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(RESEARCH ARTICLE)

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Assessment of abattoir activities on groundwater quality in mandate market, area Ilorin, Kwara state, Nigeria

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Abstract

Groundwater is a major source of drinking water for residents in Malete area in Ilorin, Kwara State. However, groundwater quality is increasingly threatened by improper waste disposal practices, especially from Mandate abattoirs activities which raise concerns on potential contamination. This study aims to assess impact of abattoir activities on groundwater quality in the Mandate market, Ilorin with a view to ascertain the pollution level and profering adequate solutions. Water samples were collected from eight specific locations within 500 m of the abattoir, four (4) from hand-dug wells and boreholes, respectively. World Health Organization (WHO) procedures were employed for the collection, preservation, and laboratory analysis of the samples. Physical and biological parameters parameters such as turbidity, colour, total solids,odour, Biological Oxygen Demand (BOD), Total Bacterial Count (TBC), and Total Coliform Count (TCC) were measured from the water samples following WHO standard methods. Descriptive statistics of mean, standard deviation and variance were used to analyzed pollution pattern of wells and borholes with distance. The obtained water quality was input into Geographical Information Software to produce water quality map for Mandate market. Turbidity, colour, Total solid and odour for all water samples ranged 52.1-321.4 NTU, 67.69-72.12 Pt, 199-2222.00 mg/L, and 1.33-4.00 TON, respectively. The BOD, TBC and TCC were in the range 9.34-15.37 mg/L, 6-19MPN/100 mL, and 10.76 - 22.61 × 10^3 CFU/mL, respectively. Water quality map was produced for the study area. The abattoir activities at Malete market have caused significant deterioration in groundwater quality, rendering the water unsafe for consumption without prior treatment. The produced water quality map will be useful for efficient water resources management in Mandate market.

Keywords: Assessment; Abattoir activities; Groundwater; Mandate market; Kwara state

1. Introduction

Abattoir, also known as slaughterhouse; has been defined as a premises approved and registered by the controlling authority for hygienic slaughtering and inspection of animals, processing, effective preservation and storage of meat produced for human consumption (Omole, 2008). While slaughtering these animals results in significant meat supply, a good source of protein and production of useful by-product such as leather, skin and bones, the processing activities involved sometimes results in environmental pollution and other health challenges that may threaten animal and human health (Ogboru, 2001).

The US Environmental Protection Agency (1999) defined meat hygiene as a system of principle designed to ensure that meat product is safe, wholesome and processed in a hygienic manner and are fit for human consumption. Previous studies have shown that the characteristics of abattoir wastes and effluents vary from day to day, depending on the number of stocks being processed. These wastes from abattoir operation can also be separated into solid, liquid and fat. The wastes are highly organic. The solid waste includes condensed meat, undigested feed, bones, horns, hair, and

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aborted fetus. The liquid waste is usually composed of dissolved solids, blood, gut content, urine, and water; while the fatty waste consists of fat oil, grease which are characterized with high organic levels (Magaji, 2009).

Animal waste is usually microbiologically contaminated by micro-organism living naturally or entering it from the surrounding such as those resulting from processing operations. The killing of animals for community consumption is inevitable in most nations of the world and dated back to antiquity which result in the pollution of the underground aquifer (Chukwu, 2008). Environmental problems are not new. Human societies have long had a major impact on environmental or natural resources. Their tendency to exploit it as if it where inexhaustible resources has repeatedly led to disaster, sometimes leading to the loss of entire human communities. Man in every corner of the world is thus making demands upon his surrounding and thereby altering his own natural environment and that of other living organisms. In Nigeria, Maduka (2005) reported that cow brought for slaughtering produce 67.8 kg of waste in dung, bone, blood, horn, and hoof. Foster (2005) submitted that the disposal of waste product is a problem that has always dominated the slaughtering sector an average of 45 percent of the waste consist of non-meat substance.

The characteristics of slaughter waste and effluent vary from day to day and it depends on the number of animals, the type of animals, the kind of stock that is being processed and the methods by which these animals are being killed in the abattoir. However, Meadows (1995) reported that waste can affect water, land and air quality, he also reported that abattoir effluent reaching streams and underground water contributes significant levels of nitrogen, phosphorus, biochemical oxygen demanded and other nutrient resulting in stream pollution. Medical experts were reported to have associated some diseases with abattoir activities which include pneumonia, diarrhea, typhoid fever, asthma, wool sorter disease. The pollution load on a water body from abattoir effluent can be quite high (Chukwu, et al., 2024).

