Pollution Impacts of Abattoir and Associated Activities Wastes on the Water Quality of Eagle Island Creek, Niger Delta, Nigeria

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Abstract
This study was conducted to examine the impacts of abattoir and associated activities wastes on the water quality of Eagle Island creek; mainly on its physicochemical parameters. Specifically, the sampling stations covered the point where the Abattoir is located, and both up and down stream of the Abattoir location. The physicochemical parameters were analyzed using the methods as described by APHA (2005) The results recorded for physicochemical parameters from the various sampling points shows significant variation across the stations and the months. The observed physiochemical parameters values ranges are as from 27.2^{o}C-30.7^{o}C for Temperature, 4.83-7.58 for pH, 14.29-45.3mg/l for Conductivity, 449.66-601ppm for Salinity, 32.4-6.91mg/l for TDS, 7.3-63mg/l for TSS, 2.47-5.7mg/l for DO, 0.9-4.6mg/l for BOD, 4.73-8.31 NTU for Turbidity, 4.06-17.83 mg/l for Nitrate, 26.66-41.66 mg/l for Total Hardness, 185.8-959.1mg/l for Chloride, 0.12-3.51mg/l for Phosphate and 1.55-43.23mg/l for Sulphate respectively. Most of the parameters were within the stipulated limits of World Health Organization (WHO), except for Phosphate, Chloride, Turbidity and BOD that were higher than the acceptable levels for drinking water by WHO standards. This study thus recommends the need for increased public awareness on the possible impacts of the pollutants impacting the creek from Abattoir and associated activities wastes.

Keywords: Abattoir, Physicochemical Parameter and Water Quality

1. Introduction

Water is an essential component of man and over the years, man has depended on it for survival (Okere et al., 2021). It is a vital medium for transport, industry, recreation and many human activities. When there is an imbalance or changes in the physical, biological and chemical condition of any body of water, there would be harmful disruptions in the balance of its ecosystem (Agarin et al., 2019). In the last few decades, pressure has been increasing and greater emphasis is laid on the deterioration of the quality of rivers within the Niger Delta. This has rendered numerous water bodies in this area inaccessible, unwholesome and unable to sustain the teeming aquatic life associated with mangrove swamp ecosystems. (Okonkwo et al., 2021).

The pollution of the aquatic environment by inorganic and organic chemicals is a major factor posing serious threats to the survival of aquatic organisms (Idowu, 2011). The pollution of water resources often results in the destruction of primary producers, which in turn leads to an immediate diminishing impact on fish yields, with the resultant consequence of decrease in diet (Aina and Adedipe, 1991).

Pollutants are therefore chemical, physical or bacteriological in nature and can be measured more or less accurately in water, the physical and chemical characteristics of water determine the quality of water in a particular area (Ogbonna and Ideriah, 2014**).** Abattoir waste water is a typical source of pollution and creates serious environmental concerns **(**Onojake, 2011). Abattoir waste water has a complex composition and is very harmful to the environment **(**Ojo, 2014**).** It is strong compared to domestic waste water, it may also contain some manure, such characteristics render's abattoir waste water treatment very difficult (Bohdziewicz and Sroka, 2005).

The practice of abattoir in the developing countries for example Nigeria is alarming, it has led to an increase in the pollution level of the aquatic environment. The high loading rate of nitrogen, phosphorus and pathogens to soil and water can occur from animal operations such as grazing and abattoir business (Selormey et al., 2021). The waste from abattoir operations which are often separated into solid, liquid, and fats could be highly organic (Deborah et al,2016). The solid part of the waste consists of condensed meat, undigested ingest, bones and hairs. The liquid aspect on the other hand consists of dissolved solid blood, guts content, urine and water, while the fat waste consists of fats and oils **(**Elemile et al., 2019**).** Contamination of river bodies from abattoir waste could constitute a significant environmental and health hazard and the effluent could increase levels of nitrogen, phosphorus and total solids in receiving water body (Omole et al, 2008). The disposal of abattoir effluent into drains and streams is a common practice which poses health and environmental hazards to the people downstream (Deborah et al., 2016).

Water quality monitoring is therefore a fundamental tool in the management of freshwater resources (Edori et al., 2016). Water quality assessment is the overall process of evaluation of the physical, chemical and biological nature of water in relation to natural quality, human effects and intended uses (Agarin et al., 2020). At present, the assessment of surface and groundwater in Nigeria is carried out mostly by Research Institutions, individual researchers in the Universities, Government Agencies and some other organizations (Akankali and Davies, 2021).

The physicochemical parameter of water refers to the physical and chemical properties of water body which could be fresh, brackish or marine. They include temperature, Dissolved oxygen, Biochemical oxygen demand, Salinity, pH, Conductivity, Depth, Turbidity, Nitrate, Total alkalinity, Total hardness, Chloride, Phosphate, Sulphate etc. (Onyema and Nwankwo 2009). The impact of abattoir and associated activities waste on physicochemical parameters on Eagle Island creek cannot be undermined. This because the enormous benefits that accrues to the society and ecosystem cannot be overemphasized. The study aims at reporting the impact of abattoir waste discharges on the physicochemical parameters of the Eagle Island creek water, as well as recommendation of better ways to Government and relevant environmental regulation Agencies of managing the aquatic environment for sustainable use by all relevant stakeholders.

