EFFECT OF ABATTOIR WASTE ON SURFACE WATER QUALITY PARAMETERS OF IWOFE RIVER, PORT-HARCOURT, RIVERS STATE, NIGERIA

ABSTRACT

Indiscriminate discharge of abattoir wastewater has been a major cause of concern globally due to its negative effect on the environment. This study analyzed the effect of abattoir waste on surface water quality parameters the of Iwofe River, Port-Harcourt, and the River's state using standard methods. The water samples were collected at three different points (upstream, midstream, and downstream) and the results were analyzed using Oneway ANOVA at $p = 0.05$. From the results; temperature, pH, salinity, conductivity, oxidation-reduction potential, and turbidity were in the range of 28.50 – 29.70 ^{o}C, 7.19 – 7, 3.00 – 6.35 PSU, 5059 – 11208 µS/cm, 91.70 – 164.80 mV, and 59.60 – 78.10 NTU respectively. The temperature was slightly above WHO standards, and pH, Electrical conductivity, and Turbidity were all within WHO acceptalimitsimit. TDS, TSS, DO, BOD_5, and COD were in the range of 2542 - 5604 mg/L, 2.90 – 7.75 mg/L, 5.90 – 12.90 mg/L, 0.42 – 3.08 mg/L, and 5.90 – 18.50 mg/L respectively. DO and TS were above WHO permissible limit while BOD_5, COD, TSS, COD, and ORQ were within WHO permissible limit in all samples. Total alkalinity, hardness, Cl-, $CO_3^{2-,}$ and NO3- were 25 – 113 mg/L, 990.00 – 1256.00 mg/L, 3669.08 – 7887.63 mg/L, 12.50 to 66.00 mg/L, 0.85 – 1.08 mg/L. SO_4^{2-}, PO_4^{2-}, oil and grease, and total coliform were in the range of 133.56 – 283.17 mg/L, 90.00 – 100.00 mg/L, 0.10 – 0.15 mg/L, 1.34×10^4 to 2.98×10^5 cfu/mL. Total Alkalinity was within limit only in upstream, while hardness, Cl-, NO3-, SO_4^{2-}, and total coliform were all above WHO permissible limit in drinking water. Heavy/trace metals results ranged as follow; As (<0.001 – 0.009 mg/L), Pb (<0.001 – 0.002 mg/L), Zn (<0.001), Fe (0.019 – 0.285 mg/L), K (8.245 – 8.540 mg/L), Mn (<0.001 – 0.005 mg/L), Mg (3.345 – 4.076 mg/L), Ca (2.452 – 4.085 mg/L), Ni (0.002 – 0.010 mg/L), Cu (<0.001 – 0.006 mg/L), Cr (0.001 – 0.003 mg/L), Cd (0.006 – 0.013 mg/L). As, Pb, Zn, K, Mn, and Ca were all above WHO permissible limit, indicating that the river was heavily polluted with metals. Most of the water quality parameters did not meet WHO permissible limits for drinking water. Also, the study indicates that the meat processing industry can potentially reduce water portability, thereby adversely affecting the range of its uses. Hence the activities of the abattoir should be monitored closely by relevant agencies in order to prevent full-blown environmental problems and health hazards in the near future.

KEYWORDS: Wastewater, Abattoir, Hazards and water.

1. INTRODUCTION

The direct release of wastewater from abattoirs to surrounding water bodies such as lakes, streams, Rivers (tributaries and meanders), seas, and oceans contributes a lot to water pollution. These wastewaters often enter water bodies through the washing of killed animal blood, dung, runoff from human body waste, feces from toilets nearby in the abattoir site, and waste from animal feeds. These phenomena arising from human activities are now of global concern as illustrated by Hillel *et al.* (2015). This is due to the scientific analysis that the discharge of untreated high-strength wastewater into water bodies results in water quality deterioration of the recipient water bodies according to Terrumun and Oliver (2015).

