

A Geo-environmental Impact Assessment of Abattoir Effluent Discharge on Groundwater Quality in Igoba Area of Ondo State, Nigeria

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Abstract: Assessment of groundwater resource around an abattoir site in Igoba area of Ondo State, southwestern Nigeria has been carried out, within 1.3 km radius from the abattoir site in order to determine the influence of the effluents discharge on quality of groundwater in the area, so as to forestall outbreak of diseases that can endanger human health. Eleven water samples were analyzed for physical, chemical and microbial parameters; and result subjected to spatial and statistical analysis using analysis of variance and Duncan's multiple range of variance. The obtained parameters mean \pm SD are pH (5.5 ± 0.50), turbidity (10 ± 5.9 NTU), temperature (27.75 ± 0.35 °C), conductivity ($240 \pm 105.99 \mu\text{S}/\text{cm}$), total dissolved solid (158.9 ± 46.8 mg/L), total hardness (92.1 ± 14.2 mg/L), nitrate (7.3 ± 4.3 mg/L), iron (0.24 ± 0.04 mg/L), total alkalinity (14.57 ± 4.87 mg/L), manganese (0.017 ± 0.0079 mg/L), calcium (26.53 ± 8.7 mg/L), magnesium (12.20 ± 8.1 mg/L), chloride (21.86 ± 7.39 mg/L), sodium (14.71 ± 4.85 mg/L), bicarbonate (13.95 ± 4.48 mg/L), nitrite (0.0336 ± 0.0269 mg/L), dissolved oxygen (1.82 ± 0.52 mg/L), chemical oxygen demand (133.1 ± 53.7 mg/L), biological oxygen demand (29.55 ± 10.93 mg/L), total coliform (9.36 ± 6.05 cfu/100ml) and E.coli (0.5090 ± 0.4700 cfu/100ml). The analysis of variance showed that statistically significant difference occurs among the parameters ($p < 0.05$). All the measured parameters are within the standard limits of WHO and FEPA standards except pH, turbidity, BOD, and total coliform for samples collected within 610 m proximate distance from the site. This contamination is strongly aided by topography of the environment, as the discharged effluents/waste water flows westward and southwardly. Subsequently there is need for proper water treatment and environmental sanitation to prevent outbreak of epidemics and infections, while the government should enforce thorough regulations guiding establishment and operation of abattoir in the site if it can't be relocated.

Keywords: Duncan's test, Igoba, microbial, effluent discharge, abattoir site

INTRODUCTION

Water is the most crucial liquid for all living beings on the planet, as none of them can survive without it. When water is contaminated, it becomes inappropriate for its intended purpose. Growing water demands and pollution loads represent major concerns to human health, agricultural and industrial output, ecological functions, and biodiversity in many lakes, rivers, estuaries, and groundwater bodies around the world. An abattoir is a public butcher for cattle, sheep, and other livestock that produces waste in the form of solids, liquids, semi-solids, and semi-liquids, as well as highly organic fats derived from dung, blood, fats, grease, hair, grit, and undigested meals (Meadows, 1995; Anunobi et al., 2015; Oloruntoba et al., 2014; Eze & Eze, 2018; Egesi et al., 2019; Ahaneku & Njemanze, 2016; Ediene & Iren, 2017). Livestock production is seen as a possible source of food for the world's needy people. However, when slaughter wastes are not properly managed, and especially when discharged into waterways, it becomes a major pollutant of the country's site and cities, as such practices can introduce enteric pathogens and excess nutrients into surface water and groundwater due to their high organic matter (Meadows,

1995; Tolera, 2019). It may also be high in salts, phosphates, and nitrates, with blood and fat content accounting for the majority of the organic load (Fearon et al., 2014). Condensed meat, undigested proteins, bones, hairs, and aborted fetuses make up the solid portion of the feces. Dissolved solids, blood, gut contents, urine, and water make up the liquid aspect, while fat waste is made up of fat and oil. When these wastes are not properly managed, they damage the environment and endanger human health (Bala et al., 2016; Elemile et al., 2019). The majority of abattoirs in Akure Metropolis discharge their effluent into adjacent ditches and streams, while solid waste is dumped on open land along roads and unidentified landfill sites without treatment. The emitted effluents contain significant concentrations of inorganic and organic compounds as by-products, resulting in land and water contamination (Elemile et al., 2019).

Contamination of water bodies is becoming a growing source of environmental concern (Akange et al., 2016). This can occur in underground waterways such as wells and boreholes due to the borehole construction process, drilling fluids, chemical casings, and other elements which could contaminate the water if they get into the well (Bala et al., 2016; Chukwu, 2008). During the construction phase, an open well might provide a direct path for contaminants from the surface to the aquifer, creating a favorable environment for chemical casing and bacterial pollution (Hassan et al., 2014). Even if there is no anthropogenic contamination, natural quantities of metals and other compounds have the ability to impair human health (Yogendra & Puttaiah, 2008). In an effort to reduce the degree of groundwater contamination at various abattoirs centers in Ondo State, the government of Ondo State created Igoba semi-mechanized abattoir center to enhance livestock industry, providing domestic meat supply and employment opportunities to its teeming youth. This was also to prevent the expansion of abattoirs in unsuitable buildings/locations run by untrained people or butchers who are usually illiterate or semi-illiterate and unaware of current disposal procedures and systems. As a result, there's a chance that the area's groundwater has been contaminated as a result of the continual effluent discharge.

Although the possible explanation for the abattoir's perpetual daily routines (receiving and holding livestock, butchering and dressing of animal carcasses, chilling of carcass products, carcass boning and packaging, freezing of finished carcass and cartooned product, rendering processes, drying of skins, treatment of wastes, and transport of processed material) and volumetric amount of their discharge is not far-fetched from rapid urbanization and increased demand for meat (Chukwu, 2008; Akange et al., 2016; Elemile et al., 2019). This discharge has become a significant source of water contamination in cities, putting strain on the urban groundwater system. As a result, a strategic framework to govern or reduce abattoir excesses and indiscriminate waste disposal from abattoir locations must be devised. Abattoir waste has been identified as a pathogenic source of water quality and a source of pollution of surface and subsurface water in previous research (Elemile et al., 2019; Addy & Green, 1997; Adelowo et al., 2012; Igbinosa & Uwidia, 2018). This is also the source of many bacteriological infections found around abattoirs. Even after treatment, abattoir wastewater is considered to have a higher strength waste than domestic wastewater. Due to the presence of blood, feces, urine, and intestinal content, it has a very high biochemical oxygen demand (BOD) and chemical oxygen demand (COD), Total Suspended Solid (TSS), nitrogenous, and phosphorus compounds (Elemile et al., 2019; Chukwu, 2008; Garba et al., 2020). The goal of this study was to investigate the bacteriological and physicochemical quality of abattoir receiving groundwater viz-a-viz wells and boreholes in Akure's Igoba neighborhood. With the objectives of examining the bacteriological and physicochemical quality of the water, understanding the water contamination, their distribution, risk assessment, and feasible remediation.

