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Original Research Article

Effects of Abattoir Waste Discharge on the Quality of the Trans-Amadi Creek, Port Harcourt, Rivers State, Nigeria

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ABSTRACT

Water pollution by effluents from abattoirs is of public health concern because bodies of water are used as sources of drinking water and discharge of waste into it can lead to destruction of primary biota. This study presents the effect of abattoir waste on the quality of the Trans-Amadi Creek, Port Harcourt, Rivers State. Physico-chemical parameters were assessed to evaluate the effect of the abattoir discharge in the Creek. Water samples were collected from three locations in Trans-Amadi Creek: upstream, middlestream and the downstream. Water samples were collected according to standard methods for laboratory analysis. Values of the parameters obtained at the Upstream, Middle-stream and Downstream were: pH 4.46; 5.09 and 5.51; Color 10, 10 and 5 pt/co; Total dissolve solids 32; 25 and 22 mg/L, Electrical conductivity 50; 38 and 34 us/cm; Total suspended solids 6.5; 10.5 and 6.0 mg/L; Alkalinity 1.04; 1.54 and 1.55 mg/L; Total Hardness 1243; 1505 and 1690 mg/L; Chloride 1205; 1820 and 3620 mg/L; NO_3 15.1; 16.60 and 18.10 mg/L; Nitrate-Nitrogen 3.40; 3.70 and 4.10 mg/L; SO4 36.1; 42.1 and 37.5 mg/L; NH_4 1.0; ND and ND; DO 4.40; 4.25 and 4.35 mg/L; BOD 3.20; 3.60 and 3.40 mg/L; COD 142.5; 140.6 and 135.1 mg/L; Phosphate 1.50; 0.50 and 1.40 mg/L; Phosphorus 0.50; 0.20 and 0.40 mg/L; Zn 0.260; 0.108 and 0.230; THC 2600; 2150 and 2860 cfu/100 mL. The results shows a negative impact on the middle-stream on some parameters which might pose a health risk to the communities around.

Keywords: Abattoir effluents, Stream water, Total Hardness, Total Dissolve Oxygen.

Introduction

The management and practice of abattoir in developing countries like Nigeria is very poor. This has led to a surge in the pollution of surface and ground water by animal wastes. This practice has raised fundamental issues as it concerns environmental and health sectors in Nigeria.[1] The high loading rate of nitrogen, phosphorus and pathogens to soil and water can occur from animal operations such as grazing and abattoir business.[2] Concentration of Nitrogen in excess of 10 mg/L in the nitrate (NO_3) form renders groundwater unsuitable for drinking. Phosphate could be transported with the sediments to lakes and streams where its most significant effect is eutrophication.[3] Animal wastes have been shown to be a source of micro-organisms pathogenic to humans.[4] When surface runoff occurs due to rainfall, contamination of water resources by enteric bacteria may result. The same bodies of water are used for sources of drinking water or recreational activities.

The wastes from abattoir operations which are often separated into solid, liquid and fats could be highly organic. The solid part of the wastes consists of condensed meat, undigested ingest, bones, hairs and aborted foetus. The liquid aspect on the other hand consists of dissolved solid blood, gut contents, urine and water, while the fat waste consists of fats and oils. The pollution of water resources often results in the destruction of primary producers which in turn leads to an immediate diminishing impact on fish yield with the resultant consequences of decrease in diet.[5] Clean water resources used for drinking, sustaining aquatic and terrestrial ecology, industry and aesthetic values, along with breathable air, rank as the most fundamental and important need of all viable communities. These water resources should remain within specific quality limits, and therefore require stringent and conservative protection measures. Raymond (1977) reported that animal wastes can affect water, land or air qualities if proper practices of management are not adhered to.[6] The same wastes however, can be valuable for crops but can also cause water quality impairment. It also contains organic solids, trace heavy metals, salts, bacteria, viruses, other micro-organisms and even sediments. Also, improper animal waste disposal can lead to animal diseases being transmitted to humans through contact with animal faeces. Sangodoyin *et al* reported that the groundwater quality in vicinity of abattoir was adversely affected by seepage of abattoir effluent as well as water quality of receiving streams that was located away from the abattoir.[7]

