

Assessment of Abattoir Effluent on Iyiokwu River, Abakaliki, Ebonyi State

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Abstract

The study was conducted at Abakaliki, the capital city of Ebonyi State, and aimed at assessing the effect of abattoir effluent on Iyiokwu River in Garki mini market. The analysis was done at the beginning of rainy season (April 2017). In order to achieve set objectives, five sampling locations were chosen; they are WQ₅₀, WQ₀, WQ₁₀₀, WQ₁₅₀ and WQ₂₀₀ respectively. Some parameters were selected based on their relative importance to abattoir effluent composition and analyzed for physicochemical and microbiological characteristics. These parameters include: Colour (pcu), Odour, Temperature (0°C), Turbidity (NTU), Conductivity (μs/cm), Total Solid (mg/l), Total Dissolved Solid (mg/l), Total suspended solid (mg/l), pH, Cl⁻ (mg/l), SO₄⁻² (mg/l), PO₄⁻³ (mg/l), P (mg/l), Ca⁺ (mg/l), Mg⁺ (mg/l), CaCO₃ (mg/l), NO₃⁻ (mg/l), NO₃⁻N, total organic carbon (%), NH₃ (mg/l), NH₃⁻N(mg/l), Pb (mg/l), Cu (mg/l), Ni (mg/l), As (mg/l), and Fe (mg/l). Total Heterotrophic Bacteria Count (cfu), Total Salmonella Shigella Count (cfu), Total Coliform Count (cfu), Total Heterotrophic Fungal Count (cfu), and Total E. coli Count (cfu). The measurement location WQ₀ which is the point of discharge has the highest concentration of most of the parameters ranging from temperature as a physical characteristic, to chemical oxygen demand as a chemical characteristic and then to total coliform count as a biological characteristic. Although there was a gradual decrease in the concentration of the parameters from sample point WQ₀ downstream, this may be as a result of dispersion along the river flow path. At measurement location WQ₂₀₀ there was a sudden and sharp increase in some tested parameters such as SO₃, Ni, NO₃, and NO₃⁻N. This may be because of the waste dump site that runs off into Iyiokwu River at this particular point. The tested result showed a statistically significant difference ($P < 0.05$) when Turbidity, Conductivity, TDS, TSS, Colour, Temperature, pH, Sulphate, Phosphate, Calcium, Magnesium, DO, E. coli, THFC, THBC, TSSC, and TCC measurements at the discharge point (WQ₀) were compared with the measurements at the control point (WQ₅₀) and also with the WHO permissible limit. It is recommended that abattoir waste be segregated before discharging into the stream, and it is advised that the discharge point be avoided as a source of domestic water supply. The liquid waste can be a source of biogas, while the solid waste can serve as manure.

Keywords

Abattoir

Dissolved oxygen (DO)

Chemical oxygen demand (COD)

E-coli

Biochemical oxygen demand.

Introduction

1.1 Background Of Study

Over the years environmental problems have increased due to poor management of our water bodies. This has led to so many problems in the aquatic environment. Diseases such as dysentery, cholera, typhoid, etc., are the major problems facing many countries of the world. The slaughtering of animals continuously and subsequent inappropriate disposal of their waste materials into waterways has contributed to bad odour and low quality of surface water (Igbiosa and Okoh, 2009).

Abattoir houses are usually located close to rivers in order to gain access to water either to wash slaughtered animals or to deposit waste generated directly into the water bodies. Meats from animals are essential food for daily living, but the manner of disposal has tremendously reduced water quality (Coker *et al.*, 2001). The terms “slaughterhouse” and “abattoir” are synonymous and used interchangeably (Cowi, 2001). An abattoir is a particular place or area set aside for slaughtering of animals whose primary purpose is for consumption and includes a slaughterhouse but does not include a place situated on a farm. The majority of abattoir houses generate wastewater that has been channeled into the river without any form of pretreatment. As such, water quality loses its value (Okonkwo, 2000).

An increase in population has led to a significant rise in meat production. In order to meet the protein needs of the population, a large number of animals are slaughtered daily, and the waste is deposited into waterways (Montgomery, 2006). According to Yusuf and Shualb (2012). Water bodies have become the easiest means of eradicating waste materials without any form of treatment. People use streams, lakes, and rivers as points of disposal. Degradation of water quality is due to the discharge of waste generated from the slaughterhouse into water bodies; this discharge of waste materials can introduce enteric pathogens and excess nutrients into surface water (Adelegan, 2002). The pollution of a surface water body in any form is a critical issue because of aquatic organisms that depend on water for their existence and the benefits that man derives from it. The moment a waterbody is polluted, its quality will be degraded. However, reports have it that large numbers of water bodies in many countries of the world are grossly polluted (Ubani and Ozougwu, 2014). The water quality situation therefore becomes very critical and of great environmental and public health concern. It has been estimated that about 50-55% of animals are slaughtered; 15% of them are waste, and the remaining 30-35% of the animals are turned into by-products such as leather, like bags, shoes, etc. (Nweke, 2000). Abattoir waste contains solid, liquid, and fatty materials, which can be highly organic; the solid parts are made up of the bones, undigested ingesta, hairs, etc. The liquid aspect is made up of urine, blood, water, and dissolved solids, while the fatty materials are made up of fats and oil. The moment these waste materials are discharged into water bodies, the nature and the quality of the water change, starting by diminishing the dissolved oxygen (DO) available for fishes to survive (Aina and Adedipe, 1991).

Excess nutrients from abattoir effluent could cause the water body to become choked with organic substances and organisms. When organic matter exceeds the capacity of the microorganisms in water that break down and recycle the organic matter, it encourages rapid growth of algae, leading to eutrophication. Equally, improper disposal systems of wastes from slaughterhouses could lead to transmission of pathogens to humans and cause gastroenteritis when consumed (Cadmus *et al.*, 1999). Improper management of abattoir wastes and subsequent disposal either directly or indirectly into river bodies portends serious environmental and health hazards both to aquatic life and humans (Chukwu, 2005).

Many countries of the world, like Norway, Sweden, Denmark, the Netherlands, and Romania in the late 18th century (Ogedenge, 2010), encouraged the building of slaughtering houses because slaughtering of animals for community consumption is inevitable.

In Nigeria, disposal of waste is irritating and requires immediate attention. Waste materials are usually exposed to the atmosphere, where rodents, flies, and other animals have access to them before disposal (Irshad, 2013). Abattoir wastes with large quantities of animal dung are often channeled directly into water bodies used for domestic purposes by human beings. The location and operation of abattoirs are generally unregulated; aside from that, they are usually located near water bodies where access to water for processing

is assured. The animal blood is released untreated into the flowing stream, while the consumable parts of the slaughtered animal are washed directly into the flowing water (Adelegan, 2002).