2. Materials And Method

2.1. Description of Study Area

Eagle island creek is located is located along Latitude N 4^{o}47’49.08 and Longitude E 6^{0}58’31.218. It is accessible by road and water though the Eagle Island Road and Iwofe river respectively, which are both adjourning locations of to Port Harcourt metropolis, Rivers, state-Nigeria. The vegetation is dominated by Nypa palm (Nypa fructicans), red mangrove (Rhizophora racemosa) and white mangrove (Avicennia germinas). The major anthropogenic activities going on within and around the Eagle Island creek include dredging activities, local boat water transportation through the use of outboard engine and in-board wooden boats, disposal of organic and inorganic wastes, including human feaces, saw milling. The abattoir activities located along the shore of the creek include slaughtering/ butchering of various kinds of goats and cows mainly, removal of the hide, intestine management, rendering, trimming, processing and cleaning activities. The wastes generated from abattoirs usually comprise of blood, oil, mineral and organic solids, salts and chemicals added during handling operations etc. The creek is also a receptacle for effluent discharges from adjourning companies such as AGIP Oil Company and numerous residential estates, schools and other small-scale businesses etc.

Three sampling Stations were cited about 500-1000m apart along the creek for this study (Fig.1)

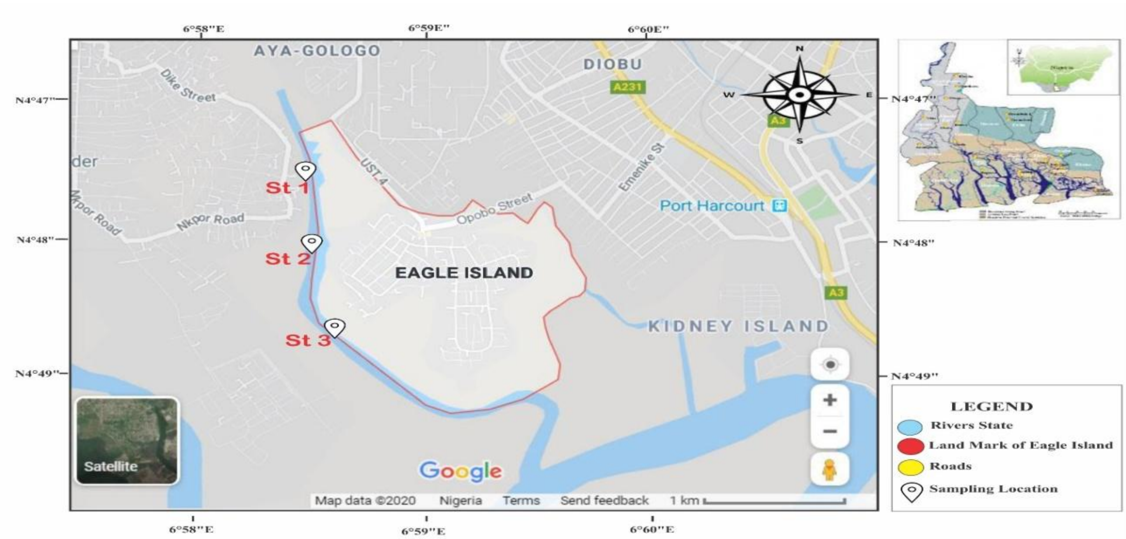

Figure 1: showing the Map of the study area

2.2. Sampling stations

Station 1: **(**N4^{0}47’49.08”and E6^{0}58’31.218”)

Station 2: **(**N 4^{0}47’39.426” and E 6^{0}58’24.498”)

Station 3: **(**N 4^{0}47’38.154” and E 6^{0}58’22.278”)

Figure 2: Showing the sample stations

2.3. Sampling

The sampling stations are shown in figures 1 and 2. A total of three stations were chosen at a distance of approximately 1000 meters apart along the Creek shore lines. Based on the peculiarities of the features observed around the study area of the creek, three sampling stations were selected within the Creek to reflect different activities in the areas: Station I, Station II and Station III.

All stations 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 area. Sampling was carried out once in a month between February to July 2020. This was carried out during the first week of each of the months that the samples were collected. Depending on the type of parameter to be measured the appropriate equipment and method of sample collection were applied as detailed under section 2.3.

2.4. Determination of Physicochemical Parameters Analysis

Surface water samples were collected using Schott glass bottles. The pH, Temperature, Salinity, Total hardness, Conductivity, Total Suspended Solids (TSS), and Total Dissolved Solids (TDS) of the water were measured using an in-situ Handheld Multimeter (EZDO Multimeter Model CTS-406) while the Dissolved Oxygen (DO) was measured with an in-situ Milwaukee Multimeter (Model MW600) Biochemical Oxygen Demand (BOD) was determined by the 5-day BOD test (APHA, 2005).