METHOD

Description of Study Area and Sample Locations

The research area is in Sango Igoba, Ondo State, Nigeria, and is part of the Akure North Local Government Area (Figure 1). The Ondo State ultra-modern semi-mechanized Abattoir is located in the town. The Centre is of international grade and unique in southern Nigeria. The abattoir Centre covers 0.25 square kilometers. Animals that are received and held before being

butchered take up the most space. The rest is taken up by the livestock processing hall and office space. At the time of this study, approximately 350 herds of cattle are slaughtered daily and processed for human consumption. The abattoir is located in Nigeria's tropical rainforest zone, which has two seasons: the wet season and the dry season. The rainy season begins in mid-March and ends in October, with average rainfall ranging from 1500 to 2000 mm, and the dry season begins in November and ends in March, with an average maximum temperature of roughly 33°C. The site's surface elevation is flat, with field elevations ranging from 365 meters above mean sea level in the southwest (Nigeria Army Barracks) to 375 meters above sea level in the northeast (Shagari Estate), as shown in Figure 2. It lies between the latitudes of 806000 and 810000 mN and the longitudes of 744000 and 748000 mE. A Global Positioning System device was used to determine the area's coordinates. The principal geologic units found at the site are biotite granite and pelitic schist (Figure 3). These rocks are part of the southwestern Nigerian basement rock.

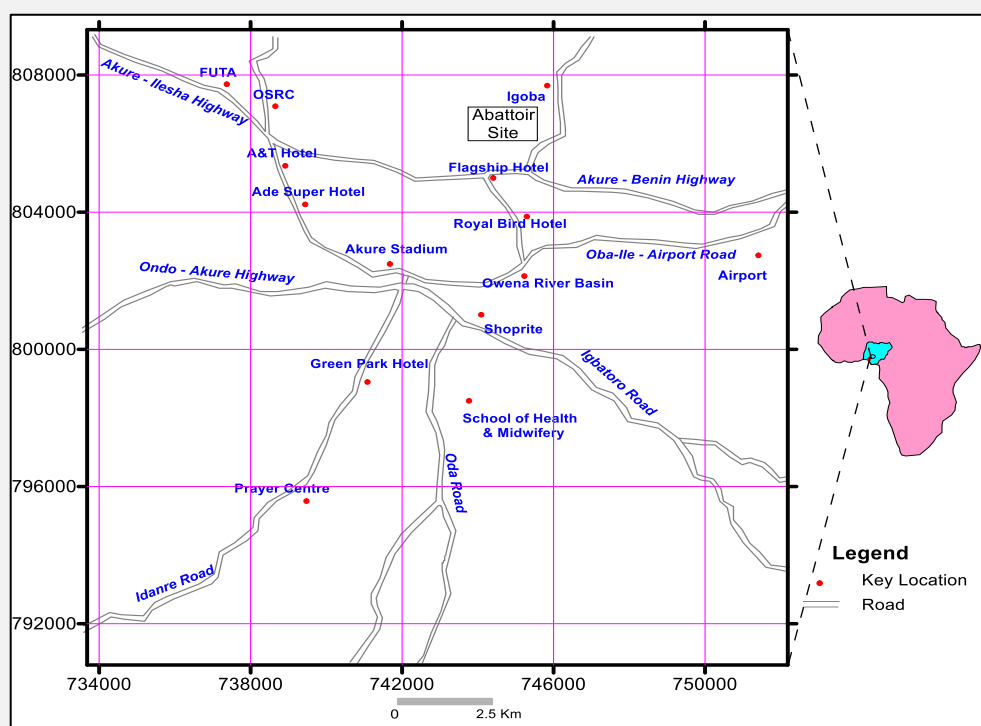


Figure 1. Location and Data Acquisition Map for the Study Area

Physicochemical and Microbial Analysis of the Water Samples

Eleven water samples from wells water were collected (Figure 4) and effluents discharged points were studied to ascertain that there was indeed discharge into the surrounding (Figure 5). The samples were subjected to various laboratory analyses to determine their physicochemical and biological characteristics. The geo-referenced distances of the sample locations to the site, elevation, compass direction from the abattoir discharge point is tabulated in Table 1, while the control sample was taken at a distance of 1.3 km from abattoir site. Criteria used in deciding the location of the control sample (CS) were topography, lack industrial activity, and waste dump. Samples were taken between the hours of 7:30am-9:30am which is the peak pollution period that butchers start slaughtering. The sampling stations were chosen within 1500 meters of the discharge point. The samples were taken during the rainy season (April 2019), when the stream's water volume and flow rate were both high. Water samples were collected from these geographical points using sterilized bottles. The collected water samples were kept in the refrigerator at 40°C for 24 hours before being analyzed at the Federal Ministry of Water Resources in Akure, Ondo State, Nigeria. The physical properties (electrical conductivity (EC), turbidity (TUD), total dissolve solid (TDS),

total alkalinity (AKL), temperature (T) and pH) were measured in the field using various digital meters accordingly. Standard analytical procedures from the American Public Health Association series of Standard Methods of Examination of Water and Effluent (APHA, 2005; Clesceri et al., 1998) were used to determine the concentrations of hardness, nitrate, iron, manganese, calcium, magnesium, chloride, sodium, bicarbonate, nitrite, dissolved oxygen (DO), biochemical/biological oxygen demand (BOD), chemical oxygen demand (COD), total coliform, and Escherichia coli (E. coli).