Port Harcourt – the capital of Rivers State has generally witnessed large scale infrastructural and population changes since the last two decades. The population dynamics have by far exceeded those infrastructure and other social amenities. The cumulative impact of this scenario has been an overstretching of most basic amenities. The Port Harcourt abattoir serves more than 80% of the town and its location beside the stream has facilitated easy disposal of the wastes into the stream channels even without any proper treatment. Port Harcourt abattoir on Thursdays, Fridays and Saturdays slaughter over 400 cows, 40 rams, and 1000 goats, and lesser number on Monday to Wednesday. The weekends serve as their peak days of business. Also, the Port Harcourt abattoir is divided

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into different units. There are areas for food stuff, slaughtering and dissection of animals, roasting and scrapping of the animal skin, and area where the animal intestines are cleaned. The unites of roasting and scrapping, and intestine cleaning are more closer to the stream although they do not make use of the stream water in their cleaning works as it has become obvious even to the lay persons that the water is heavily polluted. The management of the abattoir provides steady electricity for the pumping water from borehole. The waste that emanates from these various units varies; from food stuff unit to waste from waterproof, vegetable leaves, and some fall-off from crayfish and other cooking items. Major wastes from slaughtering and dissecting unit include blood and bones. Also, wastes like animal horn and wood remnants can be used as fuel for the roasting of animal skin. The intestine cleaning unit produce wastes like animal dung, and waste/dirty water. This very unit makes more use of water than any other unit in the abattoir.
This research therefore attempts to examine the implication of the continuous discharge of these abattoir wastes into the stream water. The research is to evaluate the water quality at some locations in the stream channel, with the aim of establishing the extent to which untreated abattoir wastes would have impacted on the stream water quality.

Materials and Methods

Description of the Study Area
Trans-Amadi Creek is located in Port Harcourt metropolis of Rivers State on longitude 6.57^0E and latitude 4.57^0N. It flow from Okrika Town down to Mini-Ewa, Rumuobia-Kani through Woji, Oginigba, Okujagu Communities and then empties into the Bonny river, from which it flows to the Atlantic ocean.[8] The Port-Harcourt abattoir is located in Trans-Amadi beside the Trans-Amadi Creek. The abattoir is the largest in Rivers State and also one of the major activities that impact greatly on the Trans-Amadi Creek. Geologically, Trans-Amadi is a typical Niger-Delta environment underlain by Benin formation classified as coastal plain sand. It consists of massive, highly porous and permeable fresh water bearing sand stones with minor clay intercalations. The formation is generally water bearing and hence it is the main source of potable ground water in the municipality. The aquifers are recharged mainly by surface precipitation and nearby drainage. [9]

Sample collection
Reconnaissance survey was conducted in the area of study. Water samples were collected from three different locations and at different distances along the creek. Sampling point A is Located in Oginigba community, 800 m upstream from the effluent discharge area is assumed as the Control Point (Less impacted area). Sampling point B is the point where abattoir effluents directly enters the Trans- Amadi creek (Impacted), water samples were obtained in this zone 50 m downstream from the discharge zone. Sampling Point C is located in Okujagu community a distance of 1000 m downstream from the discharge zone. This point serves to observe natural attenuation effect of the creek under investigation. The Sampling took place early in the morning before the effect of the sun on the creek (between 6:30 am and 10 am). This time was specially chosen in order to beat the Environmental Protection Agency (EPA) specified holding time of 8 hours from time of collection to laboratory.

Determination of Water Physicochemical Parameters
Physicochemical parameters of the water samples were determined. The zinc content in the water samples were analyzed using Atomic Absorption Spectrophometer (VGP210 Buck Scientific). The pH and Electrical conductivity were analyzed using pH meter (model PHC-25), Colour was determined by a Nessleriser, while Total dissolved solids, Suspended solids, Dissolved Oxygen, Alkalinity, Chloride, Total Hardness, Phosphate, Sulphate and Nitrate were analyzed according to standard procedures specified by American Public Health Association.[10] Sampling took place early in the morning before the effect of the sun on the creek (between 6:30 am and 10 am). The time was carefully chosen to meet the required holding time of 8 hours from time of collection to laboratory specified by Environmental Protection Agency (EPA).

