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Impact Assessment of Abattoir Effluent on the Water Quality and Environment of New Wazo Market, Ogbomoso North, Oyo State, Nigeria

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ABSTRACT

This study presents an impact assessment of abattoir effluents on the water quality and environment. Six samples were collected from and around the abattoir. The samples were evaluated for physicochemical analyses (Temperature, pH, conductivity, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD)) using American Public Health Association methods (APHA) for testing measurement. The heavy metals (Lead, Magnesium, Potassium, Calcium, Chromium, Manganese, Iron, Nickel, Copper, and Zinc) were evaluated using Inductively Coupled Plasma-Mass Spectroscopy. The results obtained were compared with the Nigerian Industrial Standard (NIS) and the World Health Organization (WHO). The physicochemical analysis results revealed that Temperature, pH, conductivity, TDS, DO, BOD and COD range from 26.8- 27.60 °C, 6.67-7.10, 229-1788µS/cm, 114.2- 892 ppm, 8.6-39.3mg/l, 7.26-24.60mg/l, and 10.05-60.34mg/l respectively. While the concentration of the heavy metals; Lead, Magnesium, Potassium, Calcium, Chromium, Manganese, Iron, Nickel, Copper, and Zinc ranges from 0.00-0.75, 8.55-17.74, 1.05-57.26, 25.15-55.24, 0.00-0.02, 0.001-1.832, 0.00-2.51, 0.00-0.039, 0.00-0.047, 0.00-0.226, all in mg/l respectively. All the sample exceeds the WHO limit for Temperature, BOD and COD for indicating high-strength pollution. Lead concentration is relatively high for samples 1, 2, and 3 when compared with the WHO, also. Potassium and Sodium concentrations are high compared with WHO standards. The study implies gradual environmental pollution (water pollution) of the study area due to the abattoir's activities, which will keep increasing if necessary, measures are not put in place.

INTRODUCTION

The abattoir industry, also known as the slaughterhouse, plays a vital role in the global food supply chain, processing animal products for human consumption. However, this industry also generates significant amounts of wastewater and effluent, posing environmental and public health concerns. Abattoir effluent contains pollutants such as organic matter, nutrients, bacteria, and other contaminants that can harm aquatic ecosystems and human health if released untreated into water bodies. Water pollution is a significant global issue, with the World Health Organization (WHO) estimating that 827 million people lack access to safe drinking water, and 2.3 billion people lack access to basic sanitation. The environmental impact of water pollution is equally alarming, with aquatic ecosystems suffering from eutrophication, habitat destruction, and loss of biodiversity. The connection between abattoir effluent discharge and water pollution is a pressing concern, as unregulated or poorly managed effluent release can contaminate surface and groundwater sources, posing serious environmental and public health risks. Eneh *et al*., 2024 reported that Nigeria continues to face persistent annual incidences of cholera outbreaks and by mid-2024, there were 1,579 suspected cases and 54 deaths (CFR 3.4%) in 32 states. Contributing factors to these outbreaks are a lack of access to potable water and poor sanitation practices, which enhance the risk of transmission (Patience *et al.*, 2019). These conditions are prevalent in many areas of Nigeria, leading to recurring outbreaks.

This study aimed to investigate the impact of abattoir effluent discharge on the water quality of surface and groundwater. Horan (2010) observed that water courses utilized by man either as a source of potable water or for washing/bathing would present potential risks if not well protected. To ensure that problems are avoided or minimized, attention should be given to the management of aquatic resources and also of the pollutants that enter the receiving waters. A sensible management strategy will inevitably involve the determination of wastewater characteristics, method of collection, subsequent treatment systems, and the quality of effluents discharged to the environment. In developing urban areas where awareness of the consequences of abattoir activities is low, it is commonplace to observe the digging of shallow wells near abattoirs. These wells may draw in contaminated water from the surrounding aquifer, particularly if their influence extends into the abattoir premises (Singh and Neelam, 2018). Abattoir effluents are typically evaluated using bulk parameters because of the broad range of abattoir wastewater and pollutant loads. Abattoir wastewater contains large amounts of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS) (Bustillo-Lecompt *et al*., 2015).

