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Groundwater quality assessment in a major livestock feedlot/abattoir (imowo-eleran) in Ijebu-ode, Ogun state, Southwestern Nigeria

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Abstract

This study assessed the quality of groundwater in Imowo-eleran, a major livestock feedlot/abattoir in Ijebu-Ode, Ogun state, southwestern Nigeria. A total of twelve (12) boreholes, grouped into A, B and C in relation to proximity to the feedlot were assessed using physico-chemical and bacteriological parameters. On-site observation and organoleptic properties of appearance, colour, odour and taste were used to determine the physical assessment while AAS, titration & gravimetry and evaporation to dryness methods were used to determine chemical constituents; the serial dilution technique used in quantifying the total bacterial count, coliform count and faecal streptococcus count with biochemical tests further carried out to characterize the isolated organisms. All the boreholes sampled were clear, colourless, odourless and without taste with mean temperature and pH values ranging between 27-32^{o}C & 7.18–7.56 respectively. The electrical conductivity, Total Dissolved Solids, total alkalinity and hardness values ranged between 30–100µs/cm, 20-70mg/L, 12-24mg/L & 24-38mg/L respectively (all within WHO standards for safe portable water). The mean values obtained in the water samples from groups A, B and C for Sodium, potassium, calcium, Magnesium, Manganese, iron, copper, zinc, nitrate and chloride were all below WHO recommended value. The results of the bacteriological analyses revealed that boreholes from Groups A and B were heavily contaminated with pathogenic bacteria including E. coli, Pseudomonas sp., Bacillus subtilis, Enterobacter sp. Streptococcus faecalis, Klebsiella sp. & faecal streptococcus with Group A having the highest mean bacterial count, coliform and faecal streptococcus counts (7.24±1.19X10^{4}cfu/ml, 3.25±1.00X10^{4}cfu/ml & 2.96±0.06X10^{4}cfu/ml respectively) followed by group B (7.00±0.92X10^{4}cfu/ml, 2.1±0.24 X 10^{4}cfu/ml & 2.5±0.48X10^{4}cfu/ml respectively) while group C had the least (0.47±0.06X10^{4}cfu/ml, zero coliform and faecal counts respectively). No pathogenic bacteria were isolated from samples in group C. Most of the underground water sources in the study area are biologically contaminated and are thus unfit for human consumption.

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Introduction

Groundwater consists of all water found beneath the earth's surfaces the water body is primarily derived from percolation and contained in permeable rock formation known as aquifer. Groundwater accounts for about 20 times more than the total of surface waters on continents and Island (Encarta, 2005)

For community water supply systems, groundwater is almost always the preferred source, surface water source are very likely to be contaminated and much more subject to seasonal fluctuation. Groundwater withdrawals often can be continued long after drought conditions have depleted rivers and streams. Use of groundwater for community water supply is probably still very much below its potential in many countries (Badmus *et al.,* 2001).

The suitability of groundwater as a resource for drinking, irrigation and industrial purpose depends upon its quality, change in groundwater quality are due to variation in climatic conditions; residence time of water with a aquifer materials and inputs from soil during percolation of water (Krishnakumar *et al.,* 2009; Mitra *et al.,* 2005).

According to Egwari and Aboaba (2002), natural process and anthropogenic activities of man can contaminate groundwater, and such activities of man could be domestic, agricultural or industrial in nature. Livestock production is considered a potential food for the world's needy people. It however, becomes a major pollutant of the country site and cities, when the slaughter wastes are not properly managed, and especially, discharged into waterways, as such practices can introduce enteric pathogens and excess nutrients into surface water (Alonge, 1991; Meadows, 1995).

The slaughtering of animals for community consumption is inevitable in most nations of the world and dated back to antiquity. Public abattoir had been traced to the 15th and 16th centuries, in Rome and France, where slaughter houses were among the public facilities provided by the State. In Italy, a law of 1890 required that public abattoirs be provided in all communities of more than six thousand inhabitants. Similar reports in Norway, Sweden, Denmark, Netherlands and Romania in the late 18th century (Jode *et al.,* 1906). In Nigeria, nearly every town and neighbourhood is provided with a slaughter house or slaughter slab. But, one type of wastes that is of great concern in both urban and rural areas in Nigeria is livestock feedlot and abattoir wastes. Almost everyday in all the urban and rural markets in Nigeria, animals are slaughtered and the meat sold to the public for consumption. Meat wastes originate from killing; hide removal or dehairing, paunch handling, rendering, trimming, processing and clean-up operations. Therefore, abattoir wastes often contain blood, fat, organic and inorganic solids, and salts and chemicals added during processing operations (Loehr, 1974; Environmental Sustainability Resource Centre (ESRC), 2011).

The wastes from livestock feedlot and abattoir operations which are often separated into solid, liquid and fats could be highly organic. The solid part of the wastes consists of condensed animal faeces, paunch, manure, meat, undigested ingest, bones, hairs, and aborted foetuses. The liquid aspect on the other hand consists of dissolved solids, blood, guts contents, urine, and water, while fat waste consists of fat and oil. The pollution of water resources often results in the destruction of primary producers, which in turn leads to an immediate diminishing impact on fish yields, with the resultant consequence of decrease in diet (Aina and Adedipe, 1991).