Statistical Analysis
The water physicochemical parameter data were subjected to statistical analysis using a statistical package for social science (SPSS) 16.0.

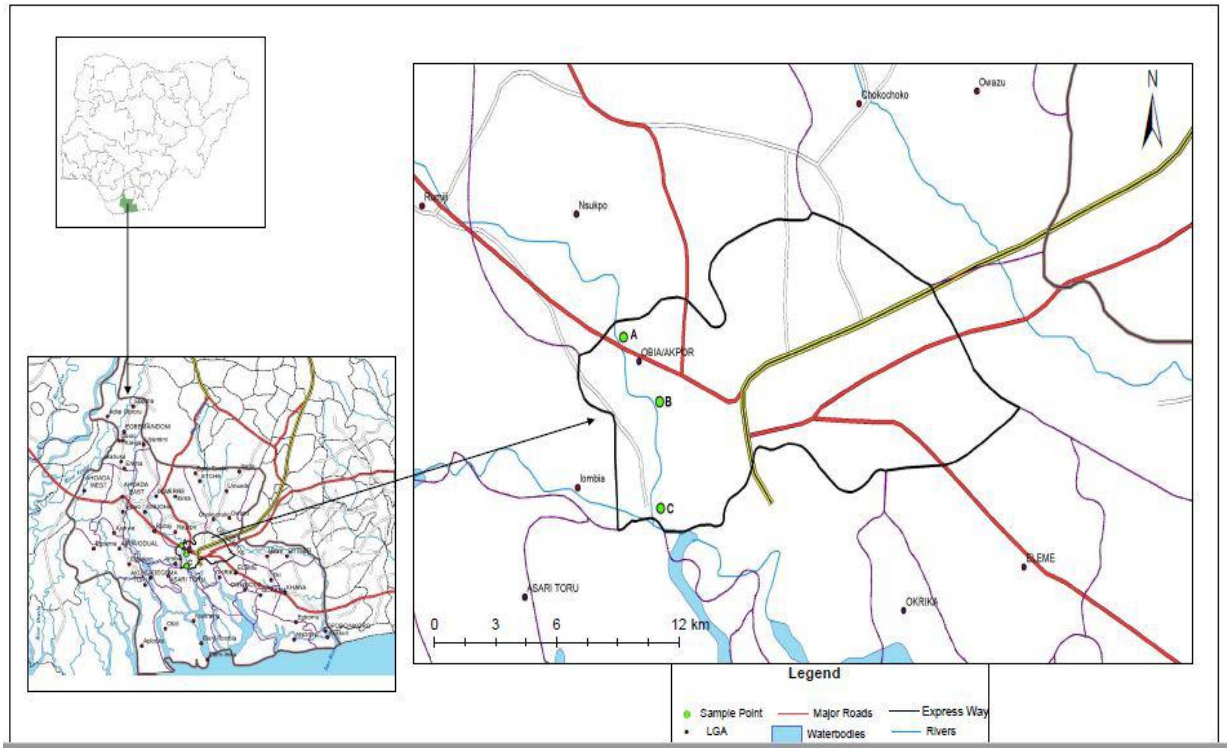

Figure 1: Map of the Study Area showing host communities and sampling points.