MATERIALS AND METHODS

The Study Area

Ogbomosho (also Ògbómọ̀ṣọ́) is a city in Oyo State, south-western Nigeria. It was founded in the mid-17th century. The population was approximately 454,690 in the 2006 census. It is the second largest city in Oyo State and also among the most populated in Nigeria. It is the 3rd most populated city in Southwestern Nigeria after Lagos and Ibadan. Although the principal inhabitants of the city are the Yoruba people, there are people from other parts of Nigeria and other West African countries who are residents of the city (Adebayo, 2020). Ogbomosho is located between the longitudes 08′ 03′ to 08′12′ and latitudes 04′ 11′ to 04′ 19′. The new abattoir encompasses a large expanse of built-up area in the immediate environment, comprising market, low, medium and high housing densities.

Materials

Materials used during sample collection at the various project sites include the following: Masking tape (label), Funnel, Sampling bottles, pH meter, Water sampler, Safety clones, Nose mask, laboratory coat and safety boots.

Design of study

The study design was a descriptive and qualitative approach. The study describes the current state of the abattoir, which was achieved by direct questioning of the key informant at the abattoir. The qualitative method was achieved by collecting water and wastewater samples using sterilized sampling bottles, air-tight brown glass bottles were filled to the brim, well-capped and packed.

Location of samples collected

ArcGIS 10.8 was used to record the Northern and Eastern geographical location of the sample's points. Six samples were collected from and around the abattoir, these are: a point close to the discharge of wastewater, upstream, downstream, shallow well at the abattoir, church, and mosque in the vicinity, making three water samples and three wastewater samples respectively. Figure 1 shows the ArcGIS 10.8 Map of the Abattoir and its layout in Ogbomoso, Oyo State, Nigeria. Plate 1 shows activities in the abattoir from the point of slaughter to effluent discharge and the existing well in the abattoir. The Sample location was recorded with the GIS tools as shown in Table 1, measuring the northern and eastern positioning. The samples were collected during the rainy season and all samples collected were transported to the laboratory and analysed within 2 hours of collection.