Sangodoyin and Agbawe (1992) identified improper management and supervision of abattoir activities as a major source of risk to public health in Southwestern Nigeria. Wastes from slaughterhouses typically contain fat, grease, hair, flesh, manure, grit and undigested feed, blood, bones, and process water, which is characterized by a high organic level (Ibeh and Mbah, 2007; Coker *et al.*, 2001; Nafarnda *et al.*, 2006).

Dumping of solid and effluent waste discharge into waterways is a lifestyle that many people have embraced regardless of the impact on human health; therefore, the study focuses on assessing the water quality of Iyiokwu River and the impacts of abattoir effluents on its quality.

1.2 Aim

To access the impact of abattoir effluent on the Iyiokwu River

The objectives are as follows:

- Determine water quality without abattoir waste
- Determine the composition of the abattoir wastewater
- Analyze water quality downstream from the waste discharge point.
- Establish the impact of the waste on the river.

1.3 Statement Of Problem

The major problem of the Iyiokwu River is the deposition of waste materials from the Garki abattoir, which is capable of transmitting zoonotic and pathogenic diseases to humans. Individuals involved in slaughtering animals dispose of their effluent that contains urine, blood, faeces and other organic pollutants from animals directly into the river without any form of treatment, and slaughtered animals are washed with the same water. Uncontrolled discharge of effluent from abattoirs has become a big challenge both to man and aquatic organisms.

Between 2004 and 2007 there was an outbreak of diseases such as cholera, which was linked to the consumption of water directly from this Iyiokwu River. This led to loss of lives and degradation of water qualities. Children within the age of 6 to 9 years died as a result of cholera. Also, in 2008 skin rashes were obvious. This is majorly from individuals who bath in this Iyiokwu River. These problems caused by the Iyiokwu River as a result of human activities are now of great concern to the people of Abakaliki, Ogoja, Calabar, and Nigeria in general. Studies have been conducted, and seminars and workshops have also been held in the immediate and remote areas in response to causes of this water quality degradation. A number of measures have been taken to control this problem, but some of these measures did not work at full capacity, and the abattoir discharge is still active.

1.4 Relevance

This study helps to inform the government and general public about the nature of Iyiokwu River and the quality of degradation that has taken place due to abattoir effluent. It equally helps to expose the enteric disease posed by the river as a result of abattoir effluent. The result obtained from this study helps people to know the adverse impact of the abattoir on the Iyiokwu River. The study serves as a catalyst for both government and individuals to improve water management and quality conservation in order to save lives. The work deeply looks into some parameters that ascertain water suitability for consumption.

1.5 Scope Of Study

This work was carried out in the Iyiokwu River in Abakaliki, Ebonyi State. The work basically covers physical, chemical, and bacteriological analysis. Samples were collected in five different locations: upstream, at the discharge point, and downstream, respectively.

Materials And Method

3.1 Brief history of Ebonyi State

Ebonyi State was created in 1996 from parts of Enugu, Anambra, and Imo state. The city is bounded physically to the east by Cross river state, to the north by Benue state and the south by Abia state. It is habited and populated primarily by Igbo. Its largest and capital city is Abakaliki. The people of Ebonyi State are predominantly farmers. The state is richly blessed with numerous solid minerals resources spread across all parts of the states.

3.2 Study Area

This study was carried out at the beginning of the rainy season (April (2017) in Abakaliki, the capital city of Ebonyi State in southern Nigeria. Its coordinates are between latitude $6^{\circ} 22' 26''$ N and longitude $8^{\circ} 06' 6''$ E. The location is traversed by a number of rivers: the Iyiudele River, Iyiokwu River, the Ebonyi River, and the Okpuru River, respectively. The study took place at Iyiokwu River, which is downstream from Iyiudele River in Garki abattoir Abakaliki. Iyiokwu River was used for this assessment because it is mostly affected by this abattoir effluent.

3.3 Climate

The climate is tropical, and the rainfall pattern classified under savannah zone of Niger. The wet season occurs between April and October, and the dry season which takes place from November to March. The average annual rainfall varies from 1750mm to 2250mm (Ofomata, 2003).



Fig 1: Map of Nigeria showing the location of Ebonyi state

Source: www.worldatlas.com



Fig 2: Map of Ebonyi State

Source: www.worldatlas.com

Vegetation

The vegetation is characterized by semi-savannah grassland with forests and swamps. It is dominated with planted forest of Melina. The predominant grasses are elephant grasses with perennial characteristics of sparse vegetation. The type of soil in that area is basically clayey loamy soil.

Population

The population of Ebonyi state is growing tremendously as a result of employment, migration and birth rate. The result of the 2006 national population and housing census exercise showed that the population of Ebonyi state was 1,739,136.

Temperature

The mean annual minimum and maximum temperatures are approximately 20.3⁰C to 34.9⁰C. The relative humidity of the study area is between 60 to 80% during rainy season (Apha, 1998).

3.3.1 Sources of Data

The data used in this research were obtained from both primary and secondary sources.

3.3.2 Primary Data

The primary data are the set of data collected from the study area through sampling and include those derived from observations made during sampling and laboratory work.

3.3.3 Secondary Data

Secondary data include all published materials used in this study. These are information and data from text books, monographs, lecture books, journals, internet and literature from other peoples work.

3.4 Materials

50 cl of plastic bottles and 20 cl of BOD were well sterilized in the lab before taking them to the field. The water samples were collected very early in the morning, around 7:30am to 11:05am, when the effluent is washed into the channel that leads to Iyiokwu River.

3.5 Sample Point Collection

The samples were collected at five different points along the flow paths. One sample was collected upstream before the discharge point, and the other four were collected after the discharge point. The upstream was selected to serve as a control, referred to in this work as WQ₅₀; the discharge point was referred to as WQ₀ while three other points represent the downstream section, which include WQ₁₀₀, WQ₁₅₀, and WQ₂₀₀.

In each sampling point, three samples were collected, making it a total of fifteen samples, which were used to analyze the physical, chemical, and biological parameters of the water samples. During sampling, sample bottles were rinsed with the sampling water to maintain homogeneity and then filled to the maximum. The

sample containers were well labelled and covered to protect them from contamination and were preserved with ice packs before transporting them to the laboratory the same day. The locations of the samples collected in the field are presented in

Table 4 below.