Turbidity was measured using a 20cm diameter Secchi disc. The sulphates concentrations were determined spectrophotometrically after 5ml of a conditioning reagent was added to 100ml of water and a spatula full quantity of BaCl2 mixture. The colorimetric end point technique was used to determine the concentrations of Chloride and phosphates in the water samples. Nitrate concentrations were determined by the use of nitrover tablets which were dissolved in 100ml of water and the levels read off from Wagtech Spectrophotometer model 5000 and then compared to standard charts provided. The concentration of phosphate was subsequently determined spectrophotometrically at 490nm wavelength. The result was compared with those in a prepared chart of calibration curve of standard phosphate solution.

2.5. Statistical Analysis

The Duncan (1955) Multiple Range Test was used to determine the difference in analyzed parameters between the seasons and across stations sampled. Test of significance was based on a 5% ($P<0.05$) level of probability.

3. Results

The physicochemical parameters of the Eagle Island creek in Niger Delta, Nigeria from February to July, 2020 are presented in Table 1. The physicochemical parameters across the Stations 1, 2 and 3 are graphically illustrated in Figures 3a to 3c.

From the result, the variation of the physiochemical parameters across the stations show that Station 2 accounted for the highest mean values for Temperature (29.23±0.79^{0}C), Conductivity(309.01±222.1 µS/cm), Salinity (348.67±267.97ppm), BOD (16.56±10.66mg/L), and Turbidity (6.87±1.61NTU), while pH, TDS, TSS, Nitrate, Total Hardness, Chloride, Phosphate and Sulphate recorded their highest mean values (6.81±0.4, 168.24±116.90mg/L, 26.33±27.6mg/L, 8.66±6.92mg/L, 88.21±128.32mg/L, 1854.2±3906.64mg/L, 2.15±2.49mg/L, and 23.26±34.29mg/L) respectively in Station 3.

The DO value (4.11±1.45mg/L) was highest in Station 1 while the lowest value (3.92±1.19mg/L) was recorded in Station 3. Temperature (28.46±1.79^{0}C), Salinity (310.83±216.79ppm), and Turbidity (6.36±1.11NTU), were lowest in Station 3 while the lowest mean values of Conductivity (291.47±210.39µS/cm), TDS (154.98±107.3mg/L), TSS (18.5±21.38mg/L), BOD (10.48±7.56mg/L), Nitrate (6.30±5.07mg/L), Total Hardness (63.36±67.01mg/L) and Chloride (1799.6±3709.01mg/L) were recorded in Station 1. In Station 2, the lowest mean values of pH (5.51±2.79), Phosphate (1.25±0.91mg/L) and Sulphate(12.64±8.47mg/L) were recorded.

Table 1: Mean Values of Physicochemical Parameters across the Months

Parameters	February	March	April	May	June	July	WHO (2011)
Temp (^{o}C)	30.7±0.1^a	29.7±0.72^a	28.7±0.36^{ab}	27.2±1.21^b	28.33±0.37^{ab}	27.83±1.05^b	24- 28
pH	4.83±4.2^c	6.24±0.1^b	6.49±0.5^b	6.48±0.5^b	6.56±0.3^b	7.58±0.3^a	6.8-9
Conductivity (µS/cm)	14.29±0.4^c	32.77±3.5^b	45.13±14.7^a	40.10±14.7^{ab}	45.53±14.3^a	45.30±12.7^a	<1000
Salinity (ppm)	601±0.0^a	564±0.6^b	503.66±25.4^b	449.66±44.5^c	498.0±27.2^c	489.0±30.5^c	600

TDS (ppt)	6.97±0.2[a]	32.5±4.2[b]	22.86±6.02[c]	20.73±3.05[c]	24.06±8.73[c]	25.93±23.02[c]	500
TSS (mg/i)	13.66±10.5[b]	63. 0±17.1[a]	12.3±2.5[c]	7.3±1.15[c]	13.3±2.51[c]	19.66±2.08[a]	30
DO (mg/l)	5.7±0.3[a]	2.47±1.36[d]	3.6±0.5[c]	4.26±0.21[b]	3.74±0.84[c]	4.44±0.35[ab]	3-7
BOD (mg/l)	5.4±0.1[c]	0.9±0.95[d]	18.3±5.5[ab]	12.3±5.5[c]	24.6±4.04[a]	18.0±2.64[b]	4
Turbidity (NTU)	6.66±0.57[ab]	6.1±0.8[b]	6.53±0.58[ab]	4.73±0.64[c]	8.31±0.61[a]	7.76±0.15[a]	5
Nitrate (mg/l)	4.23±0.12[c]	17.83±2.96[a]	8.27±1.30[b]	4.06±1.31[c]	8.09±1.26[b]	7.72±1.32[b]	10
Total Hardness (mg/l)	26.66±76.38[c]	32.66±4.04[b]	38.66±4.17[ab]	30.0±1.51[c]	41.03±3.09[a]	41.66±3.32[a]	500
Chloride (mg/l)	959.10±229.58[a]	185.8±8.32[d]	313.33±10.41[b]	265.33±14.19[c]	383.66±32.88[b]	379.0±30.31[b]	250
Phosphate (mg/l)	3.51±3.02[a]	2.27±0.15[a]	0.17±0.11[c]	0.12±0.08[c]	1.91±0.2[ab]	1.76±0.41[b]	0.1
Sulphate (mg/l)	1.55±1.27[d]	8.45±10.97[c]	15.33±3.05[b]	10.66±2.52[c]	20.70±1.54[ab]	43.23±41.59[a]	250

