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OSUN CHAPTER

Evaluation of the Effect of Abattoir and Aquaculture Effluents on Groundwater Quality in Osogbo Nigeria

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ABSTRACT

Groundwater serves as a primary source of domestic water in many developing communities. This study is to evaluate the effect of abattoir and aquaculture effluents on groundwater quality to the extent of their contamination and develop strategies to mitigate it. Water samples were taken from both deep wells and boreholes at the study area. Physico-chemical and bacteriological analyses were performed on samples collected from the groundwater sources in line with WHO and APHA Standard. From the result obtained, well water around the study area contains some bacteria which are very harmful to health of human being and this can lead to water borne diseases. Boreholes water around the fish pond and abattoir can be useful for drinking, if it is well treated. It is recommended that effluent treatment systems be established at a reasonable and safe distance from the borehole/well area, accompanied by continuous environmental monitoring.

1. INTRODUCTION

Water is essential for life, and it can be found in various sources on earth. Some of the main sources of water are surface water, groundwater and rainwater. Groundwater is one of the most reliable sources of potable water. Groundwater serves as the main source of potable water in most developing nations, including Nigeria, due to its relative availability and presumed purity. According to Ocheri et al. (2018), over 70% of rural households in sub-Saharan Africa depend on groundwater for drinking, cooking, and other domestic uses. It is a common source of drinking water in rural areas. Well water is groundwater that is accessed by drilling a well into the ground, well water can contain minerals such as iron, manganese, and calcium, which can affect its taste and color. It is also contain harmful contaminants such as bacteria, viruses, and chemicals, which can pose a health risk to humans (Centers for Disease Control and Prevention, 2022). Borehole water, drawn from underground aquifers through drilled wells, stands as a crucial source of clean and sustainable water supply for various communities around the world. These wells equipped with pumps, raw water from the underground reservoirs, providing a reliable and often decentralize water supply (Smith & Johnson, 2018). This study, therefore, investigates the combined influence of abattoir and fish pond effluents on the physico-chemical and bacteriological quality of groundwater in Halleluyah Estate (Akanni e*t al*.,2 018). Groundwater serves as the main source of potable water in most developing nations, including Nigeria, due to its relative availability and presumed purity. According to Ocheri *et al.* (2018), over 70% of rural households in sub-Saharan Africa depend on groundwater for drinking, cooking, and other domestic uses. However, its quality is highly influenced by the surrounding environment and human activities. Inadequate waste management, industrial discharge, and agricultural runoff have been identified as major sources of contamination. The increasing urbanization without corresponding improvement in sanitation infrastructure worsens the risk of pollution (Adeyemi *et al*., 2020).

Abattoir operations produce substantial amounts of organic and inorganic waste, including animal blood, fats, faeces, and chemical cleaning agents. When discharged untreated into open drains or directly onto soil, these wastes percolate into the subsurface, thereby contaminating aquifers. Elemile *et al*. (2019) found that groundwater near abattoirs contained high levels of biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate, and total coliforms, often exceeding World Health Organization (WHO) limits. Olukanni and Ebuetse (2016) highlighted that poor abattoir practices in Nigeria significantly contribute to waterborne diseases such as cholera and typhoid.

Aquaculture though economically beneficial, contributes to nutrient enrichment of well-being of people in any society. Effluent from aquaculture ponds typically contains high concentrations of nitrogen, phosphorus, and organic carbon from unconsumed feed and fish excreta. Coldebella *et al* (2010) demonstrated that aquaculture discharges significantly increased phosphate levels in adjoining water bodies, leading to eutrophication. In Nigeria, Oladejo *et al*. (2021) reported nitrate and phosphate concentrations above recommended limits in wells located near fish ponds.