Most of these are known to be hazardous to human beings and aquatic life. Likewise, improper disposal of effluent from slaughterhouse could lead to transmission of the pathogen to humans and cause diseases such as bacillus salmonella infection, brucellosis, and helminths disease and infection. It is reported that in developed countries such as Nigeria, an estimated 80 percent of all diseases and over one-third of death are caused by consuming contaminated water (UNESCO, 2006). Good quality water is safe for domestic purposes. Water intended for drinking should be free from pathogenic organisms (Ojoawo and Kolade, 2013). Hence the contamination of groundwater from abattoir activities should be prevented. When a contaminant first enters the soil, it will travel down vertically with gravity until it contacts groundwater. At this point it will begin to floor primarily in the horizontal direction. The contaminant will then spread out three-dimensionally like smoke from a chimney and is called a plume. Groundwater does not exhibit turbulent flows as found in surface water. The flow is defined by gravity, pressure and friction. It is much more constant than surface water, hence preventing the contaminant at the source (Ojoawo and Kolade 2013).

2. Materials and Methods

2.1. Description of Study Area

The study area is Mandate market in Ilorin, Kwara State, located at the Oko- Erin, Western Reservoir Road, Ilorin 240281, Kwara State, Nigeria. With Lat. 8.477592° long 4.50244° as shown in Figure 1. The study adopted a combination of qualitative and quantitative methodology, including laboratory testing and sample analyses Data were collected from both primary and secondary sources, but most of the information were obtained from the primary source. The primary source of data includes reconnaissance survey, field observation and the water sample analysis. The secondary source of data include vital information obtained from urban planning, journals, seminar paper, textbooks and the internet. Plates 1 showed the location within the study area.

2.2. Methods of Data Collection

One hundred (100) structured Questionnaire were administered to obtain information from resident as well the marketers. The Questionnaire were distributed to Health officials, inspectors and Primary Health Center officials for information on various practices going on with the abattoir at Mandate market. Insight into the practices by the health workers to prevent and mitigate groundwater contamination within the study area were also inferred from questionnaires.