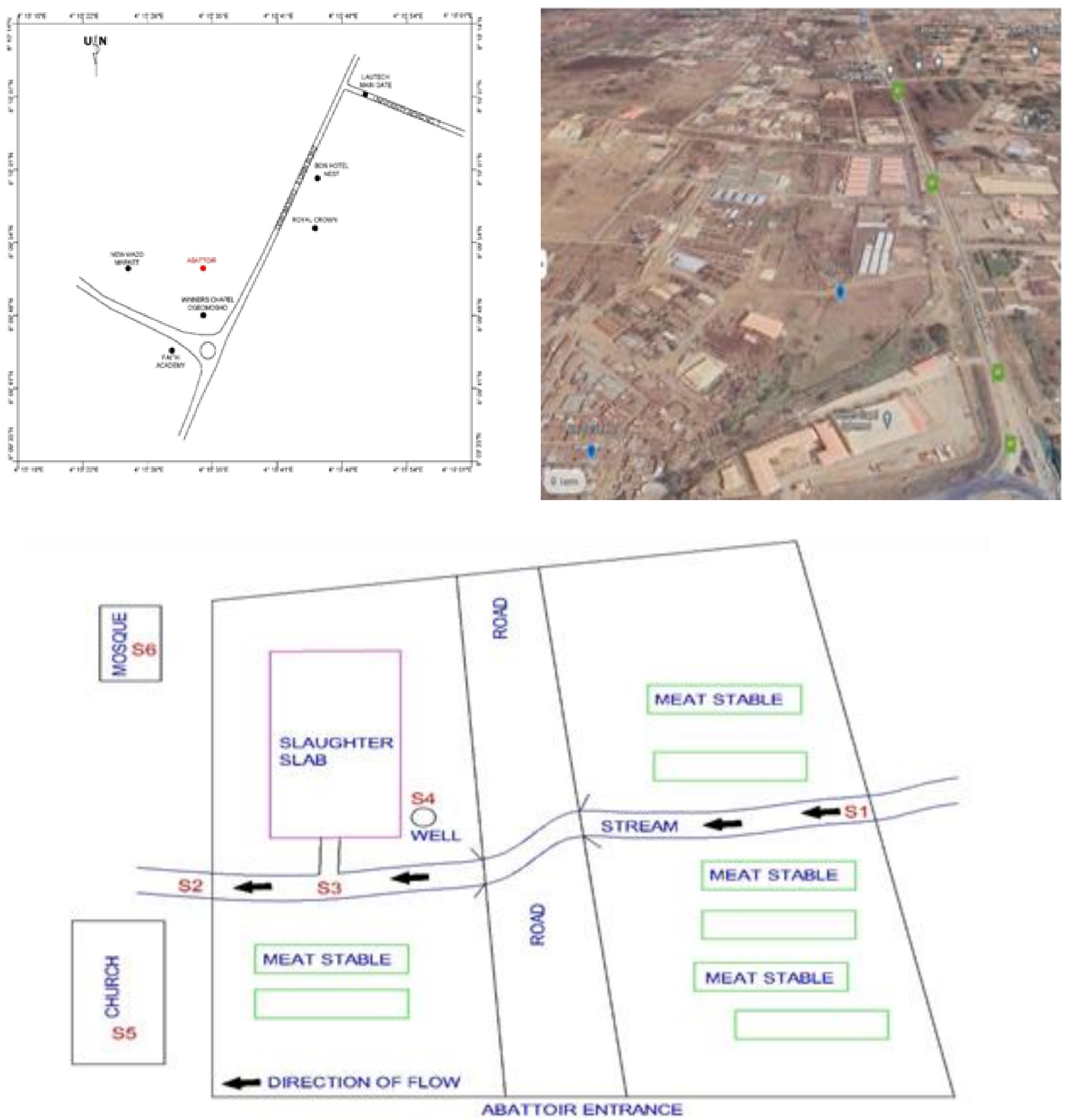
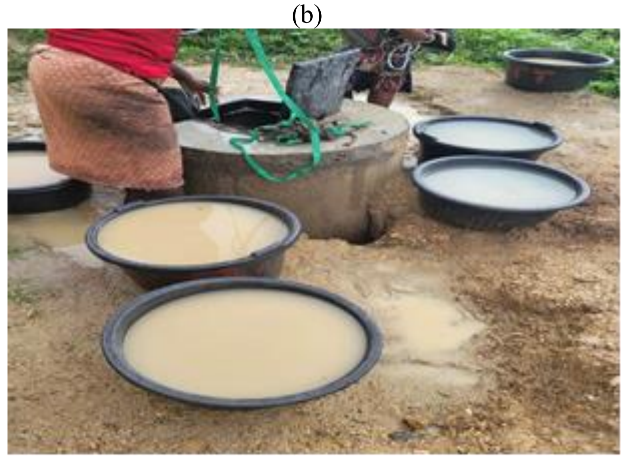


Figure 1: (a) Imagery Map showing Abattoir in Ogbomoso, Oyo State, Nigeria (b) Map showing Abattoir location Ogbomoso, Oyo State, Nigeria (c) Abattoir and sample points layout

(a)

(b)

(c)



(d)

Plate 1: (a) Slaughtering of cows in the Abattoir, (b) Cow waste being washed into the stream
(c) The stream in the Abattoir, (d) Shallow well in the Abattoir

Table 1: Sample and location

Sample	Location
S1	8°10’02” N, 4°15’34” E
S2	8°09’50” N, 4°15’24” E
S3	8°09’54” N, 4°15’31” E
S4	8°09’55” N, 4°15’30” E
S5	8°09’51” N, 4°15’29” E
S6	8°09’54” N, 4°15’27” E

Water and Wastewater Sample Analyses

The temperature of water and wastewater was determined using the KT digital thermometer, pH was measured by the Hanna HI 8314 membrane pH meter and conductivity was measured by the Cloud Prime conductivity meter. The measurements of Hardness, DO, COD, TDS, TSS, and BOD in water samples were carried out according to APHA, Standard Methods for the Examination of Water and Wastewater. Also, the presence of Heavy metals in the water samples was conducted using Induced Coupled Plasma-Mass Spectroscopy. All the results were compared with the WHO Standard (World Health Organization [WHO], 2017) and NSDWQ (2007): Nigerian Standard for Drinking Water Quality. NIS, Nigerian Industrial Standard.