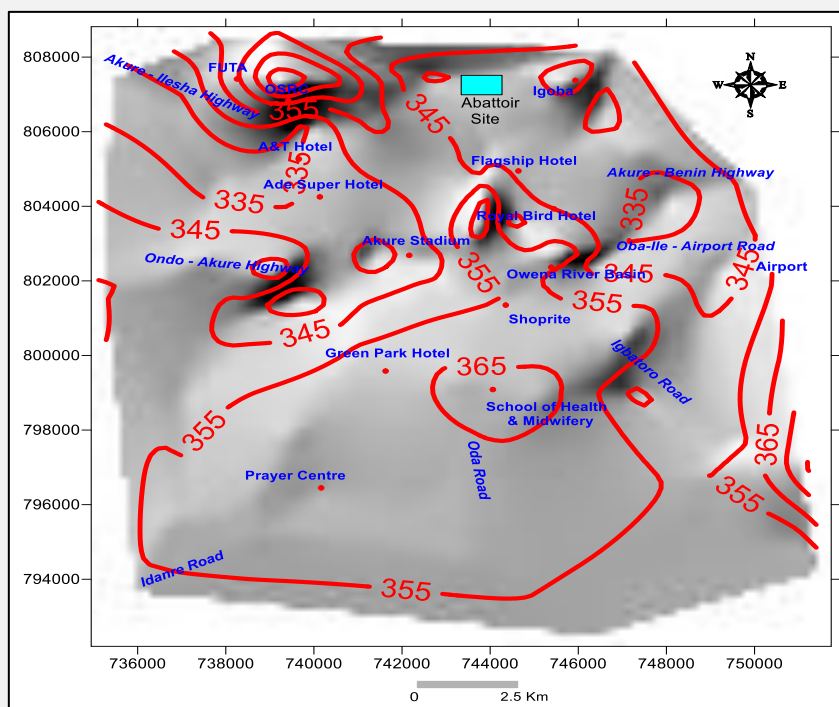


Figure 2. Topographical variation across Akure, showing the study area

The hydrogeological observations including depth of water table (DTWL) were observed in the open dug wells existing around the area. The results of the analyzed parameters were compared with Federal Environmental Protection Agency (FEPA, 2015) and World Health Organization (WHO, 2004). All data were analyzed using the statistical package SPSS version 21.0. All values were analyzed as mean and standard deviations of the mean using descriptive statistics. To assess differences among the groups of parameters, the one-way analysis of variance (ANOVA) and Duncan multiple range test (DMRT) were used, and they were compared (p-value 0.05) for significant differences.

RESULTS AND DISCUSSION

Physical Parameters

Table 2 shows the findings of the measured parameters, whereas Table 3 shows the descriptive statistics of the data. At the 95 percent confidence range for the mean, all of the acquired values of the parameters measured are within the lower – upper boundary, making the results of the water sample investigation significant at the 0.05 confidence limit. High acidity or alkalinity degrades water quality for aquatic and recreational purposes, and can irritate or harm skin and eyes. The type of chemical changes in water is indicated by the pH level. The pH ranges from 4.7 to 6.2, with a mean \pm standard deviation of 5.5 ± 0.499 and a standard error of 0.15. Sample numbers S-1, S-2, and S-5 are slightly acidic and fall outside of the 6.5–8.5 pH range recommended

by WHO (2004) and FEPA (2015). The calculated mean value, however, is within WHO guidelines and marginally confirms Adelowo et al. (2012) values of 5.7–6.7.

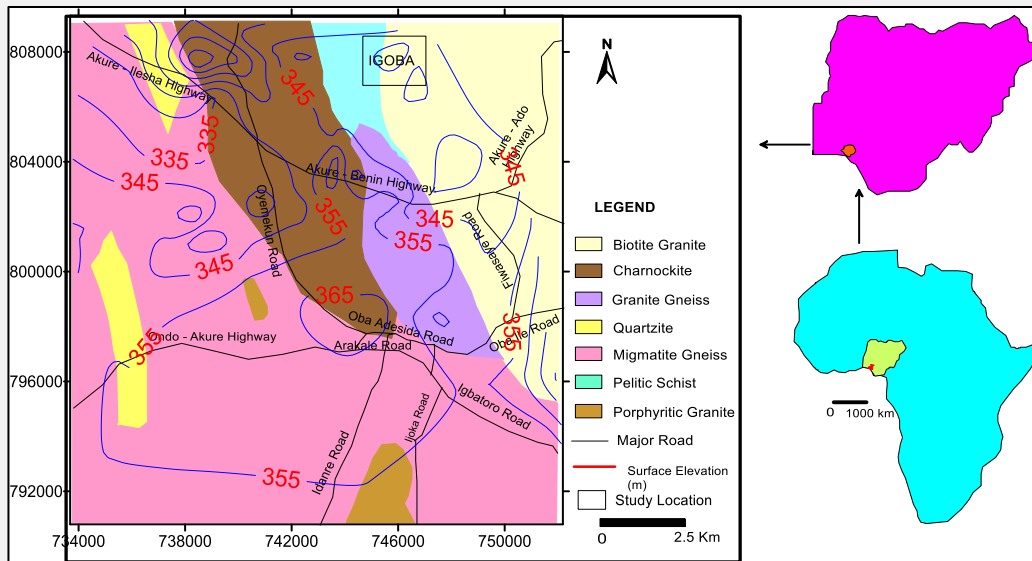


Figure 3. Geological map of Akure Area with the study area located in the Northern part with predominant biotitic granite (modified after NGS, 2006)