Table 3.1: Sample Point Location and Coordinate

Source: 2017 Sampling	S/N	NAME OF LOCATION	CODE	LATITUDE	LONGITUDE	ELAVATION (METERS)	Field Work, depth for all
	1	H ₂ O quality before DP	WQ ₅₀	N06 ⁰ 19.233 ¹	E008 ⁰ 06.233 ¹	31.82	
	2	DP	WQ ₀	N06 ⁰ 19.163 ¹	E008 ⁰ 06.559 ¹	51.40	
	3	100m after DP	WQ ₁₀₀	N06 ⁰ 19.135 ¹	E008 ⁰ 06.543 ¹	44.39	
	4	150m after DP	WQ ₁₅₀	N06 ⁰ 19.067 ¹	E008 ⁰ 06.553 ¹	25	
	5	200m after DP	WQ ₂₀₀	N06 ⁰ 19.065 ¹	E008 ⁰ 06.599 ¹	44.42	

measurement location: 0.16m

DP: Discharge Point

WQ: Water Quality

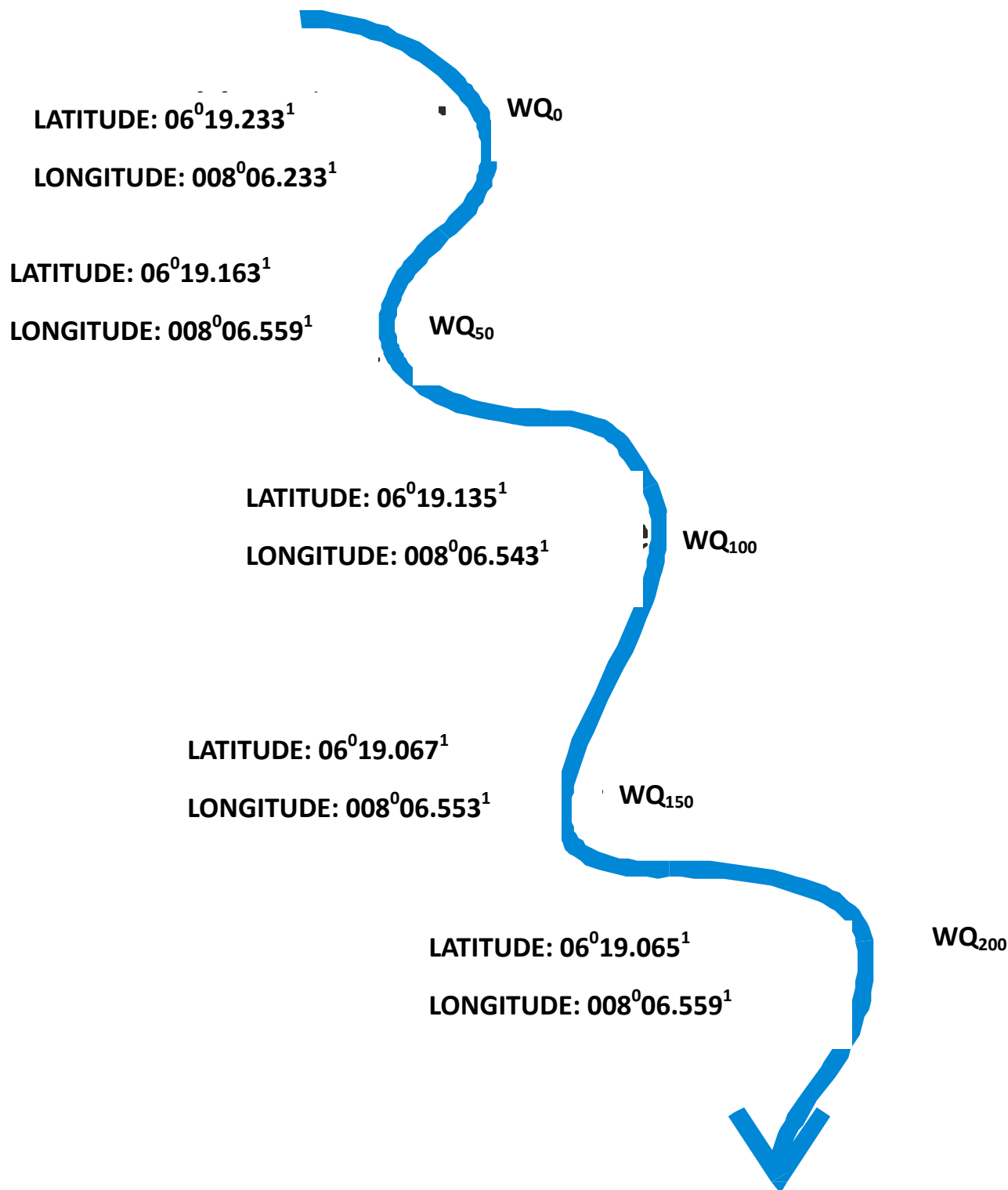


Fig3:

sampling point illustration (Iyiokwu River)

3.6 Laboratory protocol

3.7 Physical Properties Determination

The physical analyses of the water samples determined are: colour, odour, temperature, turbidity, total dissolved solids (TDS), and total suspended solids (TSS), and total solids (TS).

Colour determination

The colour of the water sample was determined by the colorimetric platinum cobalt method at 420 nm with the HI83200 model, which displayed in PCU (Platinum Cobalt Unit).

Odour determination

Odour was determined by smelling the water sample through a sensory evaluation panel according to the methods of APHA (1992).

Temperature determination

The water temperature was taken with the use of a mercury thermometer calibrated in degree centigrade (Celsius) as described by the method of Edma et al. (2001).

Turbidity determination

The turbidity of the water sample was estimated by comparing the turbidity of the water with the ampoule of standard turbidity, by holding both ampoules side by side after thorough shaking as prescribe by the association of official analytical chemist (Bartram, 1996).

Total solids determination

Total solids were determined by measuring 50ml of water sample into the weighed beaker and heated to dryness, weighed after cooling. The difference in two weights gives the total solid (TS) (Bartram, 1996).

Total dissolved solid (TDS) determination

Total dissolved solids (TDS) were determined by measuring 50ml of the sample. The sample was filtered into a weighed beaker, and then heated to dryness. It was later cooled and re-weighed

$$\text{TDS} = \frac{\text{TSX1000 (mg/l)}}{\text{Vol. of sample}}$$

Total suspended solid (TSS) determination

The amount of suspended solid or particulate matter was determined by subtracting total dissolved solid from total solids; that is,

$$\text{T.S. S} = \text{T.S.} - \text{T.D.S.}$$

3.8 Chemical parameter determination

Conductivity Determination

Conductivity of water samples was determined using the conductivity meter (Jenway model 4520) according to Edma (2001).

Total hardness determination

Hardness in water is mainly due to the presence of Ca^{2+} and Mg^{2+} ions. 50 ml of water sample was pipetted into a conical flask, and 1 ml of 5% of Na_2SO_3 drops of Eriot black indicator was added, when the sample turned red, it was titrated with 0.01m EDTA until it turned blue (Apha,1992).

Calcium

50 ml of the sample was measured into a clean conical flask, then 10 ml of distilled water was added, followed by 4 ml of KOH solution, 0.3 g of potassium cyanide, 0.3 g of hydroxylamine hydrochloride, 5 ml of monoethane buffer, and 2 drops of solochrome black-T or Eriochrome T indicator. The solution was titrated against 0.01 NEDTA (FME, 2001).

pH determination

The pH was determined by using a pH meter of an electric digestive glass dipped into 100 ml of a water sample measured into a beaker and allowed to stay for some minutes to detect the readings. (Jenway model 3510).