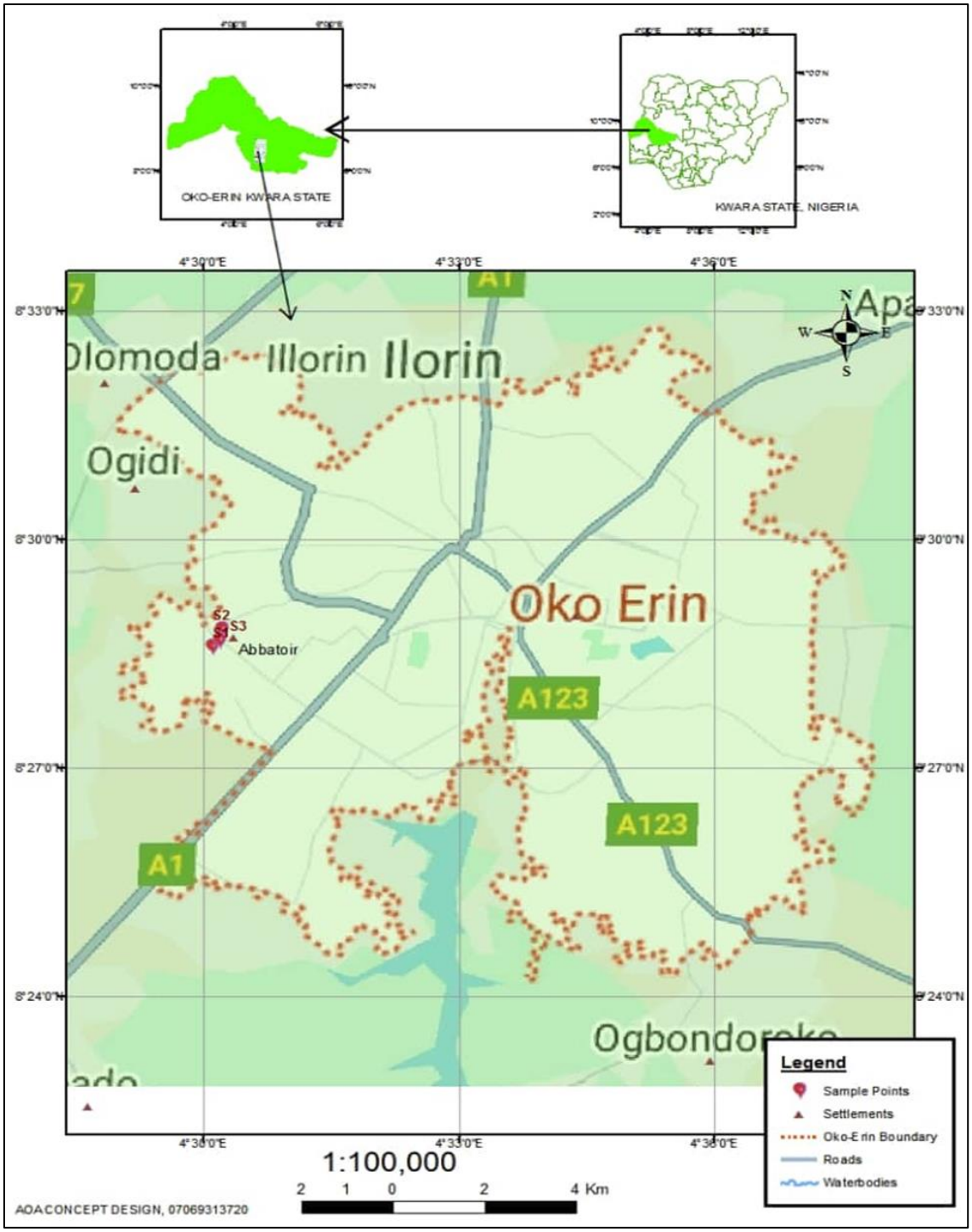

Figure 1 GIS Map of Mandate market in Oko Erin, Ilorin, Kwara state

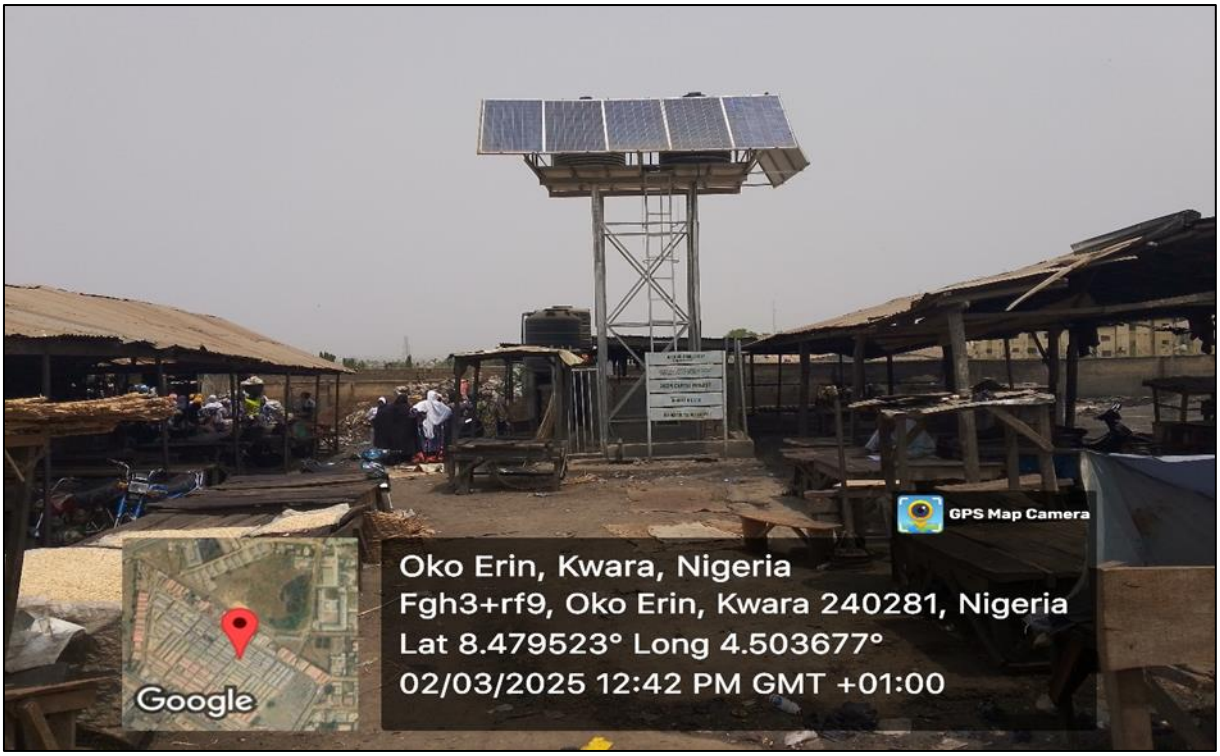

Figure 2 Abattoir Area inside Mandate market in Oko Erin, Ilorin, Kwara State

2.3. Groundwater Sampling

Groundwater sampling is a crucial methodology for evaluating the quality of underground water resources. It helps in assessing contamination levels, identifying pollution sources, and ensuring water safety for human consumption, agriculture, and industrial use.

2.3.1. Laboratory Analysis of Water Samples

The laboratory analysis of the water samples was carried out at College of Engineering, Department of Chemical Engineering and College of Science Research and Extension, Afe Babalola University Ado-Ekiti (ABRUD). Physical and Bacteriological test were carried out on the water samples. Physical and biological parameters such as Total Dissolved Solids, Total Suspended Solid, Biological Oxygen Demanded, pH, Nitrate, Turbidity and Total Coliform. The laboratory analyses were carried out using standard analytical methods and procedures for water quality analysis in line with Okoye et al., 2019. Dissolved oxygen, Flow cell, Operating manual for the meter and probe, Spare membranes and electrolyte solution for the probe, Spare batteries for the meter as outlined in equation 1 to 3, which was used to analyzed the primary data obtained.

$$Em - Eo - (\frac{RT}{nF}) \quad \ldots\ldots\ldots \quad 1$$

$$E\,m = E\,o - (RT/nF)\ln\{[ox] / [red]\} \quad \ldots\ldots\ldots \quad 2$$

$$\text{Alkalinity} = Va\ X\ C\ x\ \frac{50000}{Vs} \quad \ldots\ldots\ldots \quad 3$$

2.4. Method of Data Analysis

The collected data were analyzed using descriptive statistical tools. These include mean and standard deviation. The Analysis of variance (ANOVA) was used to determine the variation in the concentration of the parameters of water samples collected from well, borehole and control sites. The use of ANOVA tests the hypothesis at 5% level of significance.

3. Results and discussion

3.1. Analysis of Parameters