*Superscripts of different alphabets on the same row are significantly different ($p<0.05$)

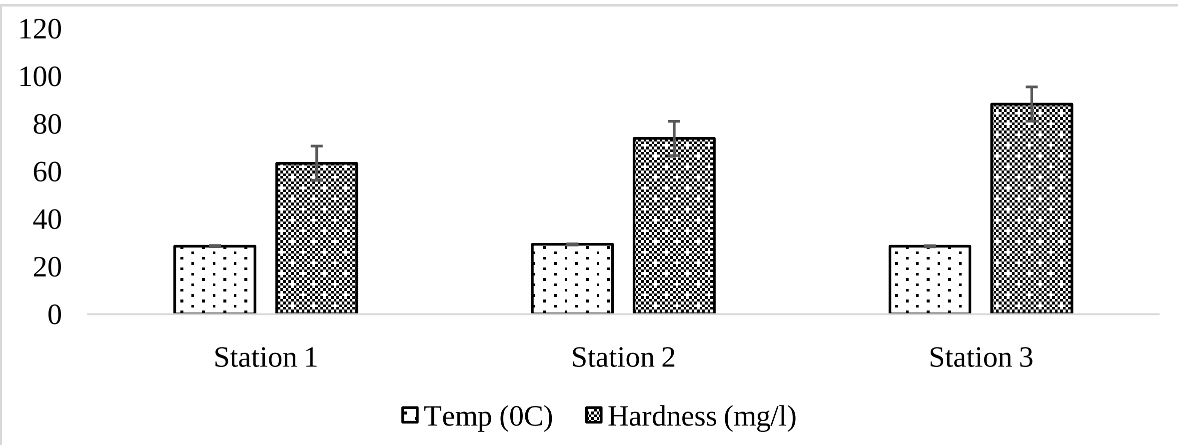

Figure 3a: The Variation of The Physicochemical Parameters Across the Stations

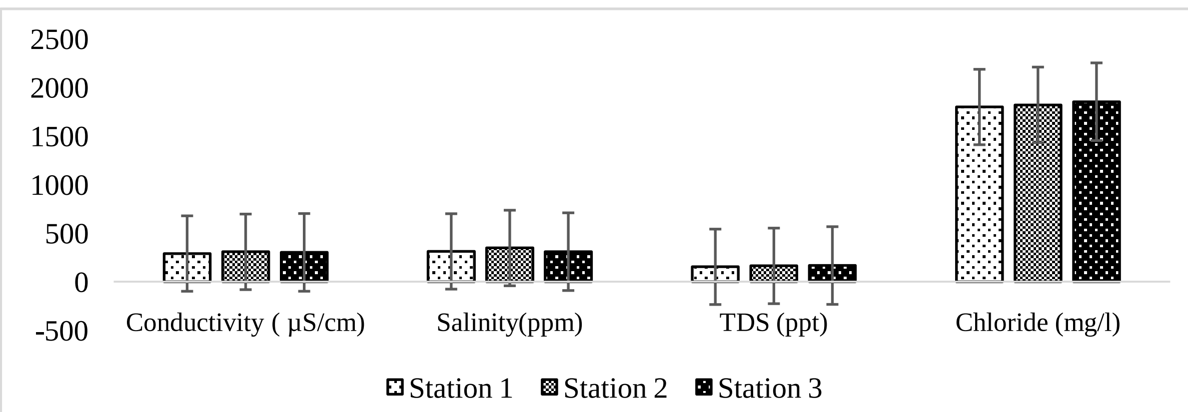

Figure 3b: The Variation of The Physicochemical Parameters Across The Stations

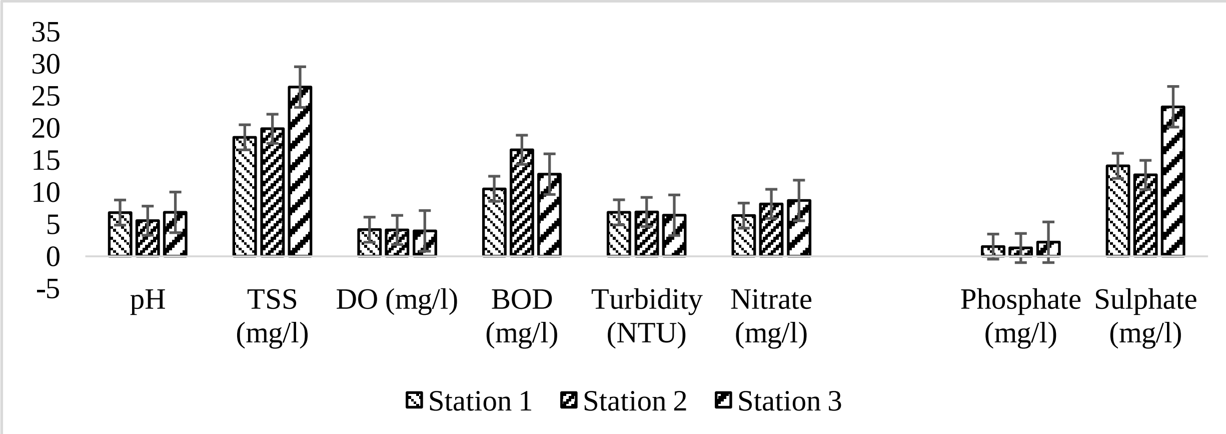

Figure 3c: The Variation of The Physicochemical Parameters Across the Stations

4. Discussion

4.1. Temperature (^oC)

Temperature showed variations between February to July and across all three sampling stations during the period of study and the values ranged from 27.2^{o}C to 30.7^{o}C. The lowest temperature (27.2±1.21^{0}C) was recorded in the month of May while the highest temperature (30.7±0.1^{0}C) was observed in February. No significant differences ($p>0.05$) between the mean values of temperature between the months of February and March but significant temperature differences were recorded between the rest months.

Temperature is one of the major physicochemical parameters used to assess the quality of a water body for either human uses or the control of many activities in waterbody such as the reduction in solubility of gases, rate of chemical reactions and amplifications of tastes and colours of water (Olajire and Imeppeoria, 2001). This study recorded a general temperature range of between 27.2 -30.70C, with variations recorded across the months of the study. The range of temperatures recorded in this study were slightly outside the lower and upper limits set by WHO (24-28°C), but were well within the limits set by FEPA, (2011); Temperatures outside the acceptable limits could directly affect the dissolved oxygen level and pH available to aquatic environment.

The temperatures observed in this study is expected, but the elevated levels beyond recommended limits and is unusual at the along the Niger Delta rivers. The factor responsible for the increase maybe unclear but in slow running rivers without obvious elevation in the river, mixing of organic nutrients could occur due to turbulence and other anthropogenic activities such as fishing and transportation (Davies and Ekperusi 2021). A similar high range of temperatures were recorded in the Niger Delta region during the dry season compared with the wet season as reported by Sikoki and Zabbey (2006) and Jamabo (2008).

The variations in temperature of the region between the dry and wet season are largely attributable to the high quantum of rainfall with a long period of rainy season typical of the region's climate (Onojake et al., 2017). The higher water temperature recorded might also be as a result of factors such as other climatic conditions, geographical conditions or depths of the ground water, which may affect the physiological and biochemical activities of organisms found in the water sources (Ekhaise and Anyansi, 2005).