Chloride determination

The chloride content was determined by using the titration method by measuring 10 ml of water sample into a 250 ml conical flask and titrating against 0.1 ml of silver nitrate (Apha, 1992).

Sulphate:

Sulphate was determined by the turbidimeter method using the HI83200 multiparameter bench photometer at a wavelength of 466 nm. 10 ml of the sample was poured into two (2) separate sample cell bottles. One (1) sachet of sulphate reagent powder pillows was added to the second sample cell compartment and timed

for 5 minutes. At the end of the countdown, the READ button was pressed to display the result in mg/l of sulphate (FME, 2001).

Phosphate determination:

Phosphate was determined by mixing 25 cm³ of each sample with 4 ml of molybdate reagent (ammonium molybdate in distilled water) acidified with H₂SO₄ and 10 drops of stannous chloride in glycerol and left for 10 mins (Pansu and Gauthoyrou, 2006).

Ammonia

Ammonia is determined by the Nessler method using the HI83200 multiparameter bench photometer at a wavelength of 420 nm. 10 ml of the sample was poured into two (2) separate sample cell bottles. One (1) was used as a blank to zero the photometer, and then 4 drops of HI93715A-0 were added to the other cuvette and the solution, then the cuvette was re-inserted into the instrument and timed for 3 minutes 30 seconds. At the end of the countdown, the read button was pressed to display the result of NH₃-N and NH₄⁺ in mg/l

Nitrate Nitrogen Determination

This was determined from adaptation of the ferrous sulphate methods. 50 ml of water sample was measured into a conical flask. 1 ml of sodium arsenite was added and shaken thoroughly; 5 ml was then taken from the solution into a separate clean test tube. 10 ml of brucine sulphate and 1 ml of conc. H₂SO₄ were added to the solution in the test tube and thoroughly shaken for proper mixing, after which the remaining 45 ml of the solution was added and allowed to stand for 30 mins. The reading was taken at 410 nm in a spectrophotometer machine (Pansu and Gauthoyrou, 2006).

3.9 Determination of Heavy Metals

The heavy metals (Pb, Cu, Fe, Ar, and Ni) were determined using the atomic adsorption spectrophotometer machine (AAS).

Dissolved Oxygen (DO₂):

The DO₂ was determined using DO₂ meter. The DO₂ meter was calibrated using 5% sodium sulphate solution. The probe of the meter was then inserted into the sample, and the meter was put on for about 10 minutes. The reading was recorded in mg/l.

Biological Oxygen Demand (BOD)

The BODs were determined using a DO₂ meter, which was calibrated using 5% sodium sulphate solution. The probe of the meter was then inserted into the sample after the meter was switched on for about 10 minutes. The reading was recorded in mg/l. The sample was then incubated in a 250 ml wrinkle's bottle for a period of 5 days at 20°C. Then the DO₂ on the fifth day was recorded by inserting the probe again into the sample. The difference in the DO₂ (5) and DO₂ (1) was recorded as BOD₅.

$$BOD_5 = DO_2 (1) - DO_2 (5)$$

Chemical Oxygen Demand (COD):

This was determined by measuring 10 ml of the water sample into a 250 ml conical flask, and then 5 ml of 0.025 N potassium dichromate solution (K₂C₂O₇) was added, followed by 15 ml of concentrated sulphuric acid. The solution in the conical flask was diluted with 40 ml of distilled water to obtain a 70 ml solution. Again, 7 drops of phenylthiol ferrous sulphate indicator were added and thoroughly shaken for uniform mixing. The solution was titrated against 0.025 N ferrous ammonium sulphate. The blank (distilled water) was also titrated against 0.025 N ferrous ammonium sulphate (FME, 2001).

3.9.1 Biological Properties Determination

The bacteriological parameters were determined using standard bacteriological technique (FME, 2001).

4.0 Result And Discussion

The effect of abattoir effluent on water quality along the measurement positions is presented in tables 4.1, 4.2, 4.3, and 4.4. A discussion of each parameter follows the tables. The data were statistically analyzed using the analysis of variance (ANOVA) according to the procedure outlined by Steel and Torie (1980). Means were evaluated for significant difference using Tukey's method at the probability level of 5%. Also, the result and the findings were presented in percentages, graphs, and tables using Minitab version 16 and Microsoft Excel.

Table 4.1: Abattoir Effluent on Physical Characteristics of Iyiokwu River

Parameters	WQ ₅₀	WQ ₀	WQ ₁₀₀	WQ ₁₅₀	WQ ₂₀₀	MEA N	WHO
Temp °C	25.50±0.265 _C	29.90±0.551 _A	27.50±0.100 _{BC}	26.50±0.173 ^B	26.30±0.299 ^B	27.14	25
Colour (PCU)	29.00±1.73 ^E	1095.00±1.73 ^A	654.00±3.61 _B	267.00±2.65 ^C	57.00±2.65 ^D	420.40	15
Odour	OB	OB	OB	OB	OB	-	UNOB
Turbidity (NTU)	9.640±0.164 _C	87.550±9.097 ^A	49.500±6.144 ^B	45.550±6.466 ^B	37.200±0.436 _C	45.88	5NTU
TS (Mg/l)	312.00±10.82 ^B	526.00±24.25 ^A	501.00±3.61 _A	444.00±112.04 _{AB}	399.67±10.69 _{AB}	436.53	500
TDS(Mg/l)	273.33±16.07 ^D	427.67±6.81 _A	417.00±2.65 _A	373.00±2.65 ^B	334.67±16.04 _C	365.13	0.2
TSS(Mg/l)	26.80±2.43 ^E	172.20±3.30 _A	98.30±3.75 ^B	83.67±3.21 ^C	38.40±2.12 ^D	83.87	20

- PCU: Platinum Cobalt Unit
- NTU: Nephelometric Turbidity Unit
- µS/CM: Micro siemens per centimeter
- Mg/l: Milligram per liter
- TS: Total Solid, TSS: Total Suspended solid, TDS: Total dissolved solid
- OB: Objectionable and UNOB: Unobjectionable

Values bearing the same superscript letters are not significantly different (p<0.05).