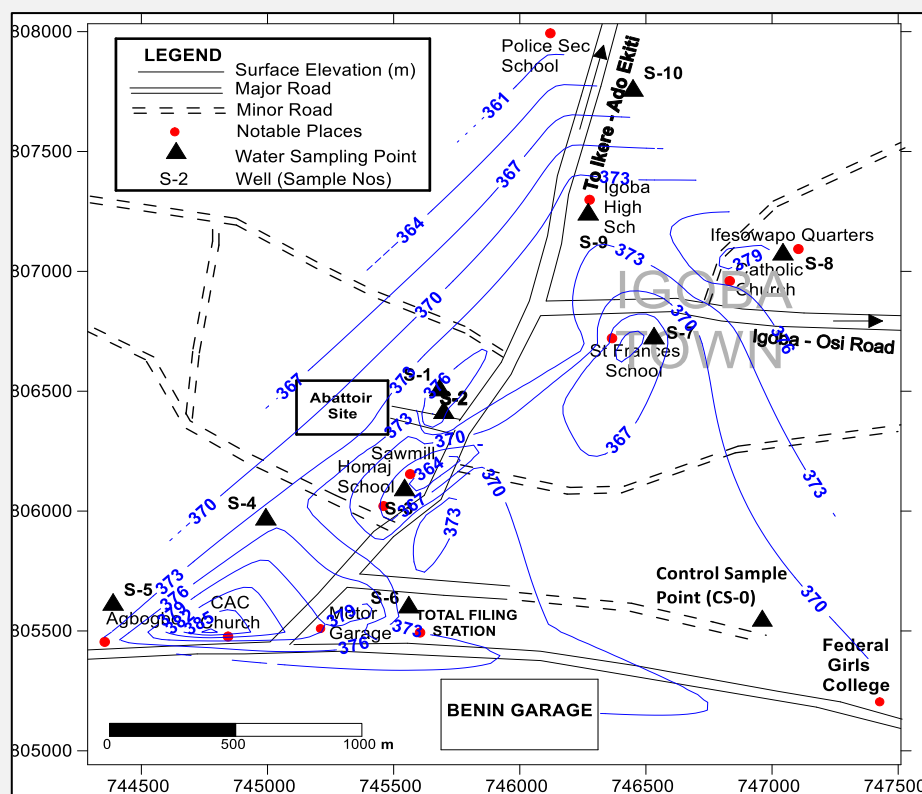


Figure 4. Data Acquisition map of the Study showing water sampling points



Figure 5. Collection of Sample at the Discharged Points

Table 1. Information of each of the sampling well and the control sample from the abattoir discharge point

Sample No.	East (m)	North (m)	Elevation (m)	Distance from Discharge Point (m)	Compass Direction from Discharge point
CS	746943	805547	368	1300	SE
S-1	745685	806508	377	150	E
S-2	745700	806399	376	160	E
S-3	745551	806087	365	180	S
S-4	744998	805965	374	220	SW
S-5	744393	805602	372	600	SW
S-6	745560	805593	371	610	SS
S-7	746540	806707	365	900	NE
S-8	747040	807070	378	1300	NE
S-9	746277	807220	373	700	NE
S-10	746451	807748	364	1200	NE

The pH distribution (Figure 6a) reveals that the groundwater is acidic, and that its value increases as you move away from the abattoir site. The presence of solids, small particles or sediments, or contaminants affects the clarity of water, which is measured by turbidity. The more sediment in water, the turbid it becomes; therefore, our drinking water must have a low turbidity. Turbidity ranges from 4.0 – 19 NTU, with mean \pm SD of 10 ± 5.9 NTU and SE value of 1.78. The mean value is above the 5NTU approved by WHO and Federal Environmental Protection Agency (FEPA) of 10 NTU. However relatively higher turbidity is observed in S-1, S-3, S-5, and S-6 (as compared with control stable sample C.S with 4.2NTU value) which are at proximately distance from the abattoir site (Figure 6b) while low turbidity dominates the east/northern part. These values are higher than those reported by Elemile et al. (2019) and less than that of Chukwu (2008). Even though the health implications of groundwater with temperatures exceeding 30°C have not been documented, water temperature is one of the essential factors used to assess water quality. The temperature (T) varies from 27.5 – 28.6°C, with mean \pm SD of 27.8 ± 0.35 °C, and SE of 0.10. The obtained range of values show no significant difference between the CS and others. This range is higher than those stated by Elemile et al. (2019) and Magaji & Chup (2012) and within the limit of 28.5 – 28.8°C. The EC of the water samples is between 102 - 491 μ s/cm, mean \pm SD of 240.3 ± 105.9 μ s/cm and SE of 31.95. Noticeable relatively higher values are observed in S-1 (491 μ s/cm) and S-2 (348 μ s/cm) which are at distances of 150 and 160 m respectively from the abattoir site, while other samples have low EC (Figure 6c). Although the average values is below the standard limit of 1000 μ s/cm set by WHO and FEPA. The TDS ranges from 94 to 262 mg/L (S-1), with mean \pm SD and SE values of 158.9 ± 46.76 mg/L and 14.10 respectively. The acquired values have some

overlap, but noticeably higher values are detected at the and around the slaughtering site (S-1 and S-2), as shown in [Figure 6d](#), which could be attributed to abattoir activities and other environmental contaminants.

The results of the chemical analysis of the water samples are shown in [Tables 2](#) and [3](#). There is an overlap in the values of TH as they are generally less than 150 mg/L recommended by WHO and FEPA. The obtained range of values, mean \pm SD and SE are 64 – 113 mg/L, 92.09 ± 14.24 mg/L, and 4.30 respectively. Consequently, the abattoir does not have much impact on hardness of the groundwater. Nitrate (NO_3) concentration in the water samples is between 1.3 – 12.50 mg/L, with mean \pm SD of 7.26 ± 4.32 mg/L and SE of 1.30. The SD and SE are indicative of little variation existing in the concentrations of nitrate across the area. Nevertheless, relatively higher values above 10 mg/L recommended by WHO and FEPA are observed in S-1 to S-4 which are close in distance to the abattoir site. [Figure 6e](#) shows higher values of nitrate in the southern part and around the abattoir site, while northern part is low (<5 mg/L).