The mean water temperature observed during the period of this study were slightly outside the standard permissible limits of WHO (2011) and SON (2007). However, the findings of Oparaocha et al. (2010) differs as they reported the maximum water temperature of 28^{o}C from different water source in Nigeria. The surface water temperatures recorded in this study were also outside the WHO recommended levels and the optimal temperature range required for some aerobic mesophilic bacteria and fungi (Milkiyas et al. 2011).

4.2. Hydrogen Ion Concentration (pH)

The pH values ranged from 4.83±4.2-7.58±0.3 across the months with the highest value recorded in July while the least was in February. There was significant variation ($p<0.05$) in the pH values across the months. The importance of hydrogen ion concentration (pH) of water is an indicator in the manner by which chemical reactions and biological activities occur in the water within a narrow range (Kolawole et al., 2013).

The pH increased as the months progressed, ranging from 4.83 to 6.5. The pH values in this study indicate the water tends towards acidity, although the pH values reduced as the months progressed. This finding is in agreement with Shittu et al. (2008), who reported a similar range for pH of water used for swimming purposes in Abeokuta, Nigeria. However, pH values obtained in surface waterbody could be linked to the predominant soil type in the area or possibly to the built-up of organic material from runoff. As organic materials decay, carbon dioxide is released and combines with water to produce weak acid, referred to as "carbonic" acid.

The mean pH values recorded is lower than 6.5 and are considered to be too acidic and can cause health concern such as acidosis infections. Also, the low pH has synergistic effects on heavy metal toxicity in waterbodies. The range of pH values recorded for each month fell below the permissible limit set by WHO (2011). Zhou et al. (1999) confirms that this pH level in water is not suitable for aquatic life. The seasonal variation observed was not in agreement with the previous work of (Onojake et al., 2017) in Bonny/New Calabar River Estuary that reported higher values during the dry season and lower values during wet season.

The variation in the hydrogen ion concentration from this study could also be attributed to fluctuations in the bicarbonate equilibrium and consequently affect the bacterial counts in the river. The variation of pH range observed can be explained in terms of vegetation decay and high influx of such decayed organic matter into the creek form its various feeder channels (Tyokumbur et al., 2002).

4.3. Electrical Conductivity (µS/cm)

The values of the conductivity recorded were between 14.29 to 45.3, with the highest in June (45.53±14.3µS/cm) while the least value was recorded in February (14.29±0.4Ns/cm). There were significant differences in electrical conductivity ($p<0.05$) between the various months sampled months for conductivity.

Conductivity measures the degree of ions in water, which greatly affects taste and most times shows significant impact on the user's preference for water (Davies et al., 2020). It is a good and rapid method to measure the total dissolved ions and is directly related to the total solids in the water sample (Singh et al., 2010). The conductivity of water is also an expression of its ability to conduct an electric current.