Robert (2005) submitted that the disposal of these waste products is a problem that has always dominated the slaughter sector, and on the average, 45 per cent of each live beef animal, 53 per cent of each sheep, and 34 per cent of each pig consist of non-meat substances. The characteristics of slaughter house wastes and effluents vary from day to day depending on the number, types of stock being processed, and the processing method (Tove, 1985).

Uncontrolled discharge of toxic effluents to the soil, stream and rivers by industries and indiscriminate dumping of garbage and faeces have been reported to heavily contaminate groundwater in Nigeria. Like any other abattoir elsewhere, Imowo-eleran feedlot/abattoir produces different type of waste ranging from air emission, liquid waste and solid waste, if these wastes are not properly disposed and maintained, they constitute nuisance, offensive odour, degrade the environment and pose risk to the water resources both surface and groundwater and no long run these water sources get polluted and become crucial issue for public health.

However, since water is often used to wash excessive waste solids to drain, the method used in handling, treatment and disposal of abattoir waste should be put into consideration, as waste dumped in the open environment, storm drainage channels, creeks, lagoons and other impoundment points which could cause serious environmental pollutions and hazards which in most cases adversely affects the air, water and probably the soil conditions and it also constitutes public nuisance (Akinro *et al.,* 2009).

Sangodoyin and Agbawhe (1992) also reported that the ground water quality in vicinity of the abattoir were adversely affected by seepage of abattoir effluent as well as water quality of receiving stream that was located away from the abattoir. Also, Chukwu *et al.* (2011) reported that abattoir operation produce a characteristics highly organic waste with relatively high level of suspended solid, liquid and fat. The solid waste includes condemned meat, undigested food, bones, horns, hairs and aborted fetus. The liquid wastes usually comprise of dissolved solid, blood, gut contents, urine and wash water.

The physico-chemical and microbiological analysis of surface and groundwater are important towards a meaningful impact assessment of domestic and industrial activities on these water bodies. As far as public health is concerned, the most important aspect of drinking water quality is the microbiological quality i.e., the presence of bacteria and viruses. It is not practical to test water for all organisms that it might possible contain instead the water is examined for a specific type of bacteria that originates in large number in human and animal excreta, and its presence is indicative of faecal contamination, faecal or thermo tolerant coliform multiplies in the human guts and can be detected relatively easily by culturing. Consequently, they are most widely used bacteriological indicator. Another somewhat less commonly used indicator organisms is faecal streptococci. When these bacteria are found in water it indicates fairly fresh contamination and the need for disinfection. Faecal bacteria are likely to be found in almost all small community water supply system. It would be excessive to condemn all supplies that contain some contamination, especially when alternatives may be even more polluted rather microbiological testing of the water determines the optimum sources can be than be chosen (Nwanta *et al.,* 2011).

Imowo-Eleran livestock feedlot and its environs, Ijebu-ode, Ogun State. Imowo-Eleran is one of the largest livestock feedlot in Ogun state, Nigeria and by far the largest in Ijebu-land in the state serving at least six cities as a major sale point of livestock and livestock products including meats, fresh dairy-milk, cheese, manure, etc. Owing to the continuous economic activities associated with the feedlot, the study area is fast becoming very densely populated with houses almost surrounding the area. This among other things informs the choice and suitability of the area for the purpose of this study.

Basically, the physico-chemical and bacteriological characteristics of groundwater source used in the feedlots and the households surrounding the study area were examined; laboratory analyses of water samples from the sources being used in the study area were carried out in order to know the effects of pollution generated by the animal wastes on the water sources, and to proffer reasonable solution to any problem found.

Materials and methods

The research entailed both the field and laboratory components. The geologic field mapping was done by traversing using the Global Positioning System (GPS) to locate the sampling points on the map. Other field instruments relevant to the sedimentary terrain mapping were employed. The fieldwork involved two stages namely:

* Reconnaissance survey

* Detailed mapping

Reconnaissance Survey

This is the preliminary investigation of the study area which commenced on February, 2013. The survey involved the terrain familiarization process. The study area falls under the sedimentary terrain thus depressions; road cuts, etc are major features to look out for during the survey.

Information about the locality was obtained from the indigenes of the community to locate geographical features such as school, churches, residential etc in order to update the topographical map of the area.

The study area, Imowo-Eleran, Ijebu-Ode, Ogun State is in the sub-humid tropical region of Southwestern Nigeria and it lies between latitude 6°49'N - 6°82'N and longitude 3°55'E - 3°92'E. Its geographical location is easily accessible from Sagamu/Lagos State and covers an area of 192km². It has population of about 222,653 projected from 2007 census. Geologically, the topsoil of the site consists of coastal plain sands. Beneath the tertiary deposits are sedimentary rocks from the cretaceous period. These rocks are mainly made up of shales, sandstone and limestone (Omatsola and Adegoke, 1980).