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Results and Discussion

Levels of physico-chemical parameters of trans-amadi creek

The levels of the physico-chemical parameters of water determined across the sampling locations within the Trans Amadi Creek is shown in Table1. The pH ranged from 4.46 ± 0.10 to 5.51 ± 0.04 across the sampling points. Color ranged from 5.00 ± 0.32 to 10.00 ± 0.24 pt/co, EC 34.00 ± 0.20 to 50.00 ± 0.30, and TDS 22.00 ± 0.27 to 32.00 ± 1.16. Total suspended solid ranged from 6.50 ± 0.15 to 10.50 ± 0.16, Total Hardness as $CaCO_3$ from 1243 ± 5.57 to 1690 ± 5.03 mg/L and Alkalinity from 1.04 ± 0.04 to 1.55 ± 0.04 mg/L. Nitrate and Nitrate-Nitrogen recorded 15.1 ± 0.02, 16.60 ± 0.02, 18.10 ± 0.32 and 3.40 ± 0.20 mg/L, 3.70 ± 0.71 and 4.10 ± 0.38 mg/L, respectively from sample A to C. Chloride ranged from 1205 ± 1.53 to 3620 ± 2.08 mg/L, Sulphate 36.10 ± 0.15 to 42.10 ± 0.51 mg/L, phosphate 0.50 ± 0.01 to 1.50 ± 0.01 mg/L while phosphorus ranged from 0.20 ± 0.08 to 0.50 ± 0.15 mg/L. High values were recorded in the concentration of COD (135.10 ± 0.00 to 142.50 ± 0.80 mg/L). Dissolved Oxygen ranged from 4.25 ± 0.03 to 4.40 ± 0.04 mg/L while Zinc ranged from 0.108±0.00 to 0.260 ± 0.00 mg/L across the three sampling points.

Spatial variation of Physico-Chemical Parameters of water samples from Trans-Amadi Creek

Figure 2. Shows that Maximum levels of pH 5.51 and Alkalinity 1.55 mg/L were recorded at the downstream (C) while zinc had a lower value but recorded highest value at the Upstream (A). Lowest values of pH 4.46 and Alkalinity 1.04 mg/L were recorded at the Upstream while the Middle stream (B) had the lowest in zinc content with value of 0.108 mg/L. Figure 3 shows that upstream recorded maximum values of TDS and Color while having lower values of TSS 6.5 mg/L. The middle stream (B) has same value with the Upstream (A) in color parameter (10 pt/co), highest value of TSS (10.5 mg/L) and lower TDS value (25 mg/L). The downstream (C) recorded lowest values in the above parameters. Figure 4 shows that Electrical Conductivity decreased from the upstream to the downstream while the Total Hardness and chloride content increased from the upstream to the downstream. Figure 5 shows that upstream recorded lowest values of Sulphate, nitrate and nitrate-nitrogen while recording highest value in phosphorus and phosphate. The middle-stream had lowest values of phosphate and phosphorus. High value in sulphate was recorded and lower values in Nitrate 16.60 mg/L and Nitrate-Nitrogen 3.70 mg/L compared to the downstream high value of 18.10 mg/L for Nitrate and 4.10 mg/L value for Nitrate-Nitrogen. Figure 6 shows that upstream recorded highest value of dissolved oxygen and COD while recording lowest value in BOD. The middle-stream had highest values of BOD and lowest values of DO. The downstream recorded lowest value of Chemical Oxygen Demand of 135.1 mg/L.

Variation in the levels of pH, Alkalinity, Odour and Zinc

The pH values of the water samples are found to be below the WHO 2011 acceptable limit. The river water is therefore regarded as acidic. This result is less than that of Osibanjo and Adie [11], which ranged from 6.92 - 8.18 in their study of Impact of effluent from Bodija abattoir on the physicochemical parameters of Oshunkaye stream. The low pH values of the creek may be an indication of low carbon (IV) oxide content in the water, such water pose a threat to aquatic life in the creek.[11]

The Alkalinity value obtained in this study was highest at the downstream and lowest at the upstream (A). The various ionic species that contribute to water alkalinity are Bi-carbonate, Hydroxide, Phosphate, Borate and Organic acid. The observed value for the three points was far lower than the WHO acceptable limits.[12] The result also indicates that water resources in Trans-Amadi Creek recorded odorless at the upstream and downstream while a faint odor was noticed at the Middle-stream which may be as a result of the abattoir effluent discharge. Therefore, such water is unsuitable for drinking and carrying out other domestic activities.

Zinc values from this study are lower than the WHO[12] standard of 5 mg/L and FEPA[13] standard of 3mg/L. The middle stream which is the point of abattoir discharge was the lowest of other sample areas with 0.108 mg/L. This is in line with Masse and Masse[14] who described abattoir wastewater as having significantly low amount of zinc content.

Table 1: Physico- Chemical characteristics of Trans-Amadi Creek at various sampling points.