The mean value recorded in this study were within WHO permissible limit and these findings were related to that reported by Adetunde and Glover (2011). This parameter showed positive relation with the months, increasing as the months progressed. The low conductivity in this study indicates that the water receives low amount of dissolved inorganic substances in ionized form from their surface catchment areas (Kidu et al., 2015). This property also relates to the ionic content of the water sample which is in turn a function of the dissolved solids concentration (EPA, 2001).

The reduction in conductivity observed in the study area as WHO permissible limit could also be attributed to the dilution effect of the increased volume of the water within waterbodies during the sampling season. Orebiyiet al. (2010) stated that reduction in conductivity is not an indication of the kind of element present in the water body but that higher value of conductivity is a good indicator of the presence of contaminants such as sodium, potassium, chloride or sulphate. Conductivity level in any aquatic body is an increasing method of measuring the total dissolved ions and is directly related to the total solids in the water sample (Singh et al., 2010).

4.4. Salinity (‰)

The salinity values ranged between 449.66±44.5ppm and 601±0.0ppm across the months with the highest value reported in the month of February while the least was observed in July. There values recorded for the months covered by the study were significantly different ($p<0.05$).

The mean values of salinity measured in the present study indicate a progressive decrease in relation to the months. However, the range reported in the current study (449.66 – 601.00ppm) fall below the limit of 10,000ppm (0.1%) set by FEPA (EPA, 2001). This result significantly differs from the report of Akankali et al. (2020); which recorded maximum and minimum values of salinity of 4.60 and 1.67 respectively. recorded at station 3 in June and station 2 in February respectively and there was a significant variation across the months. The results of this study with regards to salinity also agrees with the salinity imbalance reported during the reconnaissance survey carried out by Ezeilo and Dune (2012). Although Magaji and Chup (2012) also reported a higher salinity value (13,000ppm) from Gwagwalada. This result equally agrees with the saline imbalance noticed during the reconnaissance survey carried out by Ezeilo& Dune (2012). Davies (2009) also observed an increase in salinity downstream and attributed it to proximity of the sample stations to estuary and sea. Higher salinity compared for different seasons was reported by Onyema et al. (2009). The results recorded by this study general is of similar trends with the preceding cited results.

4.5. Total Dissolved Solid (TDS) (ppt)

The highest value of TDS was recorded in the month of July (32.5±4.2mg/L) and the least value (6.97±0.2mg/L) was recorded in February. The TDS range was between 32.4 to 6.91mg/l. There were significant variations ($p<0.05$) across the different months.

The total dissolved solid (TDS) are measures of the general nature of water quality (Olajire and Imeppeoria, 2001). Total dissolved and suspended solids, and other biochemical and chemical elements such as dissolved oxygen demand, sulphate, nitrate, chloride, phosphate and ammonia are all pollution indicators in surface water system. (Davies and Ekperusi 2021). This also includes ionized and non-ionized matter but only the former is reflected in the conductivity.

The variation in the levels of these TDS could indicate a growing level of degrading water quality and pollution in the presence of a water body (Oluyemi et al., 2010). For this study, the highest mean value was recorded in July while its lowest mean value was in February, showing that it increased across the months. All the above parameters were within the acceptable limits for freshwater ecosystems, except biochemical and chemical oxygen demand (Anyanwu, 2013). This trend in the variation across the stations and months could be attributed to the onset of the rainy (wet) season which would have increased the influx of sediment into the creek (Akankali et al., 2020). The range of TDS values observed across the months in this study from surface water were below the permissible limits of WHO (2011) for drinking water. TDS affect the taste of drinking water if present above the WHO recommended level.

4.6. Total Suspended Solid (TSS) (mg/L)

TSS recorded higher value (63.0±17.1mg/L) in the month of March and the least value (7.3±1.15mg/L) in May. There were significant differences ($p<0.05$) between February, March and, July, while no significant differences ($p>0.05$) were observed between the months of April (12.3±2.5mg/L), May (7.3±1.15mg/L) and June (13.3±2.51mg/L).

TSS refers to finely divided light solids suspended in quiescent water which may never settle or do so only very slowly (EPA, 2001). TSS in the current study increased as the months progressed. The TSS values ranged between 7.3 and 63.0mg/L across the months went beyond the limit set by FEPA (30mg/L) (EPA, 2001). However, increased levels of the total dissolved solids and total suspended solids observed in this study was expected as the time went by. Another reason for the increased level of the TSS is that a considerable quantity of the effluents with suspend solids that enters the river settles at the downstream may have also impacted on the parameters (Sikoki and Anyanwu (2013).

Although other anthropogenic factors which include human waste disposal and fishing activities leading to perturbations and disturbances from human interaction may have influenced the increase or variation in this physicochemical parameter at the study area (Akinbile and Omoniyi 2018). Other authors reported lower physicochemical parameters (TSS inclusive) in rivers in eastern and western Nigeria (Ayandirana et al., 2018; Anyanwu and Ukaegbu 2019). Ololade and Ajayi (2009) reported higher values for total dissolved solids.