Chemical Parameters

As a result, the abattoir effluents' impact may still be seen at a distance of around 200 meters around the site. High levels of nitrate in drinking water are thought to be harmful to human health, particularly in babies. Its presence in water is particularly hazardous to aquatic creatures because it fosters the growth of algae, which can quickly deplete dissolved oxygen in the water and inhibit aeration. Because high nitrate concentrations can be caused by the use of nitric fertilizers or decaying materials such as septic wastes, low nitrate concentrations in groundwater are desirable. The concentration of iron ranges from 0.01 – 0.12 mg/l; mean \pm SD of 0.24 ± 0.62 mg/L, and SE of 0.19. All the samples and the CS are less than 0.3 mg/L standard limit. However relatively higher value is obtained in S-1 (0.12 mg/L). Manganese (Mn) are very low in the water samples and within specification, as it ranges between 0.01 – 0.03 mg/L. Total alkalinity (AKL) shows significant overlap in values and varies from 9 to 24.6 mg/L, with mean \pm SD and SE of 14.57 ± 4.87 mg/L and 1.47 respectively. All the obtained values are within the specified limit of 150 mg/L. Calcium (Ca) concentration ranges from 14.4 to 42.5 mg/L, the mean \pm SD is 26.53 ± 8.66 . The values are within the specified limit of 75 mg/L. Magnesium and Sodium range between 4.86 – 29.50 mg/L and 10.1 – 24.10 mg/L with mean \pm SD of 12.20 ± 8.08 mg/L and 14.71 ± 4.85 respectively. Both the concentrations of Mg and Na are within the respective limits of 50 mg/L and 75 mg/L. The range of values of Cl is 14.4 to 37.0 mg/L, mean \pm SD of 21.86 ± 7.39 mg/L and SE of 2.23. Only CS (37.0 mg/L) and S-1 (37.0 mg/L) are characterized by relatively higher concentration, which be as result of geological influence. Significant overlap exists in the concentrations of bicarbonate across the study area, as its values varies from 8.8 – 21.20 mg/L, 13.96 ± 4.48 mg/L (mean \pm SD) and 1.35 (SE). These range of values satisfied the recommendation of WHO and FEPA. Nitrite is between 0.01 – 0.09 mg/L (mean \pm SD of 0.03 ± 0.07 mg/L) and satisfies standard limit of 0.3 mg/L.

The amount of oxygen dissolved in water is measured in dissolved oxygen, which varies seasonally and during a 24-hour period. The lowest oxygen levels occur immediately before sunrise and the highest levels occur around midday ([Addy & Green, 1997](#)). As a result, temperature and turbidity have a direct (linear) relationship. The value for dissolved oxygen (DO) ranges from 0.98 – 2.50 mg/L and mean \pm SD of 1.82 ± 0.52 mg/L. [Figure 7a](#) shows small closure of low DO are observed around the site, and in the western part. Samples S-1 to S-5 recorded less values than those far away from the abattoir site and CS. This shows that there is degree of reduction in DO as the distance to the abattoir site reduces. However, both CS and S-1 to S-5 share the value quality of DO. Consequently, the significant difference in these values could be attributed to pollution emanating from the site and organic matter. However, the obtained values are less than 5.0 mg/L specification.

Table 2. Distribution of all the measured Parameters across the study area at different distances from the abattoir site

Parameters/Sample No	C-S	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10
pH	5.8	4.9	4.7	5.5	5.2	4.8	5.8	5.5	5.9	6.2	5.8
TUB (NTU)	4.2	19.0	15.0	18.0	8.0	14.0	16.0	4.0	6.5	4.8	6.0
T (°C)	27.5	28.6	28.1	27.9	27.6	27.8	27.6	27.5	27.5	27.6	27.5
EC ($\mu\text{s}/\text{cm}$)	102.0	491.0	348.0	204.0	262.0	236.0	269.0	148.0	165.0	208.0	210.0
TDS (mg/l)	94.0	262.0	199.8	185.0	109.0	158.0	176.0	157.0	145.0	123.0	139.0
HD (mg/l)	75.0	102.0	64.0	113.0	86.0	98.0	102.0	88.0	95.0	105.0	85.0
NO ₃ (mg/l)	2.2	10.5	12.5	10.6	11.7	6.7	9.8	2.9	9.5	1.3	2.2
Fe (mg/l)	0.01	0.12	0.08	0.09	0.11	0.04	0.06	0.04	0.08	0.01	0.01
Mn (mg/l)	0.01	0.03	0.02	0.03	0.01	0.02	0.02	0.01	0.01	0.02	0.01
TKL (mg/l)	10.5	16.0	12.0	18.0	9.0	10.0	14.0	10.2	24.6	16.5	19.5
Ca ²⁺ (mg/l)	23.3	42.5	14.4	25.7	16.8	25.7	29.7	32.3	16.2	29.7	35.5
Mg ²⁺	8.9	22.5	6.23	12.0	29.5	8.30	6.83	5.45	4.86	10.1	19.5
Cl (mg/l)	32.7	37.0	18.0	21.0	15.6	23.0	26.0	18.2	14.5	20.1	14.4
Na (mg/l)	10.6	24.1	11.0	13.7	10.1	15.0	16.9	11.3	10.4	16.5	22.2
HCO ₃ (mg/l)	8.8	16.0	12.0	18.0	9.0	10.0	14.0	18.8	8.9	21.2	16.8
NO ₂ (mg/l)	0.05	0.09	0.06	0.01	0.04	0.01	0.05	0.01	0.01	0.01	0.03
DO	2.5	1.22	1.65	0.98	1.79	1.11	2.32	2.14	2.32	2.04	1.99
COD	98.0	232.0	213.0	145.0	169.0	105.0	114.0	148.0	87.0	69.0	84.0
BOD	21.0	39.0	42.0	47.0	29.0	42.0	22.0	18.0	17.0	26.0	22.0
Total coliform (cfu/100ml)	3.0	18.0	14.0	14.0	7.0	12.0	18.0	6.0	4.0	1.0	6.0
E-coli (cfu/100ml)	0	1.0	1.0	1.0	0	1.0	1.0	0	0	0	0

Table 3. Descriptive statistical analysis of the measured parameters

	Parameters	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
1	pH	11	5.4636	0.49854	0.15032	5.1287	5.7986	4.70	6.20
2	TUD	11	10.5000	5.90068	1.77912	6.5359	14.4641	4.00	19.00
3	T	11	27.7455	0.34457	0.10389	27.5140	27.9769	27.50	28.60
4	EC	11	240.2727	105.99914	31.95994	169.0615	311.4839	102.00	491.00
5	TDS	11	158.8909	46.75522	14.09723	127.4803	190.3015	94.00	262.00
6	HD	11	92.0909	14.24398	4.29472	82.5217	101.6601	64.00	113.00
7	NO ₃	11	7.2636	4.31677	1.30156	4.3636	10.1637	1.30	12.50
8	Fe	11	0.2409	0.04011	0.18528	-0.1719	0.6537	0.01	0.12
9	Mn	11	0.0173	0.00786	0.00237	0.0120	0.0226	0.01	0.03
10	AKL	11	14.5727	4.86767	1.46766	11.3026	17.8429	9.00	24.60
11	Ca	11	26.5273	8.65576	2.60981	20.7123	32.3423	14.40	42.50
12	Mg	11	12.1973	8.08168	2.43672	6.7679	17.6266	4.86	29.50
13	Cl	11	21.8636	7.39125	2.22855	16.8981	26.8291	14.40	37.00
14	Na	11	14.7091	4.85272	1.46315	11.4490	17.9692	10.10	24.10
15	HCO ₃	11	13.9545	4.48048	1.35092	10.9445	16.9646	8.80	21.20
16	NO ₂	11	0.0336	0.02693	0.00812	0.0155	0.0517	0.01	0.09
17	DO	11	1.8236	0.52359	0.15787	1.4719	2.1754	0.98	2.50
18	COD	11	133.0909	53.71118	16.19453	97.0072	169.1746	69.00	232.00
19	BOD	11	29.5455	10.93036	3.29563	22.2023	36.8886	17.00	47.00
20	Total Coliform	11	9.3636	6.05430	1.82544	5.2963	13.4310	1.00	18.00
21	E. Coli	11	0.5090	0.4700	0.15746	0.1037	0.8054	0.00	1.00