The co-location of abattoir and aquaculture facilities, as seen in many peri-urban areas, creates a compounded pollution scenario. Adewumi *et al*. (2020) noted that simultaneous discharge from multiple waste sources accelerates the degradation of water quality, causing synergistic effects on nitrate, phosphate, and microbial levels. Such combined contamination impacts both the physiochemical and bacteriological parameters of groundwater, often exceeding permissible drinking-water standards (WHO 2022; APHA, 2022),

Existing studies consistently demonstrate that both abattoir and aquaculture effluents significantly degrade groundwater quality through nutrient enrichment and microbial contamination. However, there is limited integrated research evaluating the combined impact of these effluents within the same hydrogeological setting, especially in emerging peri-urban community like Halleluyah Estate Osogbo in Osun State, Nigeria. This study therefore addresses this gap by assessing the joint influence of abattoir and fish pond discharges on groundwater quality using field and laboratory-based approaches.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

Halleluyah Estate lies between latitudes 7°10′N and 7°15′N and longitudes 3°25′E and 3°30′E. Halleluiah Estate is a peri-urban residential community located within Osogbo, Osun State, Nigeria. The area is characterized by a combination of residential, commercial, and agricultural land uses. The estate experiences a tropical wet and dry climate, with an annual rainfall of about 1,500 mm and average temperature of 27°C. The area's geology consists mainly of Precambrian basement complex rocks, which influence the groundwater flow and storage. Abattoir and Aquaculture sites are situated at the western boundary of the estate, where waste effluents are discharged directly into open drains and nearby land surfaces. Figure 1 shows the map of Osun State showing Osogbo.

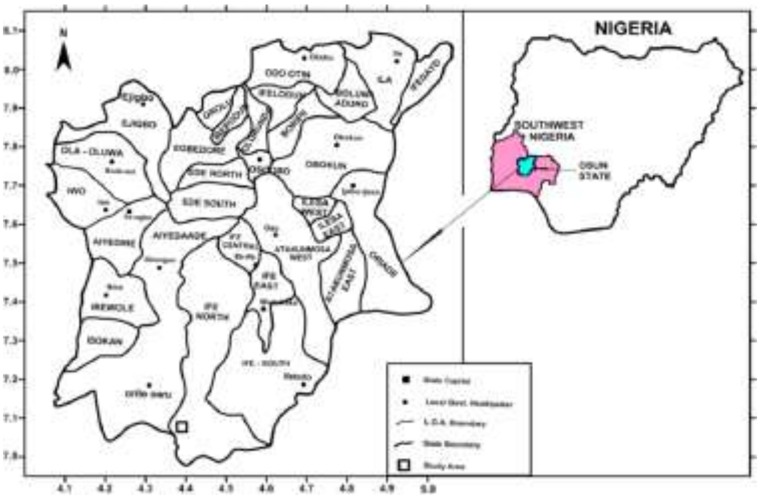

Fig 1: Map of Osun State showing Osogbo

2.2 Materials

A purposive sampling technique was employed to identify sampling points near the abattoir and fish pond effluent discharge zones. A total of four samples were collected: two from deep wells (A and B) and two from boreholes tagged C and D close to the abattoir and the fish ponds. Sampling followed WHO and APHA Standard Methods for the Examination of Water and Wastewater (2022). Water samples were collected in sterilized polyethylene bottles, preserved with ice in coolers, and transported to the laboratory for analysis within six hours.

2.3 Methods

Laboratory analysis was carried out at the Osun State Water Cooperation, Ede, Osun State. The physico-chemical parameters determined included pH, total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate (NO^{3-}), phosphate (PO_4^{3-}), chloride (Cl^-), and hardness. Bacteriological analysis was carried out for determination of total coliforms and Escherichia coli counts using the membrane filtration method. Analytical procedures conformed to APHA (2022) standards.

The physico-chemical and Bacteriological results were analyzed using statistical tools such as tables for proper visualization. The results were also compared with WHO and APHA standards.

3. RESULTS AND DISCUSSION

Well water around the study area contains some bacteria which are very harmful to human being health which can lead to water borne diseases.

3.1 Results

The results of physico-chemical and bacteriological analyses are presented in Tables 1-2.