RESULTS AND DISCUSSION

The major source of water for the residents of the area is shallow wells, which are scattered within the watershed. Wells can be found uphill and downhill of the abattoir site. An average of 47 cows is slaughtered daily, from which vendors come to purchase the meat and other parts to be sold across the town and its suburbs. The abattoir waste is not adequately managed as the heap of bones and cow dung can be seen close to the shallow well, which is the water source for the abattoir. The wash water is drained into a nearby gully.

The results of the physicochemical properties of water samples obtained from the sampling point are shown in Table 2, and Table 3 shows results for heavy metals. The values were compared with the WHO standards to ascertain the extent of pollution; in all the samples, the DO is higher than the WHO limit.

From the result obtained in Tables 2 and 3 (Appendix), and the graphical representation of its comparison with WHO, shown in Figure 2-8, pH ranges from 26.3 to 27.0, which falls within the recommended standard of WHO. All the samples exceed WHO standards for BOD, COD, and DO concentration, with sample 3 as the highest with 24.60mg/l, 60.34mg/l, and 39.3mg/l. The higher the DO, the better the water quality (Ojekunle and Lateef, 2017). Sample 3 result is expected as it's the point of entry into the stream and could result in an increased risk of waterborne diseases. The result from this finding corresponds with the findings of Ocheje, *et al*., 2021. The graphical presentation is shown in Figures 9-12, these data represent the level of heavy metals across the stream at the peak period of effluent discharge by the abattoir**.**