These samples were analyzed for a range of parameters including turbidity, dissolved solids, suspended solids, total solids, colour, odour, Biological Oxygen Demand (BOD), total coliform count (TCC), and total bacterial count (TBC). The results are interpreted with respect to their spatial distribution, compliance with health standards, and implications for environmental and public health.

3.2. Water Sources and Sampling Points

According to the documented coordinates, water samples were collected from four wells (Samples 1 - 4) and four boreholes (Samples 5 - 8) as presented in Table 1. These sources are located within a 500meter radius of the abattoir. The specific GPS coordinates show clustering of these sources around the commercial and slaughter areas of Mandate Market.

Table 1 Water Sources and Sampling Points

Samples No	Sources	Latitude	Longitude
1	Well 1	8.479526°	4.503698°
2	Well 2	8.479418°	4.503605°
3	Well 3	8.479006°	4.501921°
4	Well 4	8.477899°	4.502542°
5	Borehole 1	8.478904°	4.5044°
6	Borehole 2	8.476765°	4.503966°
7	Borehole 3	8.477643°	4.503064°
8	Borehole 4	8.480516°	4.501386°

3.3. Physical Characteristics of Groundwater Samples

This section presents the results and interpretation of the physical characteristics of groundwater samples collected from wells and boreholes around the Mandate Market abattoir. The parameters analyzed include turbidity, colour, total solids, suspended solids (SS), dissolved solids (DS), and odour as presented in Table 2. These indicators provide insights into the extent of contamination from abattoir activities and the potential impact on water quality. Turbidity values ranged from 52.7 NTU (Sample 3) to 321.4 NTU (Sample 4), significantly exceeding the WHO (2017) permissible limit of 5 NTU for drinking water. Elevated turbidity can indicate high levels of suspended organic and inorganic matter, likely introduced by abattoir runoff, including blood, feces, and animal waste particles. Sample 4 recorded the highest turbidity, correlating with its proximity to the slaughter zone and poor drainage conditions.