Table 1: Physiochemical results of the samples

Parameters	A	B	C	D	WHO	APHA
Colour (H.U)	100.00	45.00	15.00	15.00	-	-
Taste and Odour			Unobjectionable			
pH at time of collection	Nil	Nil	Nil	Nil	-	-
pH at Laboratory	6.90	6.00	6.00	6.00	6.6-8.5	7.5-8.0
Turbidity (FTU)	145.00	70.00	10.00	5.00	5-25	5
Dissolved Oxygen (ppm)	7.50	7.30	2.60	2.50	5-6	8
Temperature (˚C)	26.20	27.50	26.90	26.60	-	4-29
Total Alkalinity (mg/l)	312.00	66.00	306.00	216.00	30	200
Total Harness (mg/l)	160.00	74.00	116.00	104.00	200	300
Calcium Hardness (mg/l)	116.00	32.00	82.00	86.00	75-200	200
Calcium ions (mg/l)	46.40	12.80	32.80	34.40	100-500	150
Magnesium harness (mg/l)	44.00	42.00	34.00	18.00	50-150	100
Magnesium ions (mg/l)	11.00	10.50	8.40	4.50	-	60
Chloride ions (mg/l)	15.00	21.00	15.50	13.00	250	300
Iron (mg/l)	2.85	0.70	1.15	0.10	0.3	0.05
Silica (mg/l)	0.88	0.08	0.68	0.00	20	20
Nitrate nitrogen (NO) (mg/l)	0.27	0.04	0.07	0.00	50-100	50
Nitrate Nitrogen (NO_2) (mg/l)	0.11	0.00	0.04	0.00	-	1
Copper (mg/l)	1.60	0.38	0.66	0.00	2	1
Manganese (mg/l)	0.01	0.00	0.00	0.00	0.1	0.02
Aluminium (mg/l)	0.23	0.01	0.01	0.00	0.2	0.1
Fluoride (mg/l)	0.02	0.00	0.00	0.00	-	-
Sulphide (mg/l)	0.07	0.00	0.04	0.00	-	-
Chromium (mg/l)	4.00	2.05	1.80	0.00	0.05	0.01
Conductivity	1128.00	702.80	859.50	804.50	1000	500-1500
Sulphate (mg/l)	50.00	7.00	27.00	0.00	250	150
Zinc (mg/l)	3.30	0.50	2.40	0.00	5	5
Carbonate (mg/l)	87.40	12.30	17.10	0.00	-	-
Bicarbonate (mg/l)	451.40	134.20	329.40	317.20	100-500	-
Flocculation (PPM)	100.00	45.00	15.00	15.00	-	-
Cholrine residual (mg/l)	73.00	500.00	305.00	0.00	-	-
COD (mg/l)	15.00	0.00	2.00	0.00	-	-
BOD (mg/l)	0.00	0.00	0.00	0.00	12	5
Total Filterable Solids (mg/l)	0.00	0.00	0.00	0.00	-	0.5
Total Non-Filterable Solids (mg/l)	326.90	203.40	247.90	232.40-	-	-

Table 2: Bacteriological Result of the Sample

Sample	A	B	C	D
Growth on Mac conkey Agar at 37˚C incubation for 24 Hours	+	+	+	+
Growth on Eosin Methyle Blue Agar at 37˚C incubation for 24 Hours	-	-	-	-
Growth on Salmonella Shigella Agar at 37˚C incubation for 24 Hours	-	-	+	-

3.2 Discussion

The turbidity levels were also considerably elevated in the well samples, with well A recording 145 FTU and Well B 70 FTU, both exceeding the World Health Organization (WHO) permissible range of 5–25 FTU as shown in Table 1. High turbidity reduces light penetration, promotes microbial growth, and can interfere with disinfection processes, thereby increasing the potential for waterborne diseases such as diarrhea, cholera, and typhoid fever. In contrast, borehole samples exhibited much lower turbidity, indicating better natural filtration through subsurface layers. The pH values (6.0–6.9) were slightly below the recommended range (6.6–8.5), indicating mildly acidic water. Although this does not pose immediate health hazards, it may lead to corrosion of pipes and leaching of metals, especially in the presence of high iron and copper levels.

The total alkalinity levels were exceptionally high in Well A (312 mg/L) and Borehole A (306 mg/L), exceeding the permissible limit of 200 mg/L. Excessive alkalinity can cause an undesirable taste and may lead to gastrointestinal disturbances in sensitive individuals. However, moderate alkalinity contributes to buffering capacity, preventing sudden changes in water pH.