The Abattoir is a place where animals are slaughtered for the purpose of production of meat/protein which are supplied to the public. As much as the activity and its individual operations are to provide the needed source of protein, the way and manner it is handled and its byproducts or wastes sadly could constitute hazards when the proper steps are not taken into cognizance (Mamhobu-Amadi *et al*., 2019).

As worse as it could get, there are indicators that scientifically elaborate the above by showing that elevated levels of nutrients (nitrogen and phosphorus) in surface water due to this type of pollution emanating from human-related activities at local slaughterhouses and butcheries accelerate the growth of oxygen-depleting microorganisms whose excessive growth destroy the aquatic ecosystems and result in eutrophication of these water bodies aforementioned, (Zhang *et al.,* 2014).

The impact of these damages is interwoven ecologically as well as biologically, chemically and physically, (Terrumun & Oliver, 2015). Ecologically, harmful algal blooms (spontaneous and uncontrolled growth of algae), dead zones (areas in water bodies where aquatic life cannot survive because of low oxygen levels these are generally caused by significant nutrient pollution), and fish kills (unexpected mass mortality of wild fish over a short period of time usually attributable to pollution or contamination of waters or a combination of natural and human-induced stresses in the environment.) are the results of a process which occurs when the environment becomes highly and suddenly enriched with nutrients— eutrophication (Badruzzaman *et al.*, 2012).

Wastes from animal bowels (faces and urine from ruminants and others), their feed, decayed body parts and blood during slaughtering can be a source of pollution when it is not managed (Osibanjo *et al.*, 2011).

Previous studies have shown that waste from abattoirs pose a great risk to recipient water bodies due to its potential high content of pathogens (Arimoro, 2009). Also, if the animals are not housed, there may also be issues of erosion and sediment transport into surface waters due to their grazing activities (Terrumun & Oliver, 2015).

However, pollution of surface water from abattoir wastewater and run-offs constitutes substantial ecological and health threats due to the higher levels of biodegradable organic matter, excessive alkalinity, phosphorous, nitrogen and micronutrient concentrations as described by Del-Nery *et al.* (2007).

In Iwofe area of Obio/Akpor Local Government area of Rivers state, the wastewater from the killed animals and the washed slab where the animals are butchered have a channel the water flows from to the New Calabar River very close to it (approximately a few meters away).

Interestingly, some organic waste may be able to be diluted in the river at very minimal concentrations with the tidal characteristics of the river; it can self-cleanse by natural biological processes according to Mutamim *et al.* (2013).

In the light of the above, the research aims to decipher the impact of the slaughterhouse waste (discharged directly and by run-offs) on the physico-chemical parameters, microbiological indicators, and heavy metal content of the surface water (Iwofe River) since it is of use to humans in many ways and the aquatic community.

1. MATERIALS AND METHOD

Study Area

Iwofe, the community facing the New Calabar River (Iwofe River) houses the Ignatius Ajuru University and student lodges all-round the area (first and second Erico, Azumini police station, and eagle cement area). It is located in the Obio-Akpor local_government area in the metropolis of Port Harcourt. Iwofe Abattoir area is bordered by a small market directly facing a lodge accommodation for students. Also, the water is used to wash off the blood and stains and cow dung is dropped off during the slaughtering of the animals. Coordinates taken of the area showed the locations where samples were got for upstream, midstream, and downstream on a google earth map (Fig. 1.1)