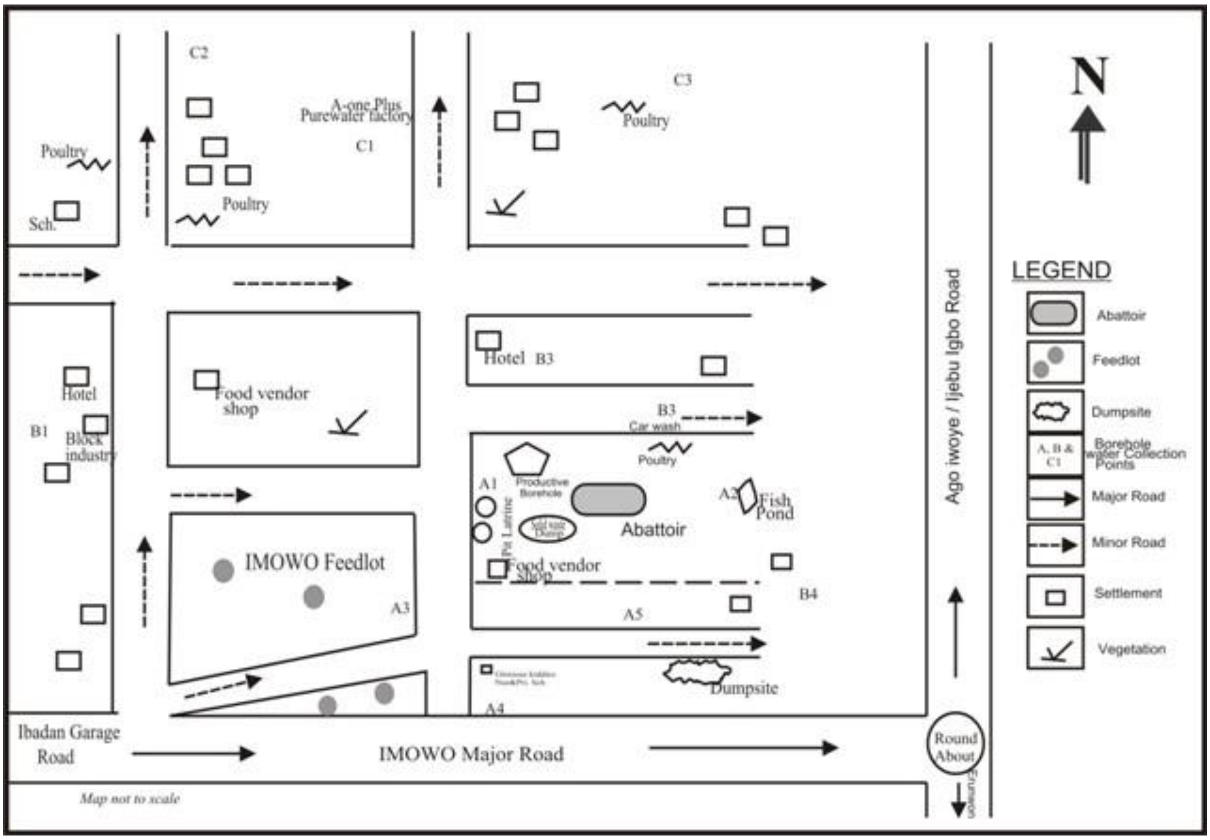

Fig. 1. Sketch Map of the Study Area

On-site Observation

This involved the assessment of the immediate surroundings of the water source from man and animal activities within the vicinity of the boreholes assessed. Observations included examination of the plinths to ascertain if they are cracked, eroded or watertight, observation for signs of water accumulation close to the borehole tap stand, identification of activities such as washing of cloths, urination, brushing of teeth, slaughtering and washing of slaughtered animals, within 5 meter radius of the borehole facility, with potential to affect water quality. Others were assessment of activities of animals e.g. cows, goats, rams and dogs around the borehole facility, assessment of closeness of the borehole to dung, septic tanks, sewers or waste dumps. In addition to these, organoleptic properties such appearance, odour and taste were assessed according to Alonge (1991).

Detailed mapping

This was carried out on a much larger scale on March, 2013. A detailed map of study area was produced showing the different locations where the Water samples were collected and other features (Fig. 1).

Sampling technique and sample collection

Random sampling technique was employed in this study. A total of twelve (12) boreholes were sampled during this study. Five (5) of the wells were sited in the ground of the feedlot/abattoir (Group A), four (4) were about 40 – 100m away from the feedlot (Group B) and three (3) were in a residential area more than 500m away from the feedlot (Group C) (Plates 1 – 4). The samples were collected, after the extracted of water from the boreholes water was left to run from the source for about 4 min to equate the minimum number of well volume and to stabilize the electrical conductivity (EC), into clean 750ml plastic containers. The containers were first rinsed with some of the water from the tap of individual borehole at point of collection before adequately filled with the water samples. Then the containers were sealed with tight fitting corks and appropriately labeled.

Plate 1. Imowo-Eleran Feedlot (Cattle Stand 1)

Plate 2. Imowo-Eleran Feedlot (Cattle Stand 2)

Plate 3. Butchers skinning the carcass of cattle on the dirty and bare floor

Plate 4. Manure mixed with blood swept into an open drainage from the slaughter hall.