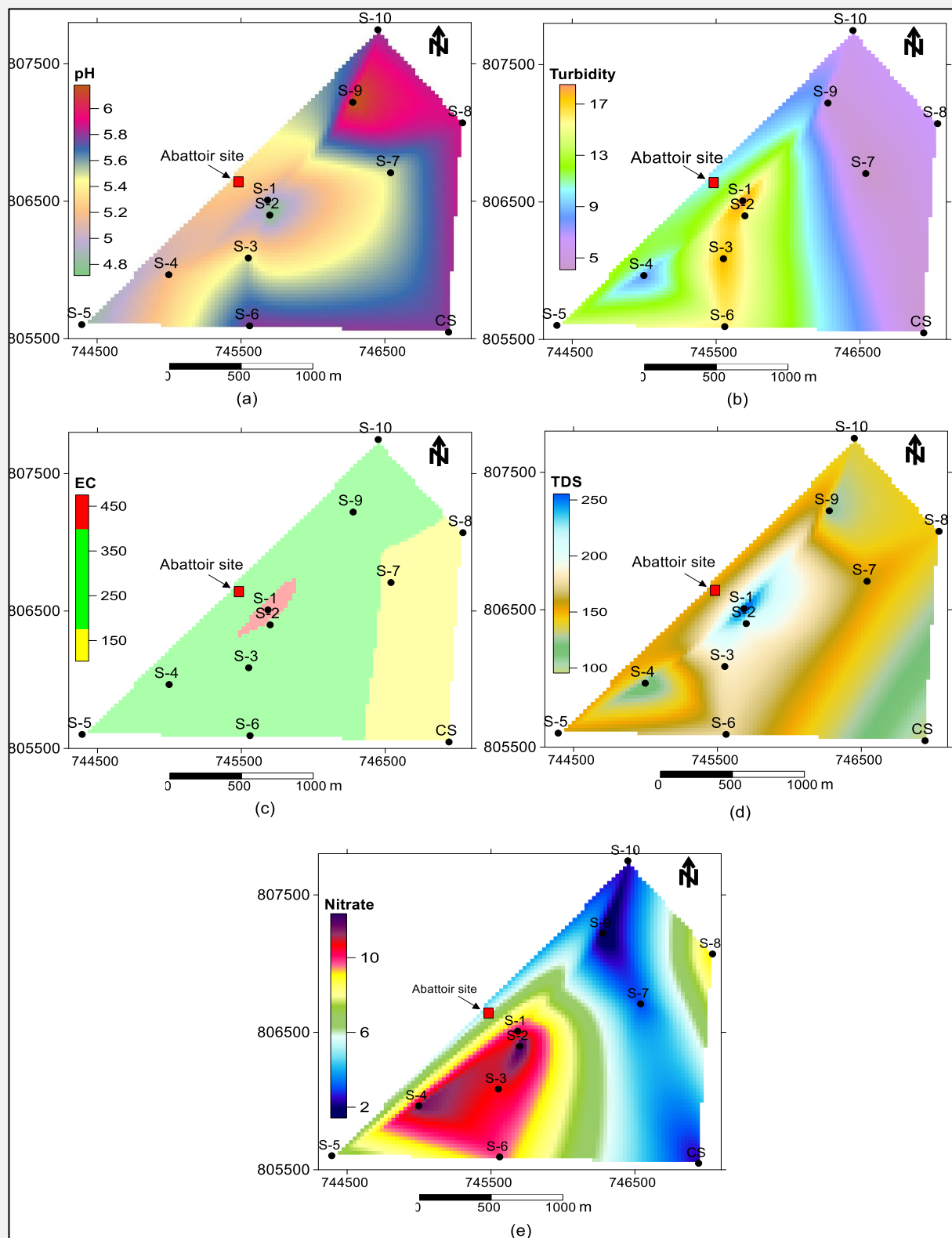
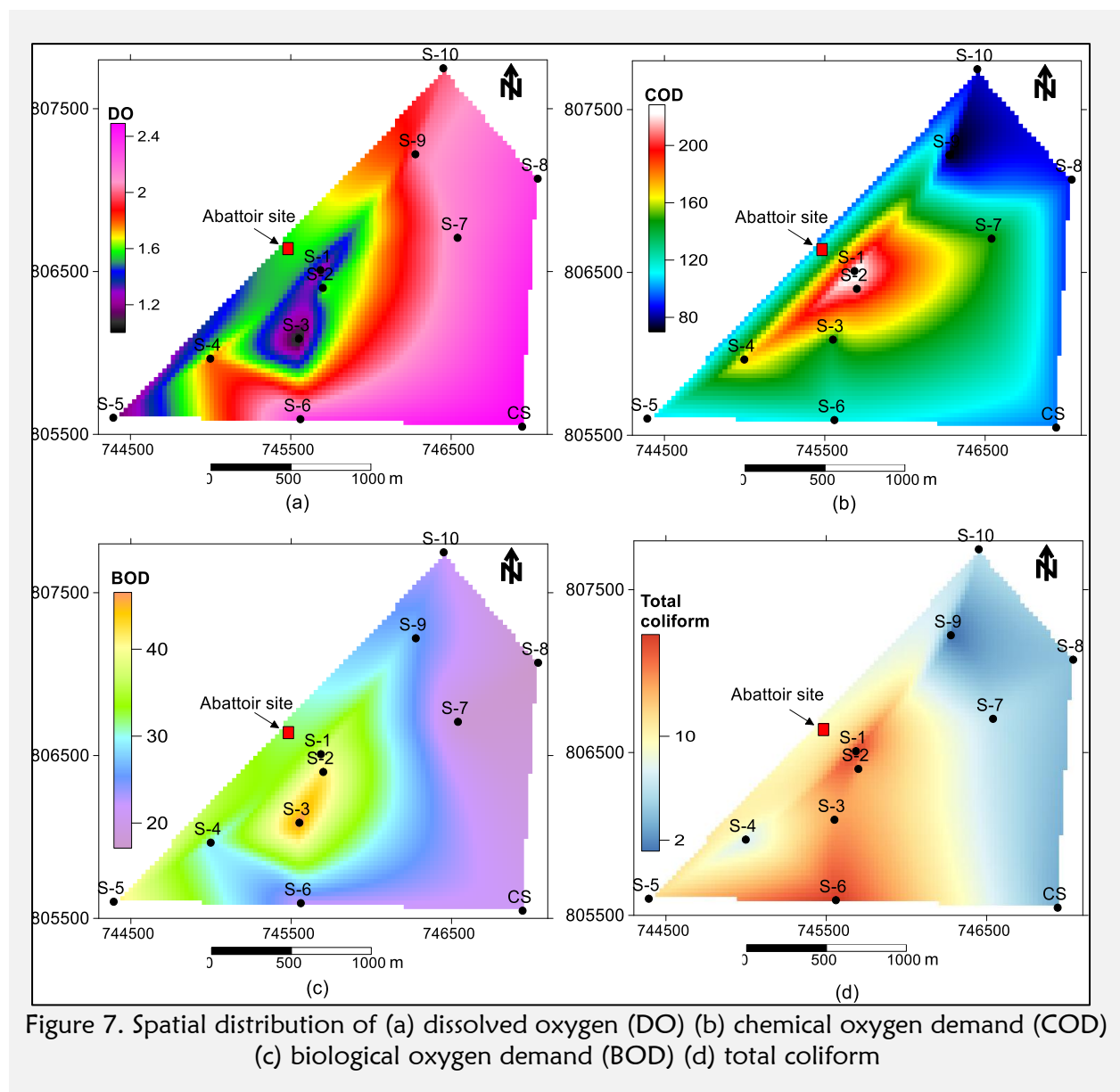