Parameters	Sample A	Sample B	Sample C	WHO 2011
pH	4.46 ± 0.10	5.09 ± 0.04	5.51 ± 0.04	6.5 - 8.5
Colour (pt/co)	10.00 ± 0.24	10.00 ± 0.15	5.00 ± 0.32	15
Electrical conductivity	50.00 ± 0.30	38.00 ± 0.36	34.00 ± 0.20	1000
TDS	32.00 ± 1.16	25.00 ± 0.05	22.00 ± 0.27	250
TSS	6.50 ± 0.15	10.50 ± 0.16	6.00 ± 0.10	5
Total Hardness CaCO3 (mg/L)	1243.00 ± 5.57	1505.00 ± 1.53	1690.00 ± 5.03	250
Alkalinity (mg/L)	1.04 ± 0.04	1.54 ± 0.03	1.55 ± 0.04	60
Chloride (mg/L)	1205.00 ± 1.53	1820.00 ± 3.51	3620.00 ± 2.08	250
Sulphate (mg/L)	36.10 ± 0.15	42.10 ± 0.51	37.50 ± 0.03	250
Nitrate (mg/L)	15.10 ± 0.02	16.60 ± 0.02	18.10 ± 0.32	50
Nitrate-Nitrogen (mg/L)	3.40 ± 0.20	3.70 ± 0.71	4.10 ± 0.38	ND
Ammonia (mg/L)	1.02	ND	ND	ND
Phosphate (mg/L)	1.50 ± 0.01	0.50 ± 0.01	1.40 ± 0.02	5
Phosphorus (mg/L)	0.50 ± 0.15	0.20 ± 0.08	0.40 ± 0.27	ND
COD (mg/L)	142.50 ± 0.80	140.60 ± 0.25	135.10 ± 0.00	40
BOD (mg/L)	3.20 ± 0.06	3.60 ± 0.24	3.40 ± 0.49	10
DO (mg/L)	4.40 ± 0.04	4.25 ± 0.03	4.35 ± 0.03	10
Zinc (mg/L)	0.260 ± 0.000	0.108 ± 0.000	0.230 ± 0.000	5
Odor	ND	Very faint fishy	ND	ND

ND = Not Detected

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Variation in the Levels of Color, TSS and TDS

The color range across the sampling locations were below the WHO acceptable limit. The high value of the color was noticed at the upstream and middle stream which could be as a result of certain types of dissolved and colloidal organic matter and the contributions of decaying plant detritus as described by Defew *et al.*[15]

The result obtained in the TDS showed low values which were quite below WHO standard for drinking water (250 mg/L)[12]. The highest value of 32 mg/L was recorded at the upstream while the middle-stream recorded 25 mg/L.

The figures of the different sample points however show that effluents have dilution effect on TDS as there is progressive decrease from the upstream section through the point the effluents enters the stream to the downstream as described by Magaji and Chup[16] in the study of the effects of abattoir waste on water quality in Gwagwalada, Abuja.

Total suspended solid (TSS) values were considered to be above the WHO acceptable limit[12]. Maximum value was recorded at the middle-stream. Tekenah *et al.*,[17] argued that abattoir waste capable of increasing TS and TSS at point source include condemned meat, undigested ingest, animal waste, carcasses etc.

Variation in the Levels of Electrical Conductivity, Total Hardness and Chloride

Electrical conductivity values from this study ranged were minimal with a mean value of 40.67. Though these figures are lower than WHO for portable water.[12] They are nevertheless higher than FAO recommended limit for agricultural purposes such as irrigation.[18]

According to Canadian drinking water quality, water with hardness value of less than 60 mg/L is classified as soft, moderately soft when the hardness value is between 60-120 mg/L, hard between 120-180 mg/L and very hard above 180 mg/L. The values obtained from the TH analysis showed that the water could be categorized as very hard with minimum and maximum values as 1243 mg/L and 1690 mg/L. The observed values were higher than WHO standards.[12]

Chloride is a water quality problem which could be an indication of pollution from industrial or domestic activities. Chloride in water above permissible level of 250mg/l can bring about laxative effect in humans, change in taste of water and toxicity to aquatic life.[19] The values of chloride observed across the three sampling points of Trans- Amadi creek showed high values especially at the downstream where value was maximum and above the WHO standard.[12]