Table 4.2 Abattoir Effluent on the Chemical Characteristics of Iyiokwu River

Parameters	WQ ₅₀	WQ ₀	WQ ₁₀₀	WQ ₁₅₀	WQ ₂₀₀	MEAN	WHO
pH(Mg/l)	3.8000±0.818 ^{5^{BC}}	5.3000±0.26 ^{46^A}	4.8000±0.156 ^{2^{AB}}	3.6000±0.100 ^{0^C}	5.1000±0.173 ^{2^A}	4.52	6.5-8.5
Conductivity (µs/cm)	458.00±1.000 ^E	658.00±4.36 ^{0^A}	642.00±2.000 ^B	622.00±11.14 ^{0^C}	558.00±4.360 ^D	587.60	500
CL ⁻ (Mg/l)	32.64±4.09 ^B	94.75±4.21 ^A	74.44±30.01 ^{A_B}	52.55±32.64 ^{A_B}	40.40±9.01 ^{AB}	58.95	250
SO ₄ ³⁻ (Mg/l)	758.81±60.79 ^{AB}	353.07±52.1 ^{3^C}	648.52±42.56 ^B	669.10±59.95 ^B	825.47±23.53 ^A	650.99	250
PO ₄ ³⁻ (Mg/l)	2.7000±0.818 ^{5^{BC}}	6.9333±1.13 ^{72^A}	4.3000±0.264 ^{6^B}	2.7000±0.818 ^{5^{BC}}	2.3000±0.264 ^{6^C}	3.78	0.3
P (Mg/l)	0.9000±0.360 ^{6^B}	2.3000±0.26 ^{46^A}	1.4000±0.351 ^{6^B}	0.9000±0.360 ^{6^B}	0.7333±0.208 ^{2^B}	1.24	<5
NO ₃ ⁻ (Mg/l)	10.800±1.058 ^C	22.000±0.43 ^{6^B}	22.000±0.436 ^B	22.400±0.529 ^B	39.200±1.082 ^A	23.28	50
NO ₃ ⁻ N (Mg/l)	2.5200±0.450 ^{8^C}	5.0000±0.43 ^{59^B}	4.9800±1.081 ^{3^B}	2.7200±0.649 ^{0^C}	8.9000±1.153 ^{3^A}	4.82	3
Carbon (Mg/l)	3.9800±1.288 ^B	6.6300±0.54 ^{74^A}	6.6800±0.060 ^{53^A}	6.8200±0.805 ^{4^A}	4.6400±0.576 ^{9^B}	5.75	5
NH ₃ (Mg/l)	0.5600±0.288 ^{3^A}	0.8800±0.07 ^{55^A}	0.8700±0.075 ^{5^A}	0.8400±0.034 ^{6^A}	0.5200±0.120 ^{0^A}	0.73	-
NH ₃ -N (Mg/l)	0.4300±0.026 ^{5^A}	0.7300±0.21 ^{66^A}	0.7300±0.216 ^{6^A}	0.7000±0.200 ^{0^A}	0.4700±0.062 ^{4^A}	0.30	-
CaCO ₃ (Mg/l)	600.00±39.3 ^C	941.43±39.3 ^A	780.47±78.3 ^B	612.19±10.8 ^C	663.41±62.2 ^{B_C}	719.5	1000
Ca ⁺ (Mg/l)	211.00±2.65 ^B	324.33±25.5 ^{8^A}	269.00±8.54 ^{A_B}	228.76±70.90 ^B	206.69±2.52 ^B	247.94	300
Mg ⁺ (Mg/l)	80.64±3.80 ^D	156.67±4.73 ^A	124.33±2.08 ^B	93.72±3.27 ^C	65.84±5.76 ^E	104.24	150
BOD(Mg/l)	1.000±0.4583 ^{BC}	5.3000±0.26 ^{46^A}	3.6000±0.529 ^{2^{BC}}	3.5000±0.400 ^{0^B}	2.9000±0.173 ^{2^C}	3.26	6.5-8.5
COD(Mg/l)	5.7600±0.918 ^{0^C}	8.4800±0.50 ^{12^A}	8.0000±0.871 ^{8^{AB}}	6.4000±0.346 ^{4^{BC}}	4.6400±0.576 ^{9^C}	6.65	6.5-8.5
DO(Mg/l)	5.4000±0.346 ^{4^A}	3.1000±0.36 ^{06^C}	3.6000±0.529 ^{2^C}	4.1000±0.360 ^{6^{BC}}	5.1000±0.360 ^{6^{AB}}	4.28	6.5

Values bearing the same superscript letters are not significantly different (p<0.05).

COD: Chemical Oxygen Demand

BOD: Biochemical Oxygen Demand

DO: Dissolved Oxygen

Table 4.3 Abattoir Effluent on the Heavy Metal

Values bearing the same superscript letters are not significantly different (p<0.05).

Parameters	WQ ₅₀	WQ ₀	WQ ₁₀₀	WQ ₁₅₀	WQ ₂₀₀	MEAN	WHO
Lead(mg/l)	0.02333±0.00577 ^C	0.15667±0.00577 ^A	0.06333±0.01528 ^B	0.06000±0.01000 ^B	0.04000±0.01000 ^{BC}	0.06	0.01
Copper(mg/l)	0.0667±0.01528 ^A	0.15000±0.03606 ^A	0.14333±0.02082 ^A	0.12667±0.06028 ^A	0.09667±0.9292 ^A	0.11	2
Nickel(mg/l)	0.03333±0.02517 ^{AB}	0.00000±0.00000 ^B	0.00000±0.00000 ^B	0.00000±0.00000 ^B	0.07333±0.03055 ^A	0.02	0.07
Arsenic(mg/l)	0.03333±0.02517 ^A	0.07333±0.02082 ^A	0.06000±0.02646 ^A	0.05333±0.03055 ^A	0.02333±0.01828 ^A	0.04	0.01
Iron(mg/l)	1.37667±0.1250 ^A	1.7600±0.1386 ^A	1.7733±0.1617 ^A	1.6067±0.1935 ^A	1.5500±0.1323 ^A	0.61	0.3

Table 4.4: Abattoir Effluent on Biological Characteristics of Iyiokwu River

Parameters	WQ ₅₀	WQ ₀	WQ ₁₀₀	WQ ₁₅₀	WQ ₂₀₀	MEAN	WHO
THBC	1.5600±0.2163 ^C	7.8000±0.7632 ^A	2.9000±0.3606 ^B	1.8000±0.1732 ^C	1.6000±0.2000 ^C	3.13	0
T ECOLI	1.0000±0.7894 ^D	9.0000±0.4583 ^A	7.0000±0.4583 ^B	3.2000±0.2646 ^C	2.0000±0.4583 ^{CD}	4.44	0
T SSC	1.0000±0.4583 ^C	4.0000±0.4583 ^A	3.0000±0.4583 ^{AB}	3.0000±0.4583 ^{AB}	2.0000±0.4583 ^{BC}	2.60	0
TCC	1.100±0.346 ^C	5.000±3.579 ^A	2.400±0.458 ^B	2.000±0.458 ^B	1.450±0.118 ^C	2.39	0
THFC	1.0000±0.7894 ^D	9.0000±0.4583 ^A	3.2000±0.2646 ^B	3.0000±0.4583 ^{BC}	1.2000±1.0859 ^{CB}	3.48	0

Values bearing the same superscript letters are not significantly different ($p < 0.05$).