The Physico – Chemical Assessment of Samples

The samples collected were analyzed for pH, Conductivity, Colour, Turbidity, Total Dissolved Solid, Total Hardness, Total alkalinity, calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}), Manganese (Mn^{2+}), iron (Fe^{2+}), copper (Cu^{2+}), lead (Pb^{2+}) and zinc (Zn^{2+}), chloride (Cl^{-}), and nitrate (NO_3^{-}). The physico-chemical analysis of water samples were carried out at the Analytical services laboratories of the International Institute for Tropical Agriculture (IITA) Ibadan, Nigeria following standard methods. Measurement of the temperature of the samples was carried out *in-situ* at the site of sample collection using a mobile thermometer. This was done by dipping the thermometer into the samples and recording the stable reading. pH and Turbidity meters were used to determine the pH and Turbidity of the water samples.

Microbiological Analysis

The method of Cheesbrough (2000) described by Oparaocha *et al.* (2010) was adopted for this analysis. All media, chemicals and reagents used were prepared according to manufacturer's specifications. The culture media used were sterilized using an autoclave at 121°C for 15 minutes, while Petri-dishes, pipettes and other glass wares were sterilized in a hot air oven at 160°C for 1 hour (American Public Health Association (APHA), 2005). The standard plate count method was used for the analysis. In this method, serial doubling dilutions of the respective water samples were made as follows: A row of sterile bottles containing 90ml of peptone water, labeled 1-5, was set up for each water sample. Ten (10ml) volume of each test sample was added to the first bottles on each row containing 90ml of diluents, to give 1:10 dilution. This was thoroughly mixed, and 10ml volume was transferred from the first bottle on the same row to the second bottle (1:100). This process was carried out up to the fifth bottle and for the respective samples using different sterile pipettes for each sample (1:10; 1:100; 1:1000; 1:10000 and 1:100,000). Thereafter, 0.1ml of each diluted sample was inoculated in duplicates unto already sterile solidified nutrient and MacConkey agar using a fresh sterile 1ml pipette for each dilution. Using a sterile glass spreader, the inoculum was spread on the surface of the solid agar medium. The inoculated plates were incubated, some at 37°C for 24 hours for the growth of faecal coliforms while some plates were incubated at 22°C for 24 hours for saprophytic coliforms. The viable organisms were counted using the electronic colony counter after incubation. Cultural and morphological characteristics of the isolates were recorded. The colonies were further purified by inoculating them onto fresh sterile nutrient and MacConkey for use in biochemical identification of the species. The Colony Forming Unit (CFU/ml) was calculated for each sample from the lowest concentration that showed viable growth. Finally microscopy and various biochemical tests were carried out for the identification of each isolate.

Statistical Data Analysis

All the experiments were carried out in triplicates and the results were found reproducible within ± 3% error. The data were statistically analyzed by setting up and calculating mean (X±S.E.M), correlation matrix and ANOVA for the various parameters using Statistical Package for Social Sciences (SPSS) software package (Norusis and SPSS Inc, 1997).

Results

On-site Observation

The result of the on-site observation and organoleptic properties of the water samples and physical survey of the environment of the boreholes sampled is presented in Table 1. Organoleptic assessment of colour, odour and taste of the water samples showed that all the borehole water samples were clear, without odour and taste. Observations revealed the presence of conditions and activities that could affect the quality of the water supplies particularly from the boreholes. The surroundings of the boreholes (except for a few boreholes) were generally dirty with stagnant water at the site (Plates 2 &3).

Table 1. Organoleptic Property and Physical Assessment of the environment of sampled boreholes

Sample water Sources	Organoleptic Properties of water samples			Observed Physical environment of the boreholes						
	Appearance	Odour	Taste	Physical Environmental appearance	Standing water at site	Washing activity (within site)	Animal activity (within site)	Proximity to Abattoir	Proximity to septic tank	Proximity to refuse dump
Group A	Clear	Odourless	Tasteless	Very dirty and highly polluted	Yes	Yes	Yes and very pronounced	<20m	< 30m to pit latrine	<10m
Group B	Clear	Odourless	Tasteless	Dirty	Yes	Yes	Yes	<40m	< 60m	<20m
Group C	Clear	Odourless	Tasteless	Moderately Dirty	Yes	Yes	No	Far	Far	Far

Physico – Chemical Assessment

The physicochemical parameters are presented in Tables 2 and Table 3. The temperatures recorded at the point of collection for all the water samples ranged between 27°C to 32°C, with a mean of 29.6°C, 27.5 °C and 29.0 °C for samples in groups A, B and C respectively depending on the environmental condition at the time of collection. The pH range of the samples in groups A, B and C was 7.18 – 7.56 with a mean of 7.35, 7.31 and 7.29 respectively. All the water samples had zero units both for colour and turbidity measurements. However the electrical conductivity (EC) and Total Dissolved Solids (TDS) measured parameters of the samples ranged between 30 and 100µs/cm (with mean EC values of 77.5µs/cm, 66.67µs/cm and 40µs/cm for Groups A, B and C respectively), and 20 and 70mg/L (with respective mean TDS values of 52.50mg/L, 43.33mg/L and 27.50mg/L for Groups A, B and C) respectively. The result further shows that the water samples had total alkalinity and total hardness values ranging between 12 - 24mg/L and 24 - 38mg/L respectively, with the groups (i.e. group A, B and C) having respective mean values of 22.00mg/L, 16.67mg/L and 15.00mg/L for total alkalinity and 31.00mg/L, 28.67mg/L and 23.00mg/L for total hardness.