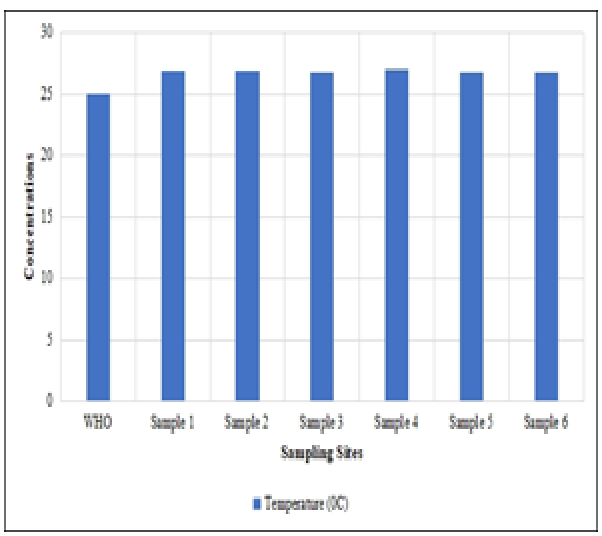


Figure 2: Concentration of WHO with Temperature

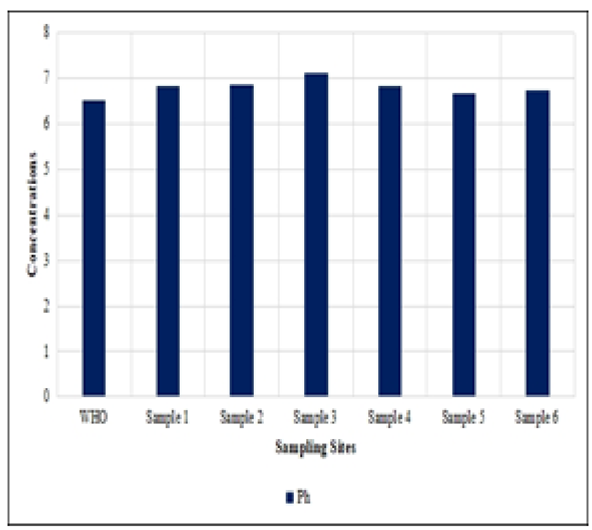


Figure 3: pH Concentration

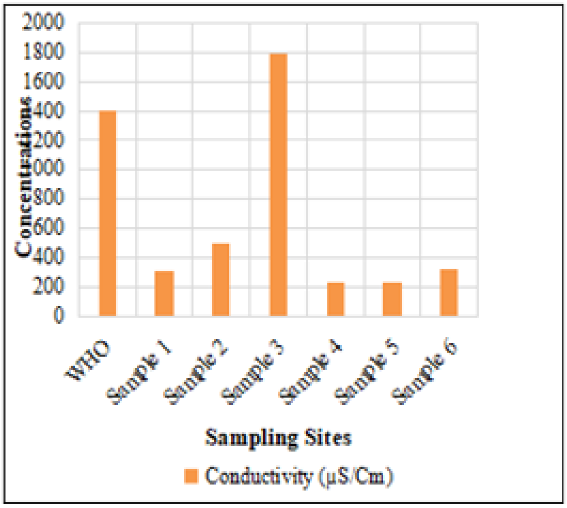


Figure 4: Conductivity Concentration

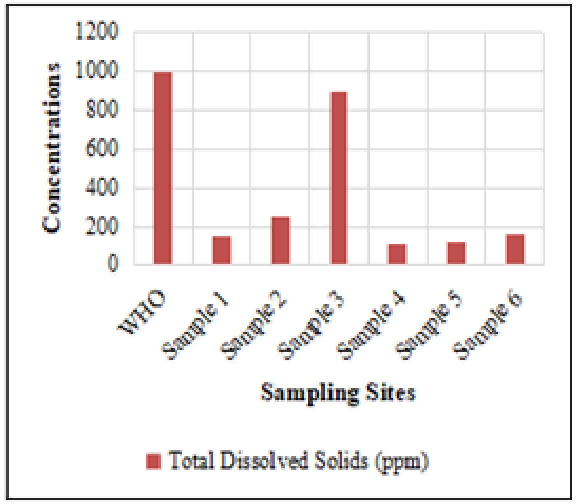


Figure 5: TDS Concentration

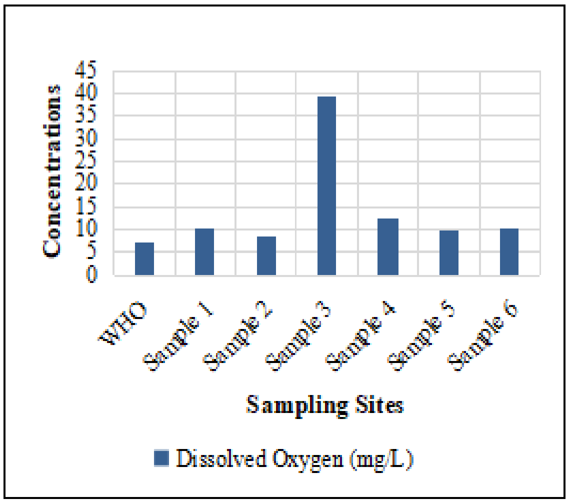


Figure 6: DO Concentration

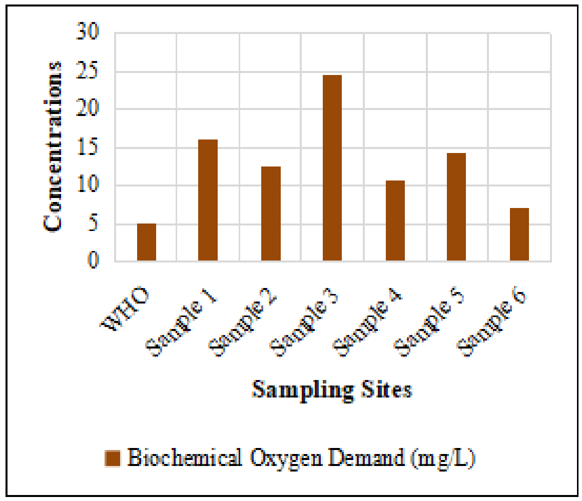


Figure 7: BOD Concentration

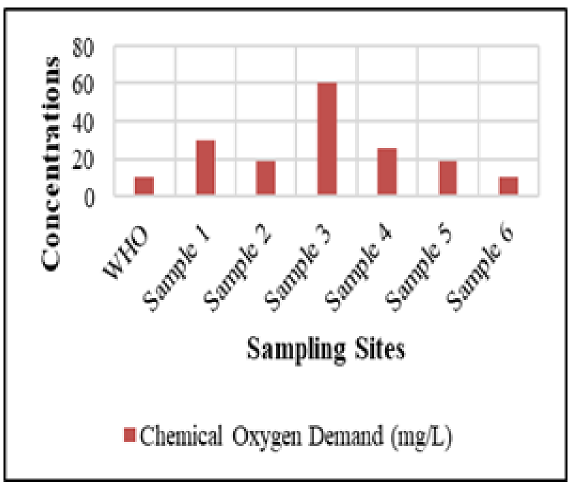


Figure 8: COD Concentration

Figures 9-12 imply health hazards. Prolonged exposure to lead, even at low concentrations, can result in severe health effects, particularly in children, affecting their cognitive development, behaviour, and overall health. Magnesium in appropriate concentrations is not harmful, but excessive intake, especially from hard water, can cause gastrointestinal issues, such as diarrhoea. Calcium, like magnesium, is a vital element for bone and dental health. The WHO has no specific health-based limit for calcium in drinking water, but its concentration is associated with water hardness. Human activities, including mining and agricultural runoff, can also introduce calcium into water sources. Calcium in drinking water is not harmful to health and can contribute positively to the dietary calcium intake, which is important for maintaining bone health. However, extremely hard water with very high calcium concentrations can lead to scaling in pipes and appliances.