- THBC: TOTAL HETEROTROPHIC BACTERIA COUNT
- T ECOLI: TOTAL E COLI COUNT
- TSSC: TOTAL SALMONELLA SHIGELLA COUNT
- TCC: TOTAL COLIFORM COUNT
- THFC: TOTAL HETEROTROPHIC FUNGAL COUNT

4.5 Discussion

From the analysis above, **the temperature** value of the sample showed a statistically significant difference ($p < 0.05$) among samples, as seen in table 4.1. The highest temperature was recorded at the point of discharge, which is WQ₀ (29.900°C). This observed temperature value was higher than WQ₅₀, WQ₁₀₀, WQ₁₅₀, and WQ₂₀₀ by 14.28%, 8.02%, 11.37%, and 12.04%, respectively. The higher temperature observed at the point of discharge could be as a result of the decomposition of animal waste from the slaughterhouse. The rise in temperature at WQ₀ may also be as a result of the turbulent movement of water at that point. However, the study corresponded with the findings in previous studies (Ubwa, 2013) and (Paul, 2013). The rate of chemical reaction can increase tremendously when the temperature increases and in turn reduce the available oxygen in water, leading to the death of microorganisms. The temperatures recorded from WQ₀, WQ₁₀₀, WQ₁₅₀, and WQ₂₀₀ are higher than the required 25°C temperature of water quality recommended by WHO (2017).

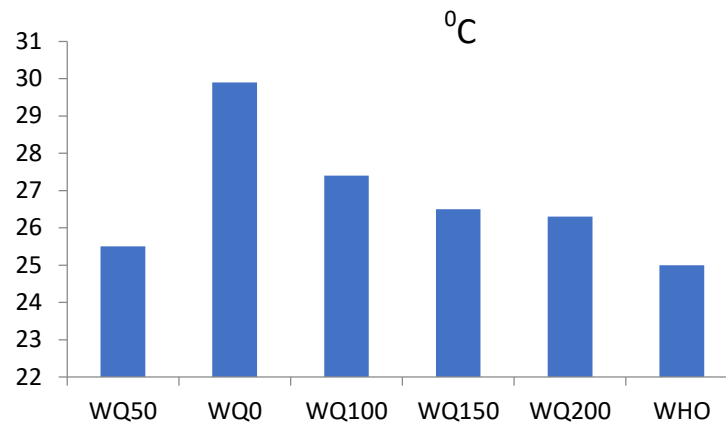


FIG 4: Effect of Abattoir Effluent on the Temperature of Iyiokwu River

The highest colour change was recorded in WQ₀ and the lowest at WQ₅₀. The value at WQ₀ is greater than WQ₅₀ by 97%, which is highly statistically significant, as seen in table 4.1.

From WQ₀ downstream the colour change progressively decreased. The colour change in water could have been as a result of dissolved and suspended materials from animal waste, such as blood mixed with urine and the skin of the animal deposited on the water. The values obtained in all the measurement locations were higher than the recommended 15 pcu of the WHO standard. However, this observed colour change was in line with an earlier study (Coker *et al.*, 2001). The colour change is presented in Fig. 5 below

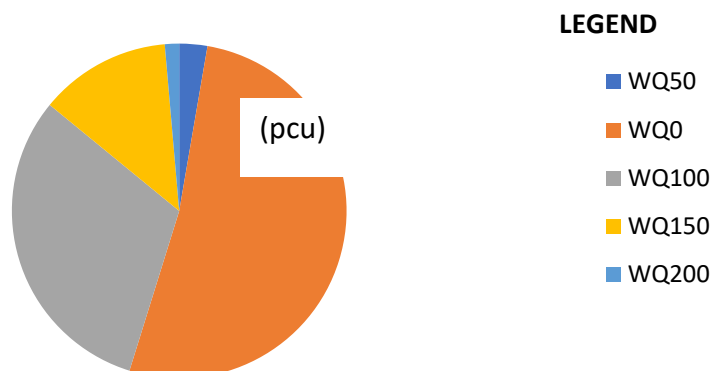


Fig. 5. Effect of Abattoir Effluent on the Colour of Iyiokwu River

The turbidity value at the measurement position WQ₀ was higher than WQ₅₀, WQ₁₅₀, and WQ₁₀₀ by 57.50%, 43.46%, and 47.97%, respectively, and this is statistically significant as seen in table 4.1. The high values of turbidity in the measurement location WQ₀ could be attributed to high suspended matter. Water quality in relation to turbidity can be classified as highly polluted when compared with the recommended 5 NTU standard of WHO. This result is similar to the study carried out in Minna (Abdulgafar, 2006).

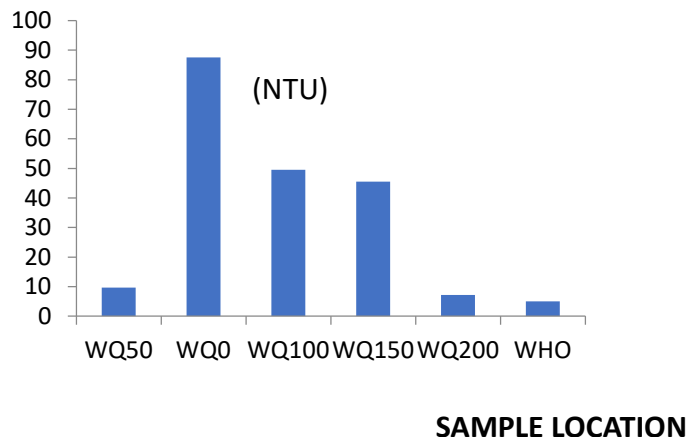


Fig 6. Effect of Abattoir Effluent on the Turbidity of Iyiokwu River

The **conductivity** of the sample ranged from 65.00 to 658.00 $\mu\text{S}/\text{cm}$, with the highest value recorded at the measurement location WQ₀. The recorded conductivity value of WQ₀ was higher than WQ₅₀, WQ₁₀₀, WQ₁₅₀, and WQ₂₀₀ by 30.39%, 2.43%, 5.47%, and 15.19%, respectively, and this is statistically significant. The highest conductivity was observed at the WQ₀ (discharge point), which indicates that the Iyiokwu River has a considerable loading of dissolved salts. The values at all the points are above the acceptable level that is 500 $\mu\text{S}/\text{cm}$ stipulated by WHO except the value at measurement location WQ₅₀ which is the control point. This result corresponded with the study of Rabah et al. (2008) in Sokoto state and also with Nwanta's (2010) research work at Nsukka in Enugu state.