Table 2. Temperature, pH, Colour, Turbidity, Conductivity, Total Dissolved Solids (TDS) Alkalinity, and Total Hardness of Borehole water used in Imowo- Eleran feedlot and its environs

Parameters	Distance from the feedlot (m)			Standards
	Group A (within the feedlot)	Group B (40-80m to the feedlot)	Group C (>500m away from the feedlot)	WHO (2006a)
Temp (°C)	29.60	27.50	29.00	-
Colour (Pt/Co Units) Raw	0.00±0.00	0.00±0.00	0.00±0.00	-
pH	7.35±0.07	7.31±0.06	7.29±0.03	6.5-8.5
Turbidity (NTU)	0.00±0.00	0.00±0.00	0.00±0.00	0.1
Conductivity (µS/cm)	77.5±11.08[a]	66.67±3.33[a]	40.00±10.00[a]	1200
TDS (mg/L)	52.50±7.77[a]	43.33±1.67	27.5±7.50[a]	1000
Alkalinity (mg/L $CaCO_3$) (methyl orange)	22.00±1.15[a]	16.67±4.67	15.00±1.00[a]	120
Hardness	31.00±2.52	28.67±4.67	23.00±3.00	500

Values are expressed as mean ± S.E.M. of three determinations.
Mean values with same letter are significantly different at (P<0.05).

Table 3. Metallic ion and Non-metallic ion levels in Borehole water used in Imowo- Eleran feedlot and its environs

Parameters	Distance from the feedlot (m)			Standard
	Group A (within the feedlot)	Group B (40-80m to the feedlot)	Group C (>500m away from the feedlot)	WHO (2006a)
Na^{+}	1.03±0.11	0.76±0.09	0.53±0.09	200
K^{+}	2.56±0.44[a]	0.92±0.30[a]	0.16±0.0[a]	200
Ca^{2+}	9.04±2.10[a]	3.55±0.41[a]	1.05±0.02[a]	100
Mg^{2+}	1.16±0.11	0.94±0.04[a]	0.10±0.02[a]	150
Mn^{2+}	0.01±0.00	0.01±0.00	0.01±0.00	0.5
Fe^{2+}	0.02±0.01	0.01±0.00	0.01±0.00	0.3
Cu^{2+}	0.02±0.01	0.00±0.00	0.02±0.02	1
Zn^{2+}	0.003±0.003	0.01±0.01	0.01±0.01	30
Pb^{2+}	0.05±0.00	0.05±0.00	N.D	0.05
NO_3^{2-}	3.64±0.28[a]	2.49±0.06	1.20±0.63[a]	10
Cl^{-}	8.62±1.23	7.64±0.53[a]	4.52±1.24[a]	250

Values are expressed as mean ± S.E.M. of three determinations.
Mean values with same letter are significantly different at ($P<0.05$).

The chemical analysis to ascertain the presence and levels of some metals and non-metals in the water samples (Table 3) showed that the concentration of Na^{+} in all the water samples ranged between 0.44 and 1.21mg/L with mean concentrations of 1.03±0.11mg/L, 0.76±0.09mg/L and 0.53±0.09mg/L for groups A, B and C respectively. K^{+} concentrations ranged between 0.09 and 3.08mg/L with mean concentrations of 2.56±0.44mg/L, 0.92±0.30mg/L and 0.16±0.07mg/L for groups A, B and C respectively. Also Ca^{2+} concentration ranged between 1.03mg/L and 12.90mg/L (with mean concentrations of 9.04±2.10mg/L, 3.55±0.11mg/L and 1.05±0.02mg/L for groups A, B and C respectively) and Mg^{2+} concentration ranging between 0.08mg/L and 1.42mg/L (with respective mean concentrations of 1.16±0.11mg/L, 0.94±0.04mg/L and 0.10±0.02mg/L for groups A, B and C). However, Mn^{2+} and Pb^{2+} exists at equal concentrations of <0.01mg/L and 0.05mg/L respectively in all the samples. Fe^{2+} ranged between 0.01mg/L and 0.05mg/L with mean concentrations of 0.02±0.01mg/L, 0.01±0.00mg/L and 0.01±0.00mg/L for groups A, B and C respectively. While Cu^{2+} and Zn^{2+} had concentrations ranging between N.D to 0.03mg/L and N.D to 0.02mg/L respectively, NO_3^{2-} and Cl- had concentrations ranging between 0.57mg/L and 4.36mg/L (with mean concentrations of 3.64±0.28mg/L, 2.49±0.06mg/L and 1.20±0.63mg/L for groups A, B and C respectively) and between 3.28mg/L and 9.85mg/L (with respective average concentrations of 8.62±1.23mg/L, 7.64±0.53mg/L and 4.52±1.24mg/L for groups A, B and C) respectively (table 3). These results show pattern of dominance of all the physico-chemical parameters in relation to the sampling points/location to be Group A > Group B > Group C.