Figure 6. Spatial distribution of (a) pH (b) turbidity (c) Electrical conductivity (EC) (d) total dissolved solids (TDS) (e) Nitrate

The obtained of DO are less than those reported by Elemile et al. (2019) and Hassan et al. (2014) but strongly agrees with Chukwu (2008). The COD varies from 69 to 232 mg/L (higher than those recorded in Elemile et al. (2019), and Yogendra & Puttaiah (2008) with mean \pm SD of 133.1 ± 53.7 mg/L and SE of 16.2. All the values are less than 1000 specification, however noticeable relatively higher values are observed in samples S-1 to S-7. Figure 7b shows the same trend as DO in Figure 7a. The BOD varies from 17 – 47 mg/L, with mean \pm SD and SE of 29.6 ± 10.9 mg/L and 3.30 respectively. Figure 7c shows that BOD values increase outwardly from the site as notable higher values characterized S-1 to S-4. As a result, proper treatment is essential before intake in order to prevent illness outbreaks and epidemics (Adio et al., 2014; Ahmed et al., 2013; Garba et al., 2020; Goopy et al., 2004; Irshad et al., 2015; Familusi et al., 2021; Makwe & Chup, 2013).

Microbial Analysis

The concentrations of the total coliform and E.coli range from 1 – 18 cfu/mL and 0 – 1 cfu/mL with mean \pm SD of 9.36 ± 6.05 cfu/mL and 0.46 ± 0.52 cfu/mL and SE of 1.83 and 0.16 respectively. Samples S-1, S-2, S-3, S-5, and S-6 above the recommended standard limit of 10 cfu/mL (for total coliform) and 0 cfu/mL (for E. coli).



All these samples are in proximate distance/circumference of 600 m from the abattoir site as shown in Figure 7d, while relatively low values of TC dominate the northern part. All the samples with high values of TC are also characterized with 1 cfu/mL value of *E. coli*. This indicates that effluent from the abattoir, street sewage outflow, and wastes arising from human and animal feces have contaminated water samples near the abattoir site (albeit insignificantly) (Olaseni & Onifade 2020; Goopy et al., 2004; Irshad et al., 2015; Familusi et al., 2021). The results of this study's microbiological investigation show the same tendency as Elemile et al. (2019), Yogendra & Puttaiah (2008), and Igbinosa & Uwidia (2018), but at lower levels. The geography, on the other hand, aids effluent transportation westward/southward because this area is at a lower elevation (less than 350 m asl) to the abattoir than the northern/eastern parts, which are higher than 350 m asl. A one-way analysis of variance (ANOVA) between the parameters nullifies the null hypothesis that there are no differences between the means of the water samples, which invariably means that there is no impact the abattoir had on the water quality in the study area (Table 4). The obtained sum of squares between groups and within groups of parameters are 890828.59 and 169827.07, while the degree of freedoms are 20 and 210 respectively. The estimate or assessment of the standard deviation gives 44541.43 and 808.70 with F-value of 55.08 and degree of significance of 0.0001. This shows that the parameters are statistically significant i.e. significant differences exists within the parameters. The scree plot shows the downward curve (Figure 8), while the component number 3 with an eigenvalue of above 2.0 is the point at which where the slope of the curve levels/flattens out, as this is the number of component factors generated in the analysis, as shown in Figure 9. The Duncan's multiple range test with $p < 0.05$ (Table 5) shows for each parameter means with the different letters (superscripts). The superscript "a", "b", and "c" shows decreasing degree of statistical significance or association where (significant difference exists). The majority of the parameters (57%) belong to superscript "ab" with the likes of pH, TUD, T, NO₃, TKL, Ca, Mg, Cl, Na, HCO₃, DO, and coliform. The superscript "a" is characterized with Fe, Mn, NO₃, BOD, and *E. Coli*; while EC, TDS, HD, and COD are associated with "c".