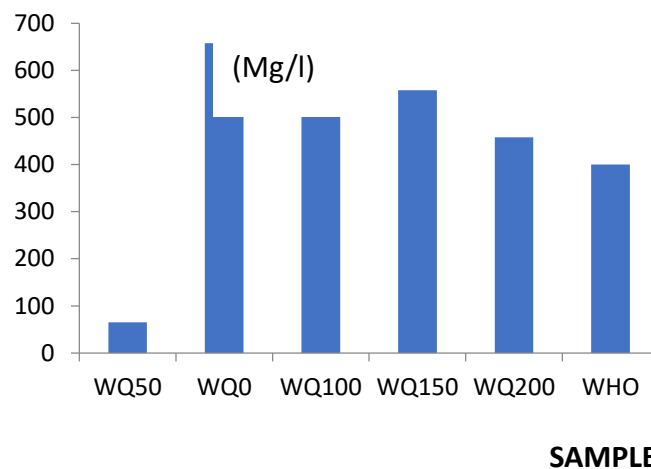


Fig 7. Effect of Abattoir Effluent on the Conductivity of Iyiokwu River

The **Total Solids** result showed that there was a significant statistical difference ($P < 0.05$) among samples collected. The highest value of Total Solids (TS) was recorded at WQ₀. The value at WQ₀ is greater than those at points WQ₅₀, WQ₁₀₀, WQ₁₅₀, and WQ₂₀₀ by 23.95%, 3.61%, 4.75%, and 40.68%, respectively. Sample locations WQ₅₀, WQ₀, WQ₁₀₀, and WQ₁₅₀, had higher solids values than the WHO standard of 150 mg/L. At sample location WQ₂₀₀ there was a notable decrease in TS levels. This could be as a result of dispersion mechanism within the river downstream. The high value recorded in the measurement location WQ₀ might be as a result of higher quantity of waste deposited on the water body without separating the solid wastes from the liquid waste before discharging. A higher concentration of total solids will make drinking water unpalatable and might have an adverse effect on people who are not used to drinking such water. This is similar to an earlier study carried out by (Sumayya *et.al*, 2013).

The lowest value of **Total Dissolved Solids (TDS)** was recorded in WQ₅₀ and the highest value was recorded at point WQ₀. The value at WQ₅₀ was lower than WQ₀ by 36%, which is statistically significant as demonstrated in table 4.1. From WQ₀ downstream, the values are noted to significantly decrease, possibly due to dispersion along the river's flow path. A similar pattern was also noted in the measurement of **Total Suspended Solid (TSS)**.

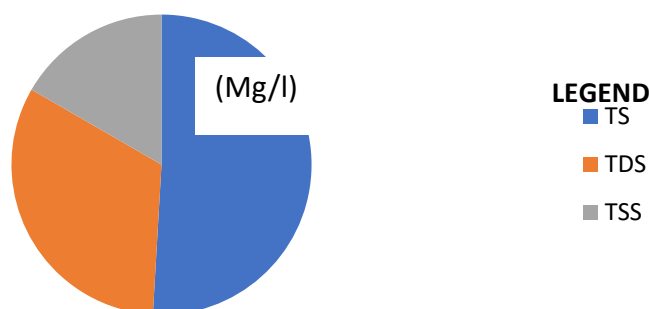


FIG. 8. Total solid, Total dissolved solid and Total suspended solid

The **pH** of Iyiokwu River is acidic. The pH at WQ₅₀ was 3.8 mg/l but increased by 28% at point WQ₀. This was statistically significant, as seen in table 4.2. This high value at the point of discharge could be attributed to the urine and the intestinal contents of the animals, which would increase the pH of the river. From the discharge point downstream, the pH gradually reduced but then suddenly increased to a near similar value with the discharge point at WQ₂₀₀. This could be as a result of the waste dump site that runs off into the river at point WQ₂₀₀. This corresponded with the research work carried out by Saldu and Musa (2012). Also, the value obtained from the analysis is lower than the recommended 6.5-8.5 of the WHO standards.

The measurement value of **chloride** at WQ₀ was greater than the value at WQ₅₀ by 65%, which is statistically significant, as seen in table 4.2. The high value of chloride in WQ₀ could be due to the presence of soluble salts (NaCl and KCl) from blood discharged into the effluent and salt used in skin processing (Lawal and Mahielbwala, 1992). From WQ₀ downstream, the value of chloride gradually decreased, possibly due to dispersion. The value obtained from this study was lower than the WHO standard.

Sulphate values ranged from 353.07 to 825.47 mg/l. The value of sulphate was lowest at the discharge point (WQ₀). The value at WQ₀ was lower by 54%, 46%, 47%, and 57% compared to WQ₅₀, WQ₁₀₀, WQ₁₅₀ and WQ₂₀₀ respectively. This is statistically significant, as seen in table 4.2. WQ₀ has the lowest value, which could be attributed to the presence of bacteria in the water sample, which tends to deplete the sulphate. The highest value was recorded in measurement location WQ₂₀₀ and this could be attributed to the waste dump site that is channelled from a particular point into the river at this location. This particular dump site might have less of the bacteria that deplete sulphate. The values obtained from all the measurement locations are higher than the recommended WHO standard and did not correspond with the study carried out by Coker et al. (2001).

The value of **phosphate** from WQ₅₀ to WQ₀ increased by 61%, which is statistically significant, as seen in table 4.2. Downstream from WQ₀ (the discharge point), the value of phosphate gradually decreased. There was a similar pattern of measurement in **phosphorus** values. Agarwal (1991) reported that the concentration of phosphate (PO_4^{3-}) above 0.5 mg/l was an indication of pollution, and based on the recorded results of phosphate, there is an indication of pollution in all the samples analyzed. This result corresponded with an earlier study by Tritt (1992).

Nitrate (NO_3) is the most available form in which nitrogen exists for plants. The result revealed that there was a 51% increase in the value of NO_3 between the WQ₅₀ (the control) and the WQ₀ (the point of discharge). This could be attributed to the high concentration of additional nutrients in the river at the discharge point. This change in the value of NO_3 was statistically significant, as seen in table 4.2. The value

remained fairly constant until at point WQ₂₀₀ where the value of nitrate was 44% greater than WQ₀. This is possibly because of the dump site that runs off to this measurement point (WQ₂₀₀).

Nitrate nitrogen (NO₃N) is found in the cells of living things and is a major component of proteins. The value of nitrate nitrogen increased by 50% from WQ₅₀ to WQ₀, obviously as a result of the discharge of abattoir effluent into the river. This is statistically significant, as seen in table 4.2. Moving downstream from WQ₀ to WQ₁₀₀ and WQ₁₅₀, the measurement of nitrate nitrogen progressively decreased, possibly because of dispersion. However, the measurement from WQ₀ to WQ₂₀₀ increased by 44%, possibly because of the aforementioned dump site that is channelled into the river at that point (WQ₂₀₀). Nitrate can quickly be converted into nitrite in the presence of bacteria that produce methemoglobin which destroys the ability of red cells to transport oxygen.