Correlation matrix of all the physico-chemical parameters carried out to obtain positive and negative Pearson correlation coefficients among the parameters is presented in Table 4. The result showed that the parameters influenced each other. For instance, significant coefficients ($p \le 0.05$) were obtained between pH and K^{+} ($r = +1.00$), pH and Ca^{2+} ($r=+1.00$), Conductivity and Cl^{-} ($r = +0.999$).

Table 4. Correlation Matrix of the Physico-Chemical Parameters of all Water Samples from Imowo-Eleran

	pH	EC	TDS	Alkalinity	Hardness	Na	K	Ca	Mg	Mn	Fe	Cu	Zn	Pb	NO3	Cl
pH	1															
EC	0.909	1														
TDS	0.942	0.996	1													
Alkalinity	0.995	0.862	0.902	1												
Hardness	0.91	1.000	0.996	0.863	1											
Na	0.99	0.96	0.98	0.97	0.96	1										
K	1.000*	0.901	0.935	0.996	0.903	0.987	1									
Ca	1.000*	0.9	0.934	0.997	0.901	0.986	1.000	1								
Mg	0.87	0.996	0.985	0.815	0.996	0.932	0.861	0.859	1							
Mn	.a	.a	.a	.a	.a	.a	.a	.a	.a	.a						
Fe	0.945	0.723	0.78	0.974	0.725	0.888	0.951	0.952	0.661	.a	1					
Cu	0.189	-0.237	-0.152	0.289	-0.234	0.046	0.207	0.211	-0.32	.a	0.5	1				
Zn	-0.945	-0.723	-0.78	-0.974	-0.725	-0.888	-0.951	-0.952	-0.661	.a	-1.000	-0.5	1			
Pb	.a	.a	.a	.a	.a	.a	.a	.a	.a	.a	.a	.a	.a	.a		
NO3	0.975	0.979	0.993	0.947	0.979	0.997	0.971	0.97	0.958	.a	0.849	-0.033	-0.849	.a	1	
Cl	0.886	.999*	0.99	0.833	.998	0.943	0.877	0.875	.999*	.a	0.685	-0.289	-0.685	.a	0.966	1

*. Correlation is significant at the 0.05 level (2-tailed).
a. Cannot be computed because at least one of the variables is constant.

Microbiological Analysis

The results of the microbiological analyses are presented in Tables 5 and 6. The quantitative microbial analysis of almost all the borehole sampled (Table 5) revealed that all the samples contain significant amount of bacteria in them when compared with the WHO (2006a) standards for drinking water. The mean Bacteria counts in X 10^4 CFU/ml obtained were 7.24±1.19, 7.00±0.9, 0.47±0.06 for Groups A, B and C respectively. Mean Coliform counts (also in X 10^4 CFU/ml) gave values of 3.25±1.00, 2.1±0.24 and none (i.e. below detection limit) for groups A, B and C respectively. The same trend was observed with the faecal streptococcus counts with mean values (in X 10^4 CFU/ml) of 2.96±0.06, 2.5±0.48 and none obtained for Groups A, B and C respectively.

The qualitative microbial analysis revealed the presence of certain pathogenic organisms most of which are of faecal origin in some of the sampled boreholes. In Group A samples (boreholes within the livestock feedlot/Abbattoir), *Escherichia coli, Pseudomonas sp., Bacillus subtilis, Enterobacter sp.* and *Streptococcus faecalis* were isolated; in Group B (40 – 100m from the feedlot), *Escherichia coli, Streptococcus faecalis* and *Klebsiella sp.* were found the water samples and there was no pathogenic organism detected in Group C (>500m away from the feedlot). This thus showed that all the samples from Group A and B were polluted with pathogenic bacteria which of significant health implication.

Table 5. Mean Bacterial, Coliform and Faecal Streptococcus Counts (CFU/ml) of the Boreholes Sampled at Imowo-Eleran, Ijebu-Ode

Samples	Bacteria Count (X 10^4)	Coliform Count (X 10^4)	Faecal Streptococcus Count (X 10^4)
Group A (within the feedlot)	7.24±1.19[a]	3.25±1.00[a]	2.96±0.06[a]
Group B (40 – 100m from the feedlot)	7.00±0.92[a]	2.1±0.24	2.5±0.48[a]
Group C (>500m away from the feedlot)	0.47±0.06[a]	NONE	NONE
WHO[22] standard	<0.001	NONE	NONE

Values are expressed as mean ± S.E.M. of three determinations (triplicates).
Mean values with same letter are significantly different at (P<0.05).

Table 6. Pathogenic Organisms isolated from the borehole samples

SAMPLES	Organism
Group A (within the feedlot)	*Escherichia coli, Pseudomonas sp., Bacillus subtilis, Enterobacter sp. Streptococcus faecalis*
Group B (40 – 100m from the feedlot)	*Escherichia coli, Streptococcus faecalis Klebsiella sp.*
Group C (>500m away from the feedlot)	NONE

Discussion

Safe water has been described as water that meets the National Standard for Drinking Water Quality for Nigeria (2004). Access to safe drinking water is a prerequisite to poverty reduction and that access to safe drinking water prevents the spread of water-borne and sanitation-related diseases; however a large proportion of Nigerians still lack access to safe clean water. In Nigeria, 52% of the population does not have access to safe drinking water. Lack of access to safe water and adequate sanitation services especially in developing countries often results in the death of about two million infants annually (UNICEF, 2005; Cosgrove and Rijsberman, 2000; Gomez and Nakat. 2002).

