Uedema-Naa B., Gabriel U.U. and Akinrotimi O.A. (2011) The relationship between aquatic macrophytes and water quality in Nta-Wogba stream, Port-Harcourt, Nigeria. *Journal of Fisheries and Aquatic Science* 5: 6-16.
- Walakira P. and Okot-Okumu J. (2011). Impact of industrial effluents on water quality of receiving streams in Nakawa-Ntinda, Uganda. *Journal of Applied Sciences and Environmental Management*. ;15(2): 289-296.
- World Health Organisation. (2006). *Guidelines for Drinking Water Quality recommendation* (3rd ed.). NLM Classification: WA 675, 20 Avenue, Appia, 1211, Geneva, Switzerland
- Yakub, A. and Ugwumba, A. (2009). A study on the macroinvertebrate fauna of lower Ogun River at Ishasi, Ogun state, south-west Nigeria. pp (1).
- Yogendra, K. and Puttaiah, E.T. (2008). Determination of water quality index and suitability of an urban water body in Shimoga Town, Karnataka. In: *Proceedings on the 12th World Lake Conference, Jaipur, India*. pp 342–346.