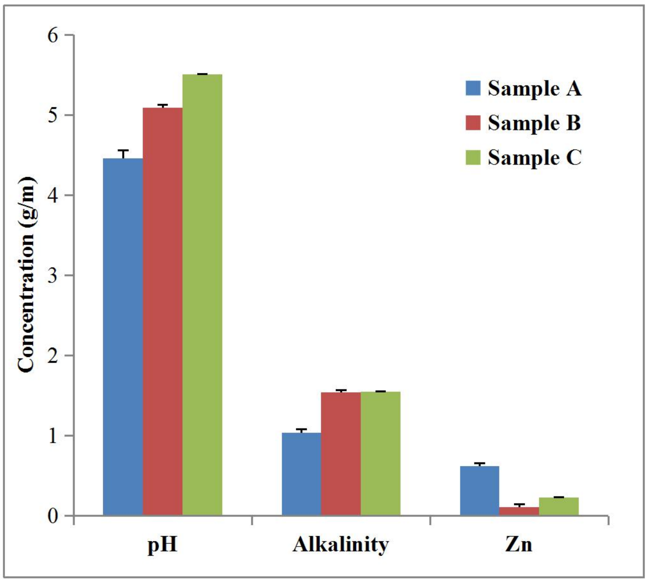

Figure 2: Variation in the levels of pH, Alkalinity and Zinc of Trans-Amadi Creek at three Sampling points.

Variation in the levels of Phosphorus, Sulphate, Nitrate, Phosphate and Nitrogen-Nitrate

Sulphate levels in this study were observed to be very low with the highest value recorded at the WHO [12] standard for drinking water (250 mg/L) and 100 mg/L standard for FEPA.[13] There are several sources of Sulphate in Creek water; decaying plants and animal matter may release Sulphate into a water body. The consumption of water containing sulphate may result in intestinal discomfort, diarrhea, salty taste and consequently dehydration.[20]

Nitrate values from this study falls below the WHO acceptable limit of 50 mg/L.[12] Excessive enrichment of nutrients contained nitrate can result in deoxygenating of the water and consequently decline in the productivity of periphyton as well as reduction in population of bottom dwelling invertebrates.[21] Chikere[22] also maintained that increase in nitrate supply in rivers could be as a result of organic detritus which consists of large amounts of protein and nucleic acids from dead organisms and nitrogenous animal wastes such as urea and uric acid as can be seen from the abattoir.

The Nitrogen-Nitrate level from this study ranged from 3.4 - 4.0 mg/L with mean value of 3.73 mg/L. The presence of Nitrate-Nitrogen in a water body can be seen as a threat or potential problem hence it can pose certain danger to human health and the health of the water. Some of the potential problems include toxicity to babies, acceleration of eutrophication in water.[20] Phosphate in water is an indicator of agro-chemical usage on land surrounding the river. The low level of content show that it may have entered the river via runoff during rainfall. The determined value of phosphate in this study is below the [12] standard as the point of discharge of abattoir effluent had the lowest amount of phosphate released compared to the upstream and downstream.

Variation in the levels of DO, COD and BOD

COD test determines the amount of oxygen needed to chemically oxidize the organics in a water or waste water. Chemical Oxygen Demand (COD) of the present study shows values which were above the FEPA standard acceptable limit of 80mg/l. This could probably be due to the rate of dilution of the pollutants that led to the decrease as the water flows downstream. The results showed that at the point of entry of the abattoir effluent into the stream, COD was 140.1 mg/L, but much higher at the upstream. High level of COD indicates the presence of chemical oxidants in the effluent while low COD indicates otherwise. High COD could likely cause nutrient fixation in the soil resulting to reduced rate of nutrient availability to plants. Chemical oxidants affects water treatment plants by causing rapid development of rust.[23]

Biochemical Oxygen Demand (BOD) exhibited significant variation across the sampling stations with highest value recorded at the point of discharge of the abattoir effluent (middle-stream) than at the upstream which recorded a minimum value of 3.2 mg/L. The high BOD load observed at the middle stream could be attributed to increase degradable organic waste load from the abattoir effluent discharged into the river. Based on the observed result in this study, it could be stated that the BOD of the creek water was affected by the discharge of the abattoir effluent and the water quality termed unclean. This assertion follows the classification of Moore and Moore[24] who opined that water bodies with BOD concentration between 1.0 and 2.0 mg/L were considered clean, 3.0 mg/L fairly clean, 5.0 mg/L doubtful and 10.0 mg/L definitely bad and polluted. The values were below the WHO permissible limit.[12] BOD concentrations in a creek may therefore serve as a pointer to the level of organic pollution. This agreed with the observation by [25] in their study on water Quality of Miniweja stream in Eastern Niger Delta.