Table 2 Physical Characteristics of Groundwater Samples

Sample No	Dissolved Solid (DS) (mg/L)	Turbidity (NTU)	Colour (Pt-co unit)	Suspended Solid (SS) (mg/L)	Total Solid (TS) (mg/L)	Threshold Odour Number (TON)	Odour interpretation
1	98.50	205.0	59.88	210.00	308.50	1.33	Very faint odour (barely perceptible)
2	17.84	93.10	110.50	310.00	327.84	1.90	Very faint odour (barely perceptible)
3	54.59	52.70	96.44	110.00	164.59	2.28	Slight odour (recognizable but not unpleasant)

4	1992.00	321.40	95.81	230.00	2222.00	3.04	Moderate odor (distinct and noticeable)
5	1671.00	140.00	66.44	210.00	1881.00	1.67	Very faint odour (barely perceptible)
6	93.60	132.40	93.00	100.00	193.60	4.00	Strong odour (objectionable)
7	75.20	181.26	80.50	310.00	385.20	2.14	Slight odour (recognizable but not unpleasant)
8	82.70	240.50	167.69	330.00	412.70	3.89	Moderate odor (distinct and noticeable)

3.3.1. Bacteriological Characteristics of Groundwater Samples

Bacteriological analysis is a critical component of water quality assessment, especially in environments where contamination by organic waste is suspected. In this paper, three microbiological parameters were analyzed across eight groundwater samples including Biological Oxygen Demand (BOD), Total Bacterial Count (TBC), and Total Coliform Count (TCC). These indicators serve to evaluate the level of microbial pollution in relation to abattoir activities.

3.3.2. Biological Oxygen Demand (BOD)

Bacteriological Characteristics of the groundwater Samples is presented in Table 3. Biological Oxygen Demand (BOD) measures the amount of dissolved oxygen required by microorganisms to decompose organic matter in water. High BOD values typically indicate elevated levels of biodegradable organic pollution, which is characteristic of wastewater from abattoir operations. BOD values in all samples ranged from 9.34 to 15.37 mg/L, with the highest recorded in Sample 3. Total Bacterial Count (TBC) Total Bacterial Count (TBC) quantifies the population of heterotrophic bacteria in water. These bacteria may not necessarily be harmful but indicate the general biological load and cleanliness of the water source. The TBC ranged from 10.76×10^3 CFU/mL (Sample 7) to 22.61×10^3 CFU/mL (Sample 3).

3.3.3. Total Coliform Count (TCC)

Total Coliform Count (TCC) is a standard indicator of faecal contamination. Coliforms include a wide range of bacteria, many of which originate in the intestines of warm-blooded animals. Their presence in water indicates contamination by sewage or animal waste. TCC values ranged from 6 MPN/100mL (Sample 1) to 19 MPN/100mL (Sample 7) and the WHO guidelines specify that drinking water should contain 0 coliforms in 100mL.

Table 3 Bacteriological Characteristics of Groundwater Samples

Sample No	BOD (mg/L)	Total Bacteria Count (CFU/mL x 10^3)	Total Coliform Count (MPN/100ml)
1	12.170	18.620	6.000
2	11.860	13.240	8.000
3	15.370	22.610	15.000
4	13.630	20.360	10.000
5	10.960	18.130	12.500
6	11.630	12.970	7.000
7	9.340	10.760	19.000
8	11.660	12.940	14.000