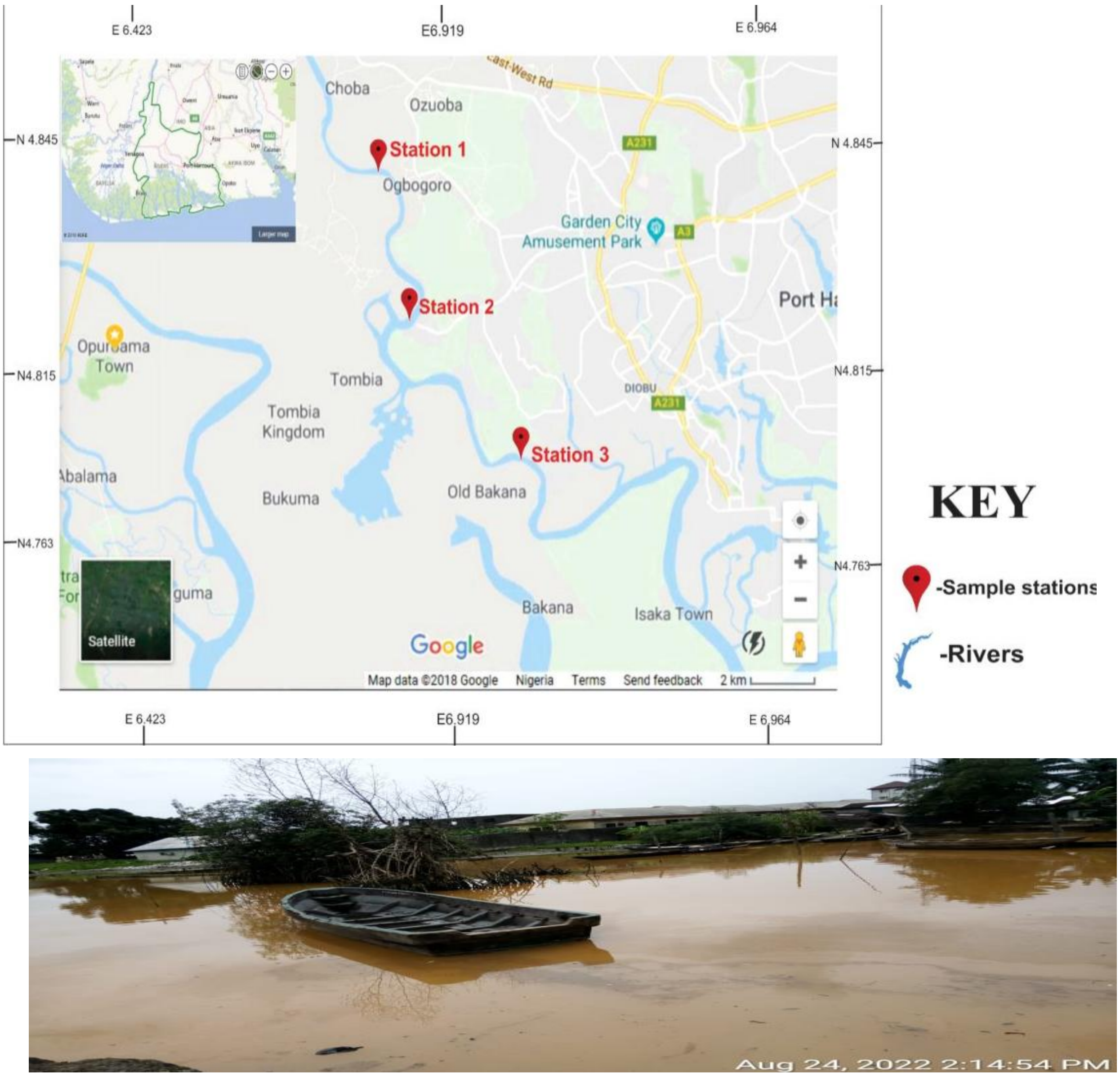

Figure 1.1: Location map showing sampling points on the Iwofe River (Adopted from Wikipedia)

Sample Collection

Water samples was be gotten from the New Calabar River which rendezvous the Iwofe slaughter axis in River's State in varying depths using standard sampling methods. The surface water collection involves rinsing each labeled container with the water at the exact geo-referenced point (Upstream, Midstream, and Downstream) recording the time and coordinates. Samples collected for the analysis of heavy metals were preserved using nitric acid while other samples will be placed in ice-packed ice chests (ALPHA, 2017).