Table 4. Summary of the ANOVA Test

Parameter	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	890828.594	20	44541.430	55.078	0.0001
Within Groups	169827.074	210	808.700		
Total	1060655.668	230			

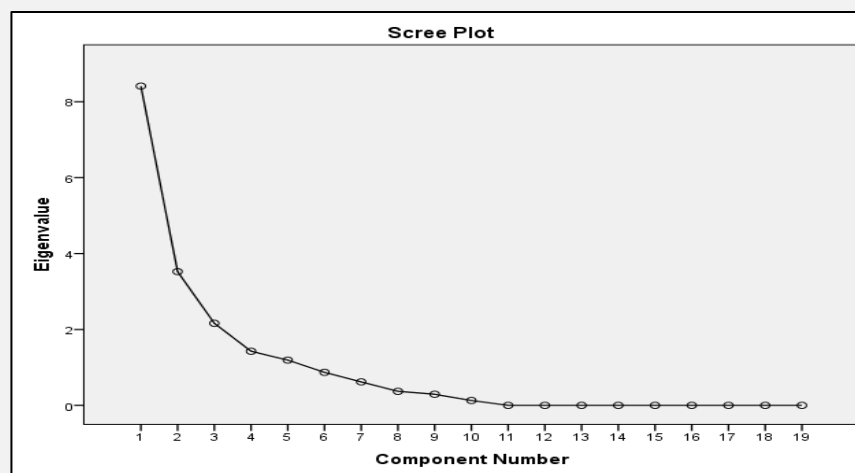


Figure 8. Scree Plot of the analyzed parameters with prominent component number 3 where the slope of the curve leveling off

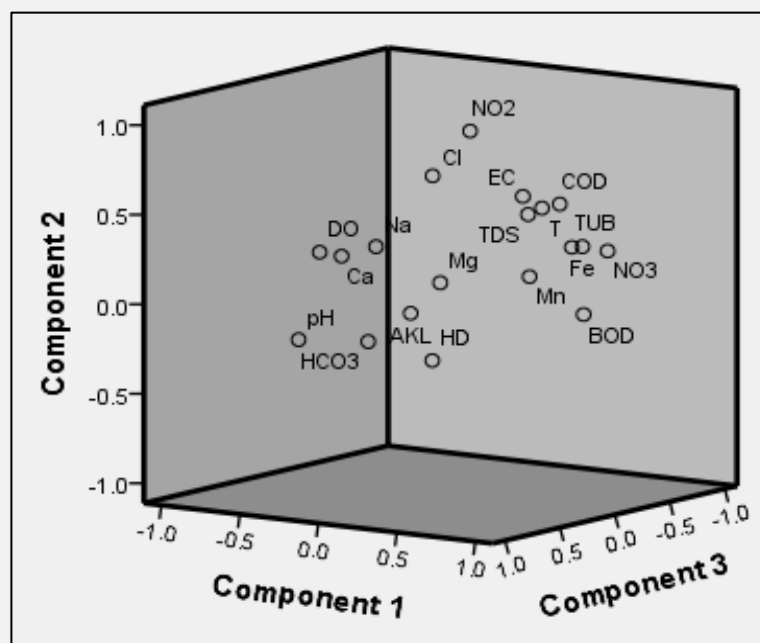


Figure 9. Component plot in rotated space

Table 5. Duncan’s multiple range test for the parameters with the mean and superscripts at statistically significant limits ($p < 0.05$)

Parameters	Mean concentration ^{Sig.}	Parameters	Mean concentration ^{Sig.}
pH	5.4636 ^{ab}	Mg	12.1973 ^{ab}
TUD	10.5000 ^{ab}	Cl	21.8636 ^{ab}
T	27.7455 ^{ab}	Na	14.7091 ^{ab}
EC	240.2727 ^c	HCO ₃	13.9545 ^{ab}
TDS	158.8909 ^c	NO ₂	0.0336 ^a
HD	92.0909 ^c	DO	1.8236 ^{ab}
NO ₃	7.2636 ^{ab}	COD	133.0909 ^c
Fe	0.2409 ^a	BOD	29.5455 ^b
Mn	0.0173 ^a	Coliform	9.3636 ^{ab}
AKL	14.5727 ^{ab}	Coli	0.4545 ^a
Ca	26.5273 ^{ab}		

CONCLUSION

The study looked into the impact of abattoir effluents on groundwater samples taken from eleven wells located at various distances from the abattoir. A one-way analysis of variance (ANOVA) of the parameters reveals statistically significant differences between them, implying that the abattoir has an impact/influence on the water quality in the research area. The bulk of the parameters (57 percent) belong to superscript "ab," comprising pH, TUD, T, NO₃, TKL, Ca, Mg, Cl, Na, HCO₃, DO, and coliform. All the measured parameters are in compliance with WHO and FEPA standards except pH, turbidity, BOD, and total coliform. However higher values above recommended values are observed around the abattoir especially samples S-1 to S-6 which are within 610 m circumference of the site. The movement of the effluents emanating from the site is highly aided by the topography of the environment as the northern part are characterized by high topography above 350 m while the southern part is generally less than 345 m, hence the discharged effluents/waste water flows westward and southwardly. These areas are prominent with high values of BOD, DO, and total coliform. As a result, the physical and biological quality of the

groundwater has been compromised, despite the fact that many mineral (chemical) constituents are within acceptable limits. The concentrations of the parameters measured in the Control Sample (CS) is generally and relatively less than other samples. Even though all samples are within the permissible limits of WHO and FEPA, the fact is that the relatively higher values obtained in S-1 to S-10 still call for concern. This shows that the abattoir effluents have impacted the sampled water within about 1200 m distance away from the site. Consequently, continuous and/or increase in discharge may further increase the concentrations of this parameters in the nearest future, which may endanger human health and compromise the sanitation of the area. Following that, proper water treatment and environmental sanitation should be implemented to prevent epidemics and diseases. If the government is unable to relocate the abattoir to a safer site, the government should design appropriate waste water treatment plant to safeguard public health within the study domain. In addition, inhabitants of the neighborhood should receive environmental education and cleanliness/sanitation enforcement from the government.

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COMPETING INTEREST

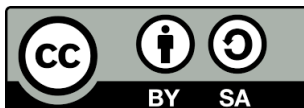
The authors declare that they have no competing interests and did not receive any funding from any source.

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