Dissolved oxygen is an important factor that determines the quality of water in lakes and rivers hence, the higher its concentration, the better the water quality. Dissolved Oxygen values from this study fell below the WHO standards of 10 mg/L.[12] The results show a decrease in value at the middle-stream from 4.40 mg/L at the upstream to 4.25 mg/L which signifies reduction in dissolve oxygen. The drop in DO level defines the putrid condition of the river at the point of abattoir effluent discharge. Factors that promote DO level in water includes, atmospheric diffusion, input from photosynthetic plants and others.[26]

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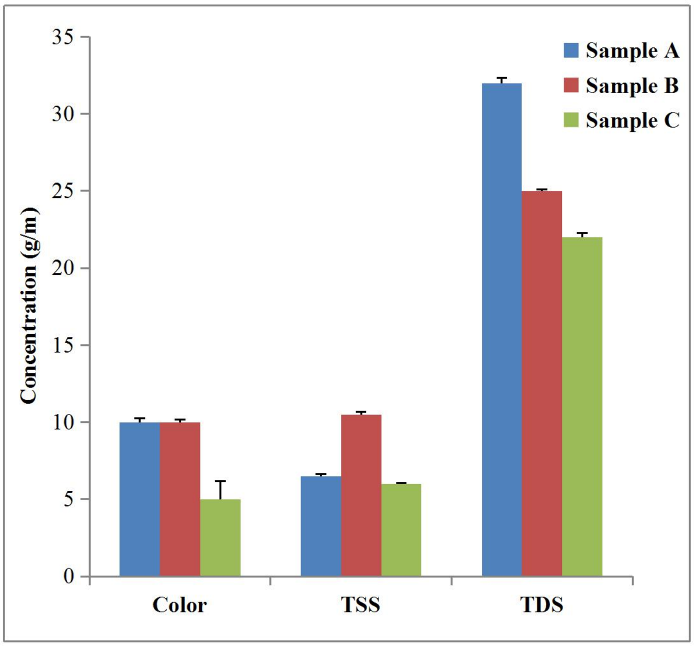

Figure 3: Variation in the levels of Color, TSS and TDS of Trans-Amadi Creek at three Sampling points.

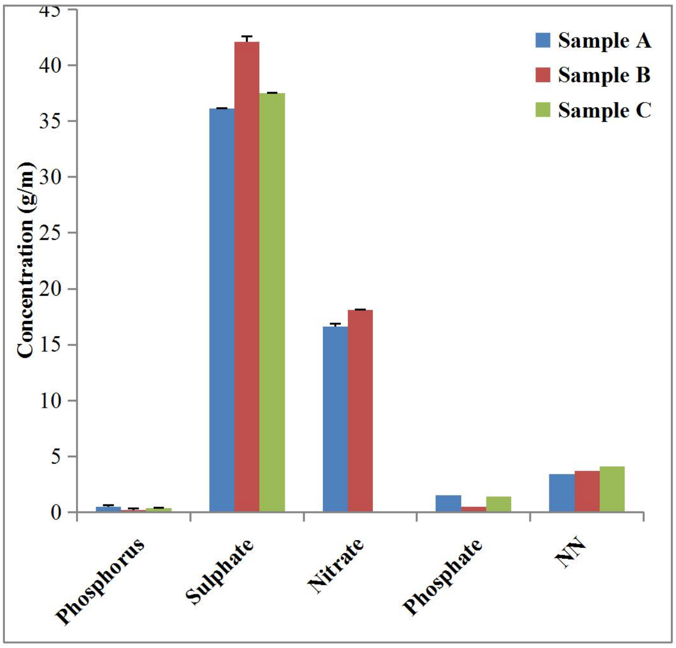

Figure 5: Variation in the levels of Phosphorus, Sulphate, Nitrate, Phosphate and Nitrogen-Nitrate of Trans-Amadi Creek at three sampling points.