Water Quality Parameters Analysis

Temperature, pH, Electrical conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solid (TSS), Total Hardness, Carbonates, phosphates, Sulphates, Nitrates, Salinity, Alkalinity, Chloride Turbidity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD_5) and Oxidation Reduction Potential (ORP) were analyzed using HANNA Multi-parameter Meter (APHA, 2017).

Metals: metal ions were determined using APHA 3030 G (Nitric acid – Sulphuric Acid Digestion) and APHA 3030 F (Nitric acid – Hydrochloric Acid Digestion) standard methods. The samples after undergoing pretreatments were analyzed for heavy metals and trace metals using Atomic Absorption Spectrophotometer (AAS) (APHA, 2017).

Microbiological Analysis: fecal and Total Coliform counts will be performed using the standard membrane filtration technique. The 100 mL water sample will be filtered using a 0.45 mm pore size, 47 mm diameter filter membrane as described by APHA (1998).

Calculation of Water Quality Index

The WQI was calculated using the three steps.

Step: 1 – Unit weight (Wn) factors for each parameter was calculated using the formula

$Wn = K/Sn$

Where, Where Wn = unit weight for nth parameter.

The unit weight (Wn) of each parameter is proportional to the weightage of each parameter;

n is the number of water quality parameters.

Sn = standard permissible value for nth parameter

k = proportionality constant.

Step: 2 Calculate the Sub-index (Qn) value using

formula

$Qn = [(Vn-Vi) \div (Vs-Vi)] \times 100$

Were,

Vn – Observed value

Vi–Ideal value (Generally Vo = 0 for most parameters except pH and DO is 7 and 14.6)

Vs – Standard value

Step: 3 Combining Step 1 and Step 2, WQI is

calculate as follows.

$WQI = \sum_{n=1}^{n} qnWn / \sum_{n=1}^{n} Wn$

(Misha *et al.*,2021)

Statistical Analysis

The analyses of water quality parameters were done in triplicates and the relationship between the upstream, midstream, and downstream water samples was analyzed at a 0.05 significance level using One-way analysis of variance (ANOVA) of the Statistical Package for Social Sciences (SPSS).

2. Results and Discussion

The results of the analysis of water quality parameters of Iwofe River are shown in Table 2.1 and Table 2.2 below.

Table 2.1: Results of physicochemical analysis of water samples from Iwofe River

PARAMETER	WATER SAMPLE			
	Upstream	Midstream	Downstream	*WHO Limit
Temperature (^oC)	28.50 ± 0.10^a	29.70 ± 0.20^c	29.30 ± 0.10^b	Ambient
pH	7.19 ± 0.02^a	$7.32 \pm 0.11^{a, b}$	7.36 ± 0.03^b	6.50 – 8.50
Salinity (PSU)	6.35 ± 0.30^b	3.00 ± 0.01^a	3.30 ± 0.03^a	NG
TDS (mg/L)	5604 ± 5.00^c	2542 ± 3.00^a	3088 ± 2.00^b	500.00
EC (µS/cm)	11208 ± 7.00^c	5059 ± 5.00^a	6151 ± 11.00^b	1000.00
Turbidity (NT U)	67.10 ± 1.20^b	78.10 ± 3.40^c	59.60 ± 1.50^a	5.00
DO (mg/L)	12.90 ± 0.30^c	9.26 ± 0.13^b	5.90 ± 1.10^a	5.00
ORP (mV)	164.80 ± 2.10^c	91.70 ± 0.30^a	109.50 ± 3.30^b	NG
TSS (mg/L)	7.75 ± 0.15^c	3.05 ± 0.03^b	2.90 ± 0.10^a	35
Total Solids (TS) (mg/L)	5611.75 ± 3.8^c	2545.05 ± 4.3^a	3090.9 ± 1.6^b	1000
BOD_5 (mg/L)	0.42 ± 0.01^a	0.60 ± 0.01^b	3.08 ± 0.11^c	5.00
COD (mg/L)	5.90 ± 0.02^a	6.25 ± 0.01^b	18.50 ± 0.10^c	NG