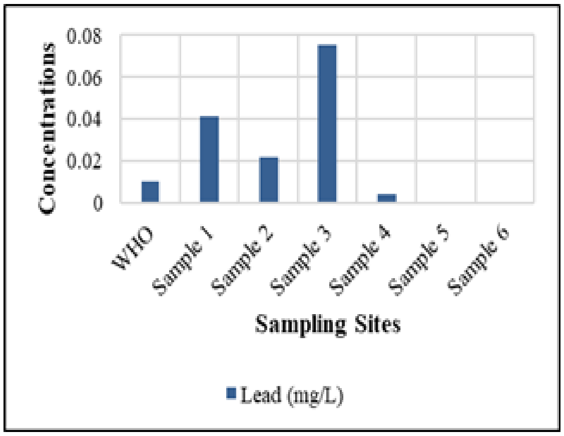


Figure 9: Concentration of Lead

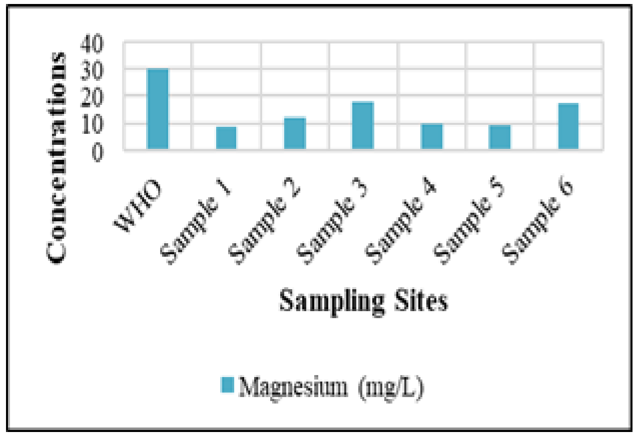


Figure 10: Magnesium Concentration

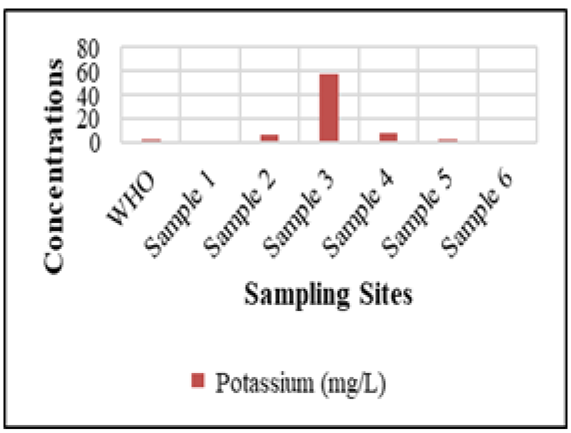


Figure 11: Potasium Concentration

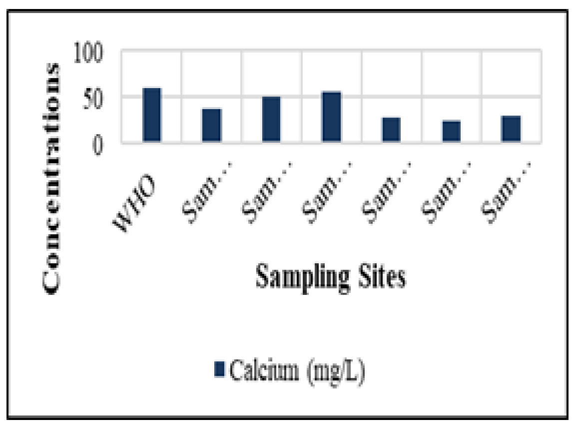


Figure 12: Calcium Concentration

STATISTICAL ANALYSIS

Descriptive and inferential statistics were used for the analysis. Appendix 2 summarizes the mean, standard deviation (SD), minimum and maximum for the physicochemical parameter. The inferential statistic was shown in Table 4, which compares sample means to WHO standards with a 0.01 confidence level, while Table 5 shows the heavy metal results.

Table 4: Inferential Statistics (One-Sample t-Test vs WHO Standard, 0.01 confidence level

Parameter	WHO Standard	t-Statistic	p-Value	Significant at 0.01?
Temperature (°C)	25	**56.00**	**0.000**	**Yes** ✅
pH	7.0	-2.67	0.044	No ❌
Conductivity (µS/cm)	1400	-3.37	0.0198	No ❌
TDS (ppm)	500	-1.77	0.137	No ❌
Hardness (mg/L)	100	-0.11	0.919	No ❌
BOD (mg/L)	5	3.83	0.0123	No ❌
COD (mg/L)	10	2.39	0.0623	No ❌
DO (mg/L)	7.0	↓	0.156	No ❌

Table 5: Inferential Statistics (One-Sample t-Test vs WHO Standard, 0.01 confidence level

Element	WHO Standard	t-Statistic	p-Value	Significant at 0.01?
Pb - Lead	0.01	1.12	0.3123	No ❌
Mg - Magnesium	30	-10.23	**0.0002**	**Yes** ✅
K - Potassium	1.5	1.27	0.2610	No ❌
Ca - Calcium	60	-4.36	**0.0073**	**Yes** ✅
Cr - Chromium	0.05	-12.12	**0.0001**	**Yes** ✅
Mn - Manganese	0.04	1.49	0.1975	No ❌
Fe - Iron	0.175	1.26	0.2639	No ❌
Ni - Nickel	0.07	-7.06	**0.0009**	**Yes** ✅
Cu - Copper	2.0	-282.95	**0.0000**	**Yes** ✅
Zn - Zinc	3.0	-78.51	**0.0000**	**Yes** ✅
Al - Aluminium	0.2	-0.12	0.9087	No ❌
U - Uranium	0.03	0.66	0.5373	No ❌
Na - Sodium	20	1.14	0.3056	No ❌

From the result, only temperature is statistically significant($p<0.01$), confirming it exceeds the WHO. BOD was significant at 0.05 but not at 0.01, meaning weaker evidence for pollution under stricter analysis. Hence, all other parameters do not significantly differ from WHO standards. From the heavy metals, findings of 0.01 confidence level statistically significant differential ($p<0.01$) were found in Mg (Magnesium, Ca (Calcium), Cr (Chromium, Ni (Nickel), Cu (Copper) and Zn (Zinc). But Mg and Ca are significantly lower than WHO standards, while Cr, Na, Cu, and Zn are significantly lower than WHO limits, suggesting they are within safe limits.