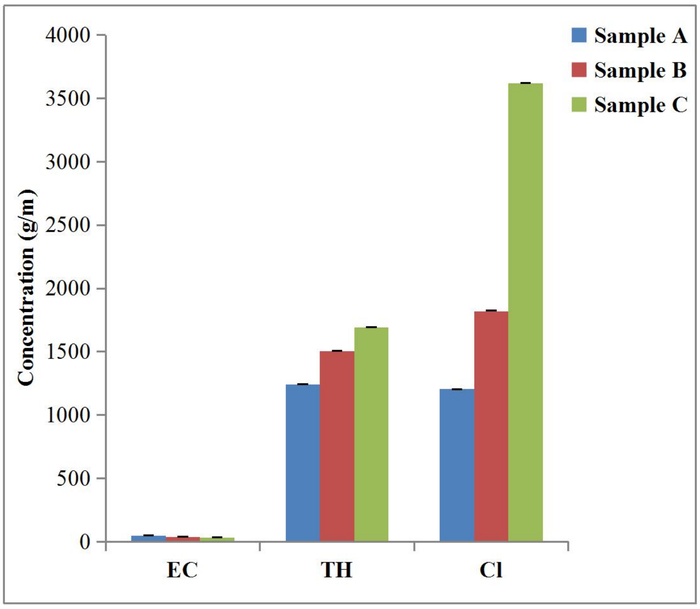

Figure 4: Variation in the levels of Electrical Conductivity, Total Hardness and Chloride of Trans-Amadi Creek at three sampling points.

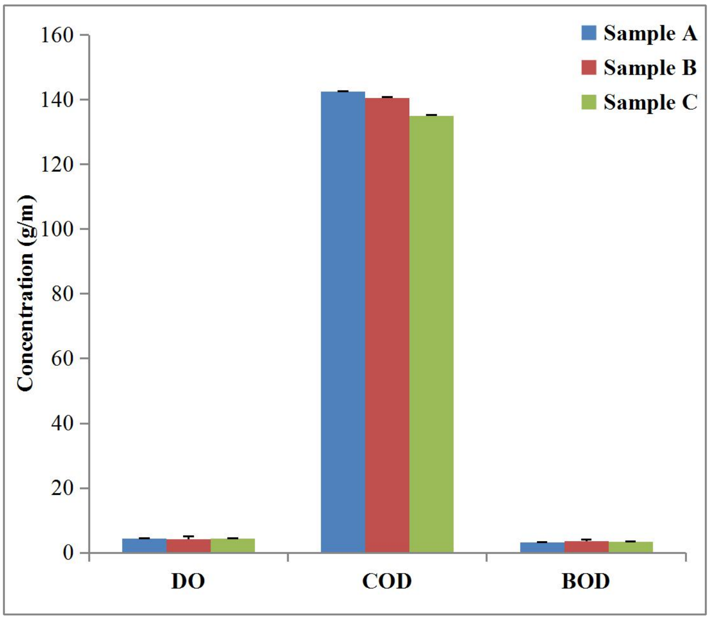

Figure 6: Variation in the levels of Dissolved Oxygen, COD and BOD of Trans-Amadi Creek at three sampling points.

Conclusion

The abattoir waste and wastewater which is discharged in the creek at the middle-stream of this study impacted negatively on some parameters. As a diffused source close to the creek, it is the major source of pollution of Trans- Amadi creek during the rainy season during which this study was carried out. While rainfall may dilute and weaken the effects of point source pollution, it also increases the contribution of non-point source or diffuse pollution through land runoff from riparian communities and agricultural farmland. Findings from this current study indicates that the meat processing industry in Nigeria has a potential to worsen scarcity of clean water availability, thereby adversely affecting the range of uses of such water bodies. Therefore, the result of the analysis generally showed that Trans-Amadi Creek is polluted and poses severe health risk to several riparian communities who rely on the Creek as their primary source of domestic water.

Conflict of interest

The authors declare no conflict of interest.

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Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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