Alkalinity (mg/L)	25.00 ± 3.00^{a}	113 ± 5.00^{c}	57.00 ± 2.00^{b}	50.00
Total Hardness(mg/L)	1123 ± 2.00^{b}	990 ± 7.00^{a}	1256 ± 5.00^{c}	150.00
Oil and Grease (mg/L)	0.15 ± 0.01^{c}	0.10 ± 0.01^{a}	0.11 ± 0.01^{b}	NG
Cl^{-} (mg/L)	7887.63 ± 5.33^{c}	3669.08 ± 9.40^{a}	4112.20 ± 3.70^{b}	250.00
CO_3^{2-} (mg/L)	12.50 ± 1.30^{a}	66 ± 3.00^{c}	28.50 ± 1.40^{b}	NG
NO_3^{-} (mg/L)	0.85 ± 0.01^{a}	0.99 ± 0.01^{b}	1.08 ± 0.02^{c}	50.00
SO_4^{2-} (mg/L)	283.17 ± 4.10^{c}	133.56 ± 1.70^{a}	144.67 ± 2.50^{b}	250.00
PO_4^{2-} (mg/L)	90 ± 2.00^{a}	100 ± 1.00^{b}	99.30 ± 0.80^{b}	NG
Total Coliform (cfu/ml)	1.38×10^{4}	2.13×10^{5}	2.98×10^{5}	10

The values are in mean ± standard deviation (SD). Values followed by different letters on the same row are significantly different ($p < .05$). NG = No Guideline. * = WHO 2004 guideli

Table 2.2: Results of Trace/Heavy Metal analysis of water samples from Iwofe River

PARAMETER	**WATER SAMPLE**			
	Upstream	**Midstream**	**Downstream**	***WHO Limit**
As (mg/L)	0.009	0.005	<0.001	0.01
Pb (mg/L)	0.002	0.001	<0.001	0.01
Zn (mg/L)	<0.001	<0.001	<0.001	3.000
Fe (mg/L)	0.285	0.019	0.082	0.300
K (mg/L)	8.540	8.245	8.270	12.000
Mn (mg/L)	0.003	<0.001	0.005	0.200
Mg (mg/L)	4.076	3.345	3.479	0.200
Ca (mg/L)	4.085	2.452	2.584	75.000
Ni (mg/L)	0.006	0.002	0.010	0.020
Cu (mg/L)	0.006	<0.001	0.003	2.000
Cr (mg/L)	0.003	0.001	0.002	0.050
Cd (mg/L)	0.006	0.006	0.013	0.003

* = WHO 2004 guideline.

Table 2.3: Water quality index grading

Water Quality Index	Level Status	Grading
0-25	Poor water quality	C
26-50	Poor water quality	C
51-75	Very poor water quality	D
76-100	Unsuitable for drinking and fish culture	E

From the results in Table 2.1, the mean temperature of the water samples (upstream, midstream, and downstream) was significantly different ($F_{2, 6} = 56.00$, $p < 0.001$). The temperature was also above the ambient temperature specified by WHO for surface water.

The mean pH (table 2.1) was significantly different for at least one of the sample collections ($F_{2, 6} = 5.306$, $p = 0.047$). The Tukey post hoc test showed that there was no statistically significant difference ($p = 0.119$) between the pH upstream and midstream water samples. However, the downstream was significantly higher than the upstream ($p = 0.047$), while the midstream and the downstream showed no significant difference ($p = 0.754$). The pH was all within the WHO permissible limit of 6.5 – 8.5, with downstream having a higher pH of 7.36.

The mean salinity (table 2.1) was significant for at least one of the sample collections ($F_{2, 6} = 341.685$, $p < 0.001$). The Tukey post hoc test showed no significant difference ($p = 0.167$) between midstream and downstream. The upstream was significantly higher than the midstream and downstream ($p < 0.001$).