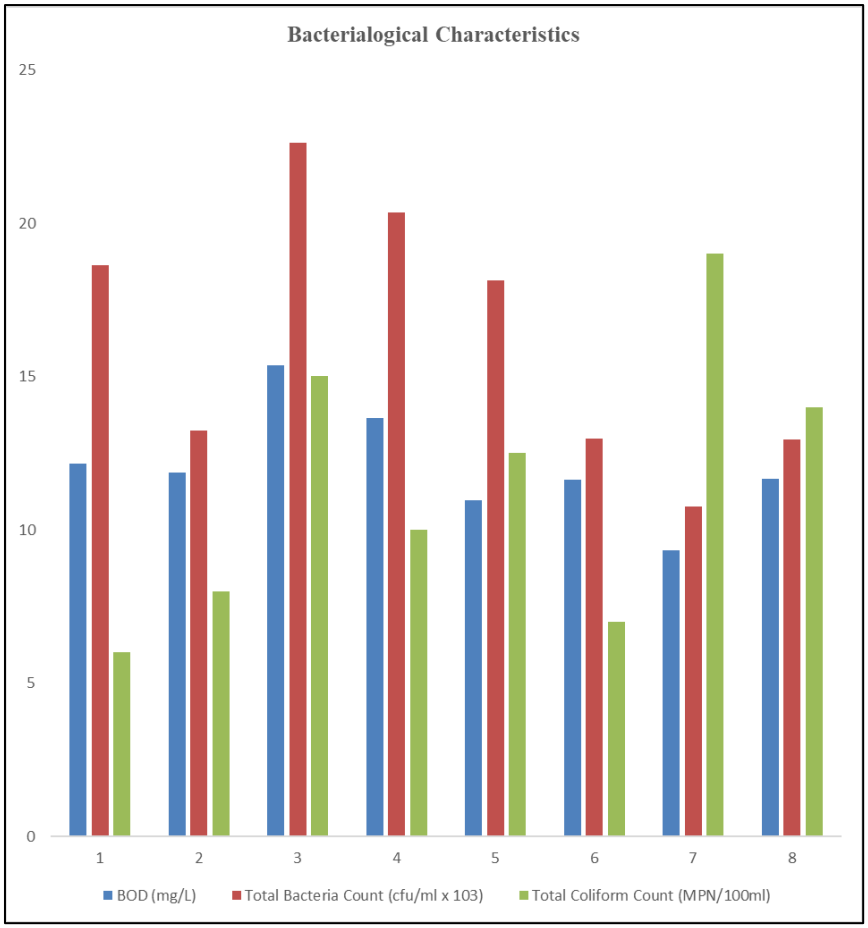

Figure 3 Variation of Bacteriological Characteristics of Groundwater Samples

Table 4 Comparison between Sample Results and WHO Standards

Parameter	**WHO 2017 Guideline Limit**	**Range in Samples**	**Compliance Status**
Turbidity (NTU)	≤ 5	52.7 – 321.4	Non-compliant in all samples
Colour (Pt-Co units)	≤ 15	59.88 – 167.69	Non-compliant in all samples
Dissolved Solids (mg/L)	≤ 1000	17.84 – 1992.00	Non-compliant in Samples 4 & 5
Suspended Solids (mg/L)	No WHO limit (aesthetic)	100.00 – 330.00	Indicates heavy pollution
Total Solids (mg/L)	No direct WHO guideline	164.59 – 2222.00	Indicates severe pollution
Odour	No offensive odour	TON 1.33 – 4.00	Non-compliant in Samples 4, 6, 8
BOD (mg/L)	≈ 0	9.34 – 15.37	Non-compliant in all samples
Total Bacterial Count	0 cfu/mL	10.76 – 22.61 × 10^3	Non-compliant in all samples
Total Coliform Count	0 MPN/100mL	6 – 19	Non-compliant in all samples

Table 5 WHO (2017) Compliance Overview

Sample No	Total Tested Parameters	Compliant Parameters	Non-Compliant Parameters	Overall Status
1	9	2	7	Unsafe
2	9	3	6	Unsafe
3	9	1	8	Highly Unsafe
4	9	0	9	Highly Unsafe
5	9	1	8	Highly Unsafe
6	9	1	8	Highly Unsafe
7	9	2	7	Unsafe
8	9	1	8	Highly Unsafe

4. Conclusions

The following conclusions are drawn from the findings :

Severe groundwater contamination attributed to the proximity of the abattoir and the improper disposal of waste. Physically, most of the water samples exceeded the WHO permissible limits for turbidity, colour, and total solids.

The groundwater in the Mandate Market area is unsafe for human use in its current state. The contamination poses a significant public health threat, particularly to residents who rely on shallow wells and boreholes for drinking and household use.

Regulatory bodies such as the Ministry of Environment and the State Environmental Protection Agency must enforce zoning laws that ensure a minimum buffer distance between slaughter facilities and water sources. Wells and boreholes should not be constructed within 500 meters of high-risk waste discharge points.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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