4.7. Dissolved Oxygen (mg/l)

The highest value (5.7±0.3mg/L) of DO was recorded in the month of February while the least value (2.47±1.36mg/L) was recorded in March. There were significant differences between four out of the months, while April (3.6±0.5mg/L) and June (3.74±0.84mg/L) were not significantly different ($p>0.05$) from each other.

Dissolved oxygen is of critical importance to all living organisms and its presence in a water body can result from direct diffusion from air or production by autotrophs through photosynthesis (Tenagne, 2009). Oxygen depletion often results during times of high community respiration and hence DO has been extensively used as a parameter delineating water quality and to evaluate the degree of freshness of a river (Singh et al., 2010). It is also an important limnological parameter indicating level of water quality and organic pollution in the water body (Wetzel and Likens, 2006).

The DO values ranged between 2.47mg/L and 4.44mg/L as compared with WHO acceptable standards (3-7mg/l) for drinking water. This agrees with Magaji and Chup (2012) who stated that most game fish require at least 4 – 5 mg/L level of DO to thrive. The temperature of the water may have influenced the amount of dissolved oxygen because lesser oxygen dissolves in warm water than cold water (Davies and Ekperusi 2021). Therefore, the relatively high temperature of the water could have been one of the factors for low DO values recorded in this study. The DO values reported during this study period from the surface water sources were within the WHO limits. Decreased in DO mean level observed in the river water samples may be indicative of too many bacteria that may use up the dissolved oxygen in it.

Another possible reason for such decreased DO in this water body may be run offs from the abattoir and associated activities (Akankali et al., 2020). This agrees with Nduka and Orish (2008) who reported that the DO oxidizes both the organic and inorganic substances, thereby interfering with their capacity to constitute a nuisance to the consumer. Dissolved oxygen may not have a direct health hazard to humans, but it could interact with other chemicals in the water thereby affecting the aquatic organisms (Olajire and Imeppeoria, 2001)

4.8. Biochemical Oxygen Demand (BOD) (mg/l)

The highest BOD value (24.6±4.04mg/L) was recorded in the month of June followed by April (18.3±5.5mg/L) and July (18.0±2.64mg/L) while the least value (0.9±0.95mg/L) was recorded in March. There were significant differences ($p<0.05$) observed across the months except for the months of February and May which show no statistical difference ($p>0.05$) between each other.

The BOD of the creek increased as the months progressed, with a range of values between 0.9 to 24.6. The upper limit of this range significantly exceeded the limits set by SON guidelines (4mg/l) set for the maximum tolerable limit of BOD for drinking water, fishes and other aquatic life.

The range of BOD obtained from this creek indicated that the water sources were highly polluted by organic matter such as fecal matter, abattoir waste effluents and other improperly disposed domestic waste materials finding their way into waterbody through runoffs. The variations in the BOD values recorded for the creek may be attributed to the high pollution level it is exposed to, especially from the abattoir effluents as well (Aghoghovwia, 2011). A similar report by WHO (2008) also supports the justification that low level of BOD in water could be caused by the amount of oxygen utilized by microorganisms such as bacteria to oxidize organic matter which is available within the water.

4.9. Turbidity (NTU)

Turbidity value (8.31±0.61NTU) was highest in the month of June and the least value (4.73±0.64NTU) was observed in the month of May. There was no observed significant difference ($p>0.05$) between the months of February and April, June and July.

Turbidity measurement in water is a key practice of good water quality management, as high turbidity in water may indicate ineffectiveness in filtration (Abdullahi & Indabawa, 2012). According to EPA (2001), turbidity is an expression of the optical property of water that scatters light and can be caused by sewage matter in a water body (EPA, 2001; Wizor and Nwankwo, 2019). Turbidity in water is formed from the presence of very finely divided solids, which are not filterable by routine methods (EPA, 2001). The range of values for turbidity was observed across the months in this study to be above the permissible limit set by WHO (2011) and could be attributed to associated wastewater discharges from sewerage, agricultural runoff or any industries around the study stations (Akankali et al., 2020).

4.10. Nitrate (mg/l)

The highest value of Nitrate was observed in the month of April while the least value was recorded in the month of May (40.6±1.31mg/L) and there were significant variations ($p<0.05$) between the values for each month. From the study, Nitrate values range between 4.06 - 17.83mg/L and exceeded the limits of set by WHO and FEPA which is 10mg/L. This was contrasting to the range of Nitrate values (6.6 - 9.68mg/L) reported by Wizor and Nwankwo (2019) from Woji Creek in Rivers State.

The nitrate concentrations from the study were also higher than report of Adejuwon and Mbuk (2011), who recorded lower nitrate concentration of 50.6 mg/l in well water in Ikorodu. The nitrate levels ranged between 0.3-5.23 mg/L and values of 1.1–7.32 mg/L from surface water samples. The low variation recorded for nitrate concentration in this study may be due to differences in hydro-geological regimes. Generally, lifetime exposure to nitrite and nitrate at levels above the maximum acceptable concentration could cause such problems as diuresis, increased starch deposits and hemorrhaging of the spleen (Reimann et al., 2003).