The mean electrical conductivity of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 323224.200$, $p < 0.001$). The Tukey post hoc test showed significant differences for each sample group ($p < 0.001$) The electrical conductivity was also above the WHO permissible limit of 1000 µS/cm, with upstream having the highest electrical conductivity as shown in Table 2.1.

The mean turbidity of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 51.098$, $p < 0.001$). The Tukey post hoc test showed significant differences for each sample group ($p < 0.001$). The turbidity was also above the WHO permissible limit of 5.0 NTU, with midstream having the highest electrical conductivity as shown in Table 2.1.

The mean dissolved oxygen (DO) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 83.764$, $p < 0.001$). The Tukey post hoc test showed significant differences for each sample group ($p < 0.001$). The DO was also above the WHO permissible limit of 5.0 mg/L, with upstream having the highest DO as shown in Table 2.1.

The mean oxidation-reduction potential (ORP) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 849.760$, $p < 0.001$). The Tukey post hoc test showed a significant difference for each sample group ($p < 0.001$), with upstream having the highest ORP as shown in Table 2.1.

The mean TDS (table 2.1) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 631745.368$, $p < 0.001$). The Tukey post hoc test showed significant differences for each sample group ($p < 0.001$) The TDS was also above the WHO permissible limit of 500 mg/L, with upstream having the highest TDS.

The mean TSS (table 2.1) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 2049.476$, $p < 0.001$). In the Tukey post hoc test upstream was significantly higher than midstream and downstream ($p < 0.001$). On the other hand, there was no significant difference between midstream and downstream (p = 0.226). TSS of the water samples was within the WHO permissible limit of 35 mg/L; upstream had the highest TSS.

The mean total solids (TS) of the water samples (upstream, midstream, and downstream) were statistically significant ($F_{2,\ 6}$ = 678668.040, p < 0.001). The Tukey post hoc test showed a significant difference for each sample group (p < 0.001), with upstream having the highest TS. The TS was also above the WHO permissible limit of 1000 mg/L as shown in table 2.1.

The mean alkalinity (table 2.1) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2,\ 6}$ = 469.895, p < 0.001). The Tukey post hoc test showed significant differences for each sample group (p < 0.001). The mean alkalinity of the upstream water sample was within the WHO permissible limit of 50 mg/L, midstream was above the permissible limit while downstream was slightly above the limit.

The mean total hardness (table 2.1) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2,\ 6}$ = 2041.038, p < 0.001). The Tukey post hoc test showed significant differences for each sample group (p < 0.001) with downstream having the highest concentration. The mean total hardness of all the water samples was within the WHO permissible limit of 150 mg/L.

The mean Cl^- (table 2.1) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2,\ 6}$ = 370764.943, p < 0.001). The Tukey post hoc test showed significant differences for each sample group (p < 0.001). The Cl^- was also above the WHO permissible limit of 250 mg/L, with upstream having the highest concentration.

The mean CO_3^{2-} (table 2.1) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2,\ 6}$ = 536.502, p < 0.001). The Tukey post hoc test showed significant differences for each sample group (p < 0.001) with midstream having the highest concentration.

The mean NO_3^- of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 201.500$, $p < 0.001$). The Tukey post hoc test showed significant differences for each sample group ($p < 0.001$) with downstream having the highest concentration. The NO_3^- of all the water samples was below the WHO permissible limit of 50 mg/L as shown in table 2.1.

The mean SO_4^{2-} of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 2409.759$, $p < 0.001$). The Tukey post hoc test showed significant differences for each sample group ($p < 0.001$) with upstream having the highest concentration. The amount of SO_4^{2-} midstream and downstream water samples was below the WHO permissible limit of 250 mg/L while upstream was above it as shown in table 2.1.

The mean PO_4^{2-} (table 2.1) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 536.502$, $p < 0.001$) for at least one of the sample collections. The Tukey post hoc test showed midstream was not significantly higher than downstream ($p = 0.812$) but significantly higher than upstream ($p < 0.001$).