CONCLUSION

This study's findings revealed that the stream across the abattoir is polluted by the activities within. This is evident from the results of laboratory tests, where contamination of the stream increased at the point of discharge, but the stream showed evidence of recovery downstream. Although most parameters were within the WHO guidelines, indicating good overall water quality. However, Sample 3 exhibited elevated levels for several key parameters, suggesting potential contamination. Simple physical treatment of effluents from the abattoir could be carried out by channeling the effluents into the natural retention pond. The study underscores the need for stricter regulations and effective effluent treatment solutions to mitigate the environmental impact of abattoir discharges on water resources. The study implies gradual environmental pollution (water pollution) of the study area due to the abattoir's activities, which will keep increasing, if necessary, measures are not put in place.

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APPENDIX 1

Table 2: Result of Physicochemical Test

Samples	**Temperature ^0C**	**pH**	**Conductivity (µS/Cm)**	**TDS (ppm)**	**Hardness (mg/L)**	**BOD (mg/L)**	**COD (mg/L)**	**DO (mg/L)**
S1	26.9	6.84	312	155	86.9	16.19	29.953	10.3
S2	26.9	6.87	492	247	86.351	12.63	18.61	8.6
S3	26.8	7.10	1788	892	176.567	24.60	60.337	39.3
S4	27.0	6.82	229	114.2	75.231	10.61	25.334	12.6
S5	26.8	6.67	231.2	115.4	70.390	14.27	18.791	9.6
S6	26.8	6.74	324	163	94.304	7.26	10.049	10.3
WHO	12-25	6.5-8.5	1400	500	100	5	10	5.0-9.0

Table 3: Heavy Metals Parameters of the water samples.

Element	**Concentration (mg/l)**						
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**WHO**
Pb – Lead	0.0411	0.0217	0.0752	0.0042	0.0000	0.0000	0.01
Mg – Magnesium	8.5521	12.1591	17.7391	9.9777	9.1817	17.6710	10-50
K – Potassium	1.4836	6.7816	57.2565	7.8002	2.6886	1.0532	1-2
Ca – Calcium	37.7080	50.6031	55.2401	29.0548	25.1470	29.4637	20-100
Cr – Chromium	0.0003	0.0130	0.0206	0.0000	0.0000	0.0000	0.05
Mn – Manganese	1.8305	0.3401	0.6683	0.0030	0.0023	0.0014	0.04

Fe – Iron	2.5071	0.0200	2.4304	0.0087	0.0017	0.0000	0.05-0.3
Ni – Nickel	0.0377	0.0000	0.0387	0.0188	0.0000	0.0000	0.07
Cu – Copper	0.0048	0.0149	0.0465	0.0141	0.0297	0.0000	2.0
Zn – Zinc	0.0000	0.0000	0.2264	0.0000	0.0000	0.0000	3.0
Al – Aluminium	0.0122	0.0439	0.9428	0.0370	0.0049	0.0489	0.2
Ag – Silver	0.0075	0.0082	0.0095	0.0038	0.0139	0.0111	
U – Uranium	0.0726	0.0749	0.1131	0.0000	0.0000	0.0000	0.03
Na – Sodium	23.4530	36.5032	202.8455	14.5462	20.5324	26.7824	20

APPENDIX 2

Parameter	Mean	SD	Min	Max
Temperature (°C)	26.87	0.08	26.80	27.00
pH	6.84	0.15	6.67	7.10
Conductivity (µS/cm)	562.7	607.85	229.00	1788.0
TDS (ppm)	281.1	303.16	114.2	892.0
Hardness (mg/L)	98.29	39.31	70.39	176.57
BOD (mg/L)	14.26	5.93	7.26	24.60
COD (mg/L)	27.18	17.59	10.05	60.34
DO (mg/L)	15.12	11.92	8.60	39.30