Hardness values and calcium, were within acceptable limits, suggesting that the water is soft to moderately hard. Although such water does not pose any direct health hazard, extremely soft water can be corrosive and may contribute to metal dissolution from plumbing systems. Magnesium hardness and ion levels were within permissible limits, indicating an acceptable mineral balance for domestic use.

The concentration of chloride and sulphate ions in all samples remained below the WHO threshold, signifying low salinity and no risk of laxative effects. Conversely, the high levels of iron and chromium observed in Well A and Well B represent serious contamination concerns. Iron levels (up to 2.85 mg/L) exceeded the standard limit of 0.3 mg/L, while chromium concentrations (up to 4.00 mg/L) were dangerously higher than the permissible limit of 0.05 mg/L. Prolonged consumption of such contaminated water may result in organ damage, carcinogenic effects, and other chronic health complications.

Trace metals such as copper, zinc, aluminum, and manganese were generally within or slightly above the recommended limits. While their concentrations are not immediately harmful, continuous exposure may lead to cumulative toxicity and adverse health effects such as neurological impairment or liver dysfunction. The nitrate and nitrite concentrations were very low across all samples, indicating the absence of significant agricultural or sewage contamination. The chemical characteristics of the analyzed water samples reveal that well waters, particularly Well A, are chemically unsuitable for direct human consumption due to high levels of iron, chromium, and alkalinity. The borehole samples, though of relatively better quality, still require minor treatment and pH adjustment to ensure compliance with international drinking water standards. Effective treatment processes such as aeration, oxidation, filtration, and chemical precipitation are recommended to improve the water's chemical safety for domestic and potable use.

All samples are contaminated with enteric Gram-negative bacteria, though not necessarily *E. coli*. Sample C may contain pathogenic organisms *Salmonella Shigella (SS*) as in Table 2. The absence of Eosin Methyle Blue Agar (EMB) growth but presence on SS agar points toward non-coliform, pathogenic species**.** This pattern is typical of water or environmental samples contaminated by animal or human waste, such as abattoir effluents, fish pond runoff, or sewage discharge.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The work demonstrates that both abattoir and aquaculture effluents significantly affect the physiochemical and bacteriological quality of groundwater in Halleluyah Estate. The physical analysis shows that the well water samples exhibit poor quality in terms of colour, turbidity, and acidity**,** rendering them unsuitable for human consumption without adequate treatment. The chemical characteristics of the analyzed water samples revealed that well waters, particularly Well A, are chemically unsuitable for direct human consumption due to high levels of iron, chromium, and alkalinity. The borehole samples, though of relatively better quality, still require minor treatment and pH adjustment to ensure compliance with international drinking water standards. Effective treatment processes are recommended to improve the water's chemical safety for domestic and potable use. The microbiological analysis revealed that all tested samples showed growth on MacConkey agar, indicating the presence of Gram-negative enteric bacteria, while no growth occurred on Eosin Methylene Blue agar, suggesting the absence of *Escherichia coli (E.Coli)*. However, growth on Salmonella–Shigella agar in one of the samples (Sample C) pointed to the possible presence of pathogenic organisms such as *Salmonella Shigella* species.

These findings demonstrate that the samples are contaminated with enteric microorganisms, most likely of fecal origin. Such contamination poses significant public health risks, including the potential transmission of waterborne diseases such as typhoid fever, dysentery, and gastroenteritis. Continuous exposure to these pathogens can result in serious illness, especially among children, the elderly and immunocompromised individuals.

It is therefore essential to implement proper waste management, regular microbial monitoring, and effective disinfection of water and effluent sources to prevent environmental pollution and safeguard human health

4.2. Recommendations

Due to the results obtained from this research, the following are recommended;

- There should be treatment of abattoir effluent and regulate discharge from fish ponds.
- Wells should be located at least a distance of 100m away from potential pollution sources.
- Residents should be educated on water treatment and hygiene practices.
- Environmental regulations and monitoring of waste management should be strengthened.

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