The mean BOD_5 (table 2.1) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 1616.878$, $p < 0.001$). The Tukey post hoc test showed upstream was significantly lower than midstream ($p = 0.032$) downstream ($p < 0.001$). The BOD_5 of all the water samples was within the WHO permissible limit of 5.0 mg/L.

The mean COD (table 2.1) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 44135.00$, $p < 0.001$). The Tukey post hoc test showed significant differences for each sample group ($p < 0.001$) with downstream having the highest concentration.

The mean oil and grease (table 2.1) of the water samples (upstream, midstream, and downstream) was statistically significant ($F_{2, 6} = 44135.00$, $p = 0.002$). The Tukey post hoc test showed that upstream was significantly higher than midstream ($p = 0.002$) and downstream ($p = 0.006$), whereas there was no significant difference between midstream and downstream ($p < 0.483$).

The total coliform count of the various water samples was above the WHO permissible limit of 10 cfu/ml; with downstream having the highest coliform count as shown in table 2.1.

The results in Table 2.2 shows that the concentration of arsenic (As) was in the range of <0.001 – 0.009 mg/L and was within the WHO threshold limit of 0.01 mg/L; upstream having the highest level of As. Lead (Pb) was below the WHO permissible limit of 0.01 mg/L; upstream had a higher concentration. Zinc was also below the WHO threshold limit of 3.0 mg/L with each of the water samples having less than 0.001 mg/L. Iron (Fe) and potassium (K) were below the WHO permissible limits, upstream recording higher concentrations in each case. Manganese (Mn) was highest downstream but below the WHO limit of 0.30 mg/L. All the water samples recorded high concentrations of magnesium (Mg) which was above the WHO threshold limit of 0.20 mg/L; upstream was the highest. The concentrations of calcium (Ca), copper (Cu), and chromium (Cr) were below the WHO permissible limit with upstream recording higher concentrations in each case. On the other hand, downstream was higher in nickel (Ni) and cadmium (Cd), but while Ni was below WHO limit; Cd concentration was above the 0.003 mg/L limit in all three samples.

The water quality index grading is summarized in Table 2.3 according to the varying depth of the river where samples were collected (Brown et al., 1972). With respect to drinking water quality, the river falls under category C, D, and E, that is not suitable for drinking and of poor water quality. The higher values of WQI are contributed to very high turbidity and phosphate values. Hence the WQI index reveals that river water is not suitable for drinking and domestic activities without proper treatment and disinfection, this trend is similar to the trend observed by Misha, et al.,2021.

Conclusion

The results of this analysis carried indicate that the level of contamination of the Iwofe River significantly affects its water quality parameters, with most of the results exceeding WHO permissible limits. The upstream was highly affected by the trend of contaminations due to its proximity to the abattoir site. It can be inferred that the direct discharge of various streams of untreated abattoir waste is a major contributor to the poor quality of the water body. Although some heavy/trace metals were still within recommended standards, it is however under threat if the present habit of discharging untreated abattoir wastes continues. Residents living in the abattoir vicinity may in no distant time begin to experience severe consequences of pollutants from abattoir activities located in their neighborhood. Hence there is a need for proper waste management and disposal.

Recommendations

In view of the findings of this work, and due to the fact that the abattoir is located at Ignatius Ajuru University, with student lodges all-round the area, and also in view of the fact that the discharge of untreated abattoir wastes may continue unabated, the following recommendations are made:

- In line with national and international efforts being made to safeguard the water environment, provide clean water as well as protect human health, sanitation in our local meat processing industries should be closely monitored.

- The enforcement of existing health and hygiene regulations, as well as the provision of standard equipment and functional units within abattoirs, should be encouraged.
- Efforts should be made to commence activities towards the relocation of the abattoir to an area away from residential areas.
- Immediate steps should be taken to put in place machinery that will enable treatment of the abattoir wastes before they are disposed of.
- Aggressive public awareness and enlightenment on the possible impacts of pollution from abattoir wastes should be embarked upon by relevant agencies.

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