4.11. Total Hardness (mg/l)

The mean values for Total Hardness ranged from 26.66±76.38mg/L to 41.66±3.32 mg/L with the highest value recorded in the month of February while the least was recorded in July. No significant difference ($p>0.05$) was observed in the values recorded in February (26.66±76.38mg/L) and May (30.0±1.51mg/L), likewise between the months of June (41.03±3.09mg/L) and July (41.66±3.32mg/L). However, both pairs were significantly different from each other. Generally, there were significant variations in the recoded values across the months.

Total hardness has no adverse health effects except for impacting water bodies (Mahato, et al.,2018). Total hardness is taken to comprise the calcium and magnesium concentrations and is expressed as Mg/L CaCO3. From the current study, total hardness increased as the months progressed with a range of values of 26.66 - 41.66 mg/L which were within the acceptable limits of (500 mg/l) by WHO (2011). (Wizor and Nwankwo, 2019) reported a similar range of values (21- 41mg/L) for Nitrate from Woji Creek. This result also agrees with Elemile, et al., (2019) who reported similar values of total hardness at different sample stations and attributed it to discharges from the domestic wastes through drains and wash off from the neighboring abattoir effluents.

4.12. Chloride

The mean values for Chloride ranged from 185.8±8.32mg/L to 959.10±229.58mg/L across the months. No significant difference ($p>0.05$) was observed between the values of April (313.33±10.41), June (383.66±32.88mg/L) and July (379.0±30.31mg/L). However, February (959.10±229.58mg/L), March (185.8±8.32mg/L) and May (265.35±14.19mg/L) were significantly different ($p<0.05$) from each other and the rest of the months.

Chloride and Phosphate exhibited a negative relationship with the months as both parameters decreased as the months progressed. The range of values for Chloride was between 185.8 - 959.10mg/L; Sulphate range between 1.55 - 43.23 (mg/l), which exceeded the acceptable limits of WHO. In contrast, the increase in the levels of this parameter as the months progressed indicated a positive relationship with the months. This could be attributed to the geology or geochemistry of the underlying or surrounding soil of the sampled locations.

4.13. Phosphate,

Phosphate values ranged from 0.12±0.08mg/L to 3.51±3.02mg/L, with the lowest value recorded in the month of May and the highest in February. No significant difference ($p>0.05$) was observed between the months of February (3.51±3.02mg/L) and March (2.27±0.15mg/L) and April (0.17±0.11mg/L) and May (0.12±0.08mg/L).

The values of phosphate observed in this study can be attributed to seepage from run offs or discharges from the abattoir waste. The principal adverse impact of the high levels of this phosphate on water quality is that it leads toes eutrophication, which is more common in lakes and sometimes rivers (Abolude et al., 2016).

4.14. Sulphate

The values of Sulphate varied between 1.55±1.27mg/L in the month of February to 43.23±41.59mg/L in July. The months of March (8.45±10.97mg/L) and May (10.66±2.52mg/L) showed no statistical differences ($p>0.05$), but were significantly different from the other months. The mean values were significantly different ($p<0.05$) from each other.

Sulphate occurs naturally in the aquatic environment through dissolution of sulphide such as pyrite from the interstratified materials by percolating water which then produces sulphate ions (Olobaniyi and Owoyemi, 2006).

The low level of sulphate recorded in this study can be attributed to the geological profile of the mineral constituents of the of water. This study also revealed that the low mean sulphate values from the surface water sources were within the EPA stipulated limits of 250mg/L. The low concentrations of sulphate in the creek could be attributed to the absence of high anthropogenic activities that influence the concentration in waterbodies apart from the abattoir (Akankali et al., 2020). Although there were significant inputs of pollutants from municipal and other wastes into the river, the level might not have been high enough to impact significant increase in sulphate concentrations above the permissible limits of WHO (2011) (Adesakin et al., 2020).

5. Conclusion

This study which examined the impact of abattoir and its associated activities on specific physicochemical parameters and quality of the creek around Eagle Island generally showed significant variations in the physicochemical parameters of the water. There was significant variation across the months. Most of the parameters were within the acceptable limits of WHO with the exception of Phosphate, Chloride, Turbidity and BOD which was higher than the acceptable levels for drinking water.

If over time these parameters in excess of approved limits by the relevant local regulatory Agencies such as FMNE, FEPA and WHO, it will progressively lead to the disruption of the physiological processes of the aquatic organisms living therein. This situation will invariably lead to significant decline in the aquatic resources the Creek, either through direct mass mortality or un-conducive environment for reproduction and growth of the organisms inhabiting the Creek. The findings of this study therefore justify the need for the protection of this natural aquatic environment, the biodiversity and the health of the public from the obvious pollution impacts arising from the Abattoir and other associated wastes being discharged into the environment.

There is therefore a need to create an increased public awareness on the obvious adverse impacts of their pollution inducing activities, especially for people living, defecating and working along this creek. This will help to minimize the level of untreated wastes and effluent discharges, such as sewage and abattoir waste which in the aquatic Creek waters.

To improve the quality of water, it is therefore recommended that steps should be taken to routinely monitor and reduce the number of wastes discharged into the Creek. Regulatory implementation should also be enhanced to ensure that violators of set standards for effluents discharge into water are penalized appropriately. Furthermore, research should be carried out to analyse the impact of these activities on the biological communities of the aquatic organisms living in this creek.

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