The acceptability and use of potable water for recreational and other domestic needs are influenced by physicochemical parameters such as pH, total dissolved solids and conductivity. Inorganic minerals however constitute the greatest source of raw water contaminants, of which mineral salts are introduced as water moves over the soil structure (Nwodo *et al.,* 2011). A major factor affecting water quality is socio-economic activities arising from rapid industrialization and urbanization (Ubalua and Ezeronye, 2005). Improper waste management techniques and poor sanitation practice characteristic of many livestock farms in Nigeria that results in massive discharge of animal wastes into rivers and erosion courses further pose very serious threat to water quality (Orheruata and Omoyakhi, 2008). For instance, trace metals gain access into rivers possibly through anthropogenic and natural sources. These trace metals can be accommodated in three basic reservoirs: water, biota and sediments Florea and Busselberg, 2006; Hung and Hsu, 2004). Some trace metals are potentially toxic because they act on the cell membrane or interfere with cytoplasmic or nuclear functions after entry into the cell. Hence, their accumulation in the human body could result to malfunctioning of organs (Jarup, 2003). At high concentrations, they cause acute systemic poisons. Also, the use of raw water with high salts result to nauseous, saline taste with purgative tendency and dehydration. Of great concern are salts containing nitrates and nitrites. These are known to cause methaemoglobinemia in children (Fecham, 1986; Burtkart and Kolpin, 1993; Groen *et al.,* 1988).

From the results obtained, the groundwater is clear, tasteless and odourless. This is expected as the water samples are from deep wells and agrees with the findings of Adeyemo *et al* (2002) and Adekunle *et al* (2007). The temperature regime of the groundwater is virtually constant and ranged between 27.5^{o}C and 29.6^{o}C. Although this largely depends on the environmental conditions at the time of collection, but according Awofolu *et al* (2007) ^{water} temperature may affect the chemistry of the groundwater as well as metals toxicity. pH values of the well samples are in the normal range of the WHO (2006a) standards in drinking water of 6.50 – 8.50. This result compares well with the findings of Adeyemo *et al* (2002) on the water quality and sanitary conditions in a major abattoir (Bodija) in Ibadan, Nigeria. Turbidity which stems from the reduction of transparency due to the presence of particulate maters such as clay, silt, finely divided organic matter, plankton or other microscopic organisms in water (Adekunle *et al.*, 2007), in the studied groundwater samples is zero corroborating the observations earlier reported of the organoleptic properties of the samples. Electrical Conductivity (EC) indicates the presence of dissolved solids and contaminants especially electrolytes but does not give information about specific chemical. Most drinking waters have conductivity measurement below 2000 µS/cm but the WHO recommended value is ≈250 µS/cm. Conductivity increases as the concentrations of ions in water sample increases. The conductivity levels of the groundwater samples from wells studied were all less than 200µS/cm. This result serve as an indication of the total dissolved solid (TDS) content of the water samples in some cases (Orheruata and Omoyakhi, 2008). The total concentration of dissolved solids (TDS) in water, which is a general indication of its suitability for any particular purpose (Omofonmwan and Eseigbe, 2009) [39], obtained from the analyzed water samples falls within the WHO (2006a) standards for drinking water of <500mg/L (Table. 2). The total alkalinity value of water is expressed as the acid neutralizing ability of the water and is determined by how much carbonate, bicarbonate and hydroxide is present. Excess alkalinity results to a distinct flat and unpleasant taste, scale formation (Orewole *et al.,* 2007). From Table 2 the alkalinity of the groundwater samples ranged between (15.00±1.00 – 22.00±1.15 mg/L) and it falls within the WHO specifications (of 120mg/L) allowed for domestic and recreational purposes of water. Hard water is water with high mineral content mostly calcium (which occurs in the form of calcium carbonate ($CaCO_3$)), and magnesium ions. As presented in Table 2 above, the total hardness in the groundwater ranged between 23.00±3.00 – 31.00±2.52mg/L and falls below the WHO recommended standard for portable water. This implies that the sampled groundwater can be described as soft (Environment Canada, 1979).

From Table 3, Sodium and potassium concentrations ranged between 0.53±0.09 – 1.03±0.11mg/L and 0.16±0.07 – 2.56±0.44mg/L respectively and are both within WHO permissible limits for portable water. Although the presence of these metals has no recorded health effects on humans, but our results negates the observation of (Adediji and Ajibade, 2005) that the concentration of K should normally be around one-tenth of sodium concentration and less than 10.0 mg/L for potable groundwater. This may however be due to certain factors, part of which is the underground geological formations peculiar to the terrain of the study area, the prevalent anthropogenic activities in the area among many other factors.