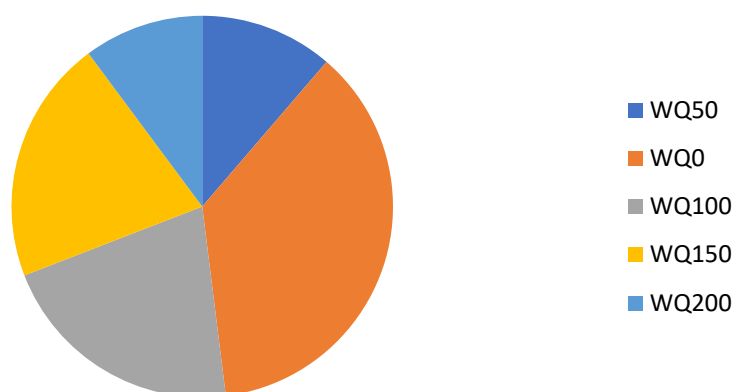


FIG9: Effect of Abattoir on the Concentration of Nitrate In Iyiokwu River

Total Organic Carbon increased from WQ₅₀ to WQ₀ by 40%, which is statistically significant as seen in table 4.2. From WQ₀ the change in value was not statistically significant until WQ₂₀₀ where the value of total organic carbon significantly reduced, maybe due to dispersion.

Ammonia is a colourless gas with a strong pungent odour. The value of ammonia was highest at the point of discharge (WQ₀) but the values across all the points were not statistically significant. This pattern of measurement was similarly replicated in **ammonia nitrate** (NH₃NO₃). Although there is no stipulated value recommended by WHO.

The calcium value at WQ₅₀ was 211 mg/l and increased by 35% at the discharge point (WQ₀) to 324 mg/l. This is statistically significant, as seen in table 4.2 above. From WQ₀ downstream the value of calcium gradually reduced. This may be due to the effect of dispersion. The value of calcium at the discharge point is well above 300 mg/L, which is the upper limit of the WHO-recommended standard. There was a similar trend in the measurements of **calcium carbonate** (CaCO₃) and **magnesium**. A similar result was also reported in an earlier study by Nwanta et al. (2010).

In the case of lead (Pb), the highest value was recorded at WQ₀, and was higher than WQ₅₀ by 85%, which is statistically significant, as seen in table 4.3. From the WQ₀ downstream, the values significantly decreased, possibly due to dispersion. However, all the recorded values were above the WHO standard. This is in line with the work carried out by Yusup and Oluwole (2009).

There was no trace of **Nickel** from WQ₀ to WQ₁₅₀ while there was a trace of nickel at WQ₅₀ and WQ₂₀₀. This means that other elements discharged into the river might have had a negative effect on nickel measurement, and that could explain why it was found at the control sample and the most downstream sample, WQ₂₀₀.

The highest value of **iron** was recorded at the discharge point, and this might be because of the presence of bones, blood, and other remains of the animals, which were not separated before being dumped into the water. However, the values throughout the different points did not show any statistically significant difference, as seen in table 4.3. This is similar to the measurement value of **arsenic** and similarly did not

show any significant difference. Iron concentration was higher throughout the measurement locations when compared with the WHO standard but corresponded with a previous study carried out by Yusuf and Osibanjo (2006).

There was a similar trend of change in the value of **copper**, but even though the highest value was found at the discharge point, there was no statistically significant difference in the values in all the samples. This was similarly reported in an earlier study by Yusup and Oluwole (2009). The copper values were, however, within the WHO recommended standard of 2 mg/l.

Chemical oxygen demand (COD) indicates the amount of oxygen that can be consumed by reaction in a measured solution (Apha, 1992). The COD value at WQ₀ was highest at the discharge point (WQ₀) and it was higher than WQ₅₀ by 32%, which is statistically significant, as seen in table 4.3. From WQ₀ downstream, the value of COD progressively decreased, possibly due to the dispersion effect. The higher level of COD at WQ₀ might be because of effluent discharge. There might be the presence of chemical oxidants in the effluent, and low COD indicates otherwise. Higher COD levels mean a greater amount of oxidizable organic materials in the sample, which will reduce dissolved oxygen levels and thereby threaten aquatic lives (Chukwu, 2005).

The lowest value of **dissolved oxygen (DO)** was recorded in WQ₀, while the highest value was recorded in WQ₅₀. The value at WQ₀ is lower than the value at WQ₅₀ by 43%, which is statistically significant, as seen in table 4.3. From WQ₀ downstream, the value of DO gradually increases, possibly as a result of dispersion. The recorded values of DO are all below the WHO standard of 30 mg/l. A low DO level makes water taste flat. DO is a vital indicator of the health of aquatic ecosystems. Another important factor that could contribute to the reduction in DO of the water sample may be the temperature of the effluent. This is because cold temperature holds more oxygen in solution than warm water. Therefore, since the effluent is always warm at the point of discharge, the DO will be low, and this can affect the life of aquatic organisms; a moderately high DO content will be good (Chukwu *et al.*, 2007).

The highest **Biochemical Oxygen Demand (BOD)** was recorded at WQ₀ and the lowest at WQ₅₀. The value at WQ₀ is greater than WQ₅₀ by 81%, which is highly statistically significant, as seen in table 11. From WQ₀ downstream, the BOD progressively decreased. The greater the BOD, the more rapidly the oxygen is being depleted in the river. This means less oxygen is available for aquatic life. Thus, the consequences of high BOD may lead to aquatic organisms in the Iyiokwu River becoming stressed, suffocating, and dying. This result corresponded with the study carried out by Lokhande *et al.* (2011).

The **Total Heterotrophic Bacterial Count (THBC)** measurement value was highest at the discharge point and lowest at the point of control (WQ₅₀). The value of THBC at WQ₀ is higher than the value at WQ₅₀ by 80% (Rock and Rivera, 2014). This is highly statistically significant, as seen in table 4.4. From WQ₀ downstream, the values are noted to significantly decrease. Similar results are replicated in **Total E. coli Count**, **Total Salmonella Shigella Count**, **Total Coliform Count**, and **Total Heterotrophic Fungal Count**. This may be as a result of the deposition of these microorganisms from the animal remains into the river through the discharge point, and the values decrease downstream possibly due to dispersion. This is similar to the results reported in earlier studies by (Adesemoye *et al.* (2006) and Abiade Paul *et al.* (2005).

5.1 Conclusion

The study has shown that the discharge point revealed a significant rise in many of the parameters measured, which means that effluent from the abattoir is highly loaded with contaminants that pose an environmental risk to the receiving Iyiokwu River.

The dissolved oxygen (DO) value obtained from the discharge point WQ₅₀ to WQ₂₀₀ downstream is below the WHO permissible limit; this indicates that the lives of aquatic organisms are in danger. Also, biochemical oxygen demand (BOD) and chemical oxygen demand (COD), which are important parameters

for testing water quality, were higher at the discharge point; this implies that there is high depletion of available oxygen, which could lead to reduction in available aquatic organisms and foul smell of Iyiokwu River. Another point of concern is at the measurement location WQ₂₀₀ where some parameters increased as a result of a waste dump that was channelled into the river from another source.

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