Calcium concentration (ranging between 1.05±0.09 – 9.04±2.10mg/L) is within the 10-100 mg/L WHO permissible concentration in potable groundwater (Adediji and Ajibade, 2005; Walker, 1973). Calcium has no health effects on human. Magnesium concentrations in the sampled borehole water also fall within 1.0-40 mg/L normal range values in potable groundwater (Adediji and Ajibade, 2005). Mean concentrations are within the WHO limits permitted in potable water.

Except for the mean value of lead (Pb) (0.05±0.00 mg/ L) observed in all the borehole water samples (Table 3), the rest metal concentrations i.e. Manganese, Iron, copper, zinc fall bellow their respective WHO standards. Pb has being classified as potentially hazardous and toxic to most forms of life (USEPA, 2004). It also causes a number of ailments in humans such as chronic neurological disorders in fetuses and children.

Nitrate and Chloride mean concentrations are within the WHO minimum permissible limits of 10 and 250 mg/L respectively. High chloride concentration in groundwater may indicate pollutions by sewage, industrial wastes or saline water intrusions (Bertram and Balance, 1998). Both chloride and nitrate (within permissible limits) have no health implication on human but at high concentrations chloride could impart taste in water while nitrate could cause methemoglobinemia to growing infants. The symptoms of methemoglobinemia are paleness, bluish mucous membranes, digestive and respiratory problems (McCasland *et al.,* 2007).

Although, the obtained values of all the parameters were lower than WHO standards for drinking water, however, a comparative evaluation of boreholes on and near the feedlot/abattoir (Group A and B) and those far from it i.e. residential area of Imowo-eleran (Group C) revealed that all the parameters follow the trend Group A > Group B > Group C in measurements/concentrations (Table 2 and 3). This could be attributed to the activities going on around the areas (livestock feedlot, abattoir, dumpsite pile, manure pile etc) which are notable pollution sources for groundwater depending the porosity of the underlying formation/terrain.

The positive significant correlation obtained between some of the parameters (table 4) indicated that the presence of one of the parameters positively influence the other. For instance the pH values obtained is influenced to a significant degree by the presence of potassium and calcium salts in the water samples. Both metals produce acidic salts with weak tetraoxosulphate IV acid which have tendency of reducing the pH of a solution[47]. Also metallic chloride salts in water readily form mobile ion of Cl^- and can affect significantly electrical conductivity of water (Ababio, 2008; Orebiyi *et al.,* 2010; Adegbola. and Adewoye, 2012; Adekunle *et al.,* 2007). This explains the observed positive correlation between EC and Cl^- (Table 4).

An important indicator of water quality is the number of bacteria present in the water. Though it would be difficult to determine the presence of all bacteria in a sample, certain types of microorganisms can serve as indicators of pollution (Adegbola. and Adewoye, 2012; Oparaocha *et al.,* 2010). Chief among these are the coliform bacteria which survive better, longer and are easier to detect than other pathogens (Kegley and Andrew, 1998; Agunwamba, 2000). The concept of coliforms as bacterial indicator of microbial water quality is based on the premise that coliforms are present in high numbers in the faeces of humans and other warm-blooded animals. If faecal pollution has enters in groundwater; it is likely that these bacteria will be present, even after significant dilution (Mor *et al.,* 2005). From the results, the mean values of bacteria count in all the samples were significantly high when compared with the WHO standards. The World Health Organization has recommended a zero value of bacteria and total coliform count in drinking water. Also, the significantly high mean values of total coliform and streptococcus counts in samples from sites A and B is an indication of heavy pollution with pathogenic organisms of the groundwater which possibly due to leachate (generated from the animal wastes of the livestock feedlot/abattoir) percolation into the groundwater (Burtkart and Kolpin, 1993). The presence of this faecal contamination is indicates that a potential health risk exists for individual exposed to this water.

Among the pathogenic bacteria isolated in this study was *Escherichia coli. E. coli* is regarded as the most sensitive indicator of faecal pollution. Its presence in the borehole water samples is of a major health concern and calls for remedial attention (CDC, 1997). The presence of this pathogen in the samples was an indication of the likely presence of other enteric pathogens (Petridis *et al.,* 2002). Other important pathogens identified in the samples included *Streptococcus faecalis*, *Pseudomonas sp., Bacillus subtilis, Enterobacter sp.* and *Enterobacter sp*. These organisms have been variously implicated in gastro-intestinal disorders and other significant water-borne diseases (Nwidu *et al.,* 2008; WHO, 2006b). The Group C water samples were found to be free from all pathogens indicating a very high microbial quality.

Conclusion and Acknowledgements

Although, the physico-chemical analyses results obtained for all the borehole water samples in the study area were lower than permissible limits recommended by WHO (2006a) for drinking water indicating that the livestock wastes generated from the feedlot little had no effect on physicochemical properties of the groundwater, but the high values of the bacteriological parameters obtained (bacteria, total coliform and faecal streptococcus counts) are an indication of heavy pathogenic bacteria contamination of almost all the underground water sources in the study area. This thus renders the water in this area unfit, either for human consumption or for any other food-related purpose(s). It is recommended that concerned environmental protection agencies at any levels of the government to enforce effective waste management laws and policies on the operators of this feedlot/abattoir and monitor strict compliance to them so as to safeguard the safety and health of the residents, preferably the feedlot/abattoir should be move far away from residential premises.

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