International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 29 No. 3 Jun. 2020, pp. 821-830
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http://www.ijias.issr-journals.org/

Environmental Impact of Abattoir Effluents Discharge on the Quality of Well Water in Abakpa, Enugu State-Nigeria

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ABSTRACT: Studies were carried out to evaluate the environmental impact of abattoir effluents discharge on the quality of well water in Abakpa, Enugu State-Nigeria using standard analytical procedures and instrumentation. The samples were collected and the physiochemical parameters were analyzed using standard techniques. The heavy metals analyzed in the water samples involved wet digestion and aspiration of the digest onto the spectrophotometer for the determination of the concentration of the studied metals.

The mean range of values for samples S_1, S_2, S_3, and control were 6.64-7.07, 3.03-6.26NTU, 71.02-117.32, μ5/cm and 116.29-200.61mg/l, 41.04-53.08mg/l, 1.04-2.88mg/l and 22.14-29.12 mg/l for pH, turbidity, electrical conductivity, total dissolved solids, chloride ions, biological oxygen demand and nitrate ions respectively.

The mean range of values for the heavy metals analyzed in the water samples were 2.14-12.31, 0.38-1.59, 1.03-2.81, 0.06-0.26 and 0.003-0.008µg/g for Zn, Cu, Fe, Pb and As respectively.

Sampling points S_1 and S_2 consistently exhibited higher values for all the studied physiochemical parameters and heavy metals than other sampling points (S_3 and control). Of all the studied physicochemical parameters and heavy metals, only turbidity and Zn in sampling point S_1 and Pb in sampling points S_1 and S_2 exceeded the recommended permissible limits for a safe drinking water. The study reveals that the proximity of sampling points S_1 and S_2 to the abattoir, where effluent discharge occurs, could have been the reason for the higher values they exhibited for all the studied parameters than the other sampling points (S_3 and control). The levels of the studied physicochemical parameters and heavy metals in samples S_1, S_2, S_3 and control were statistically significant. The study therefore recommends that environmental health agencies should ensure that future sitting of abattoir around residential areas are prohibited and those still operational are strictly supervised to ensure that they operate within standard sanitary guidelines in order to protect the health of the people from water and food borne illnesses.

KEYWORDS: Abattoir effluents, Heavy metals, Physicochemical parameters, Well water, and Pollution.

1 INTRODUCTION

Water is the most important natural resources very central to man's existence. Without it nothing would survive on the earth. Water can be gotten everywhere but safe and clean water are hard to come by in many countries of the world [1].

Water performs three role of transporting body nutrients to other vital organs, regulating the body temperature as well as carrying waste out of the internal organs of the body and is second only to air in its importance on and uses (2) Ground water is the commonest potable water source around the world and its chemical composition is an indicator of how suitable it is for consumption by human beings, animals and plants [3].

Ground water is characterized by adequate aquifer protection, excellent microbial and chemical quality and therefore requires minimal or no treatment in a less anthropogenic active environment.

The quality of water is essential for existence and also a health issue. Water as an essential part of life is daily used in homes, offices, markets and industries and therefore proper handling of it is critical to safe guarding the health of the people [4].

Accordingly, water quality and sustainability for use is determined by its taste, odour, colour and concentration of organic and inorganic materials [5]. According to [6], although water is essential for life, it also remains an important source of disease transmission and a major cause of mortality in developing countries because of limitation in access and quality occasioned by environmental pollution.

The advent of industrial revolution has led to wide spread environmental pollution around the world. According to [7] different pollutants are discharged into the environment through anthropogenic (agricultural and industrial) activities, natural and geogenic processes.

The extent of pollution depends on the rainfall pattern, depth of water table from the source of contamination and soil properties like permeability, composition of its recharge components as well as the geology and hydrology of the area [7].

Pollutants when present in water can affect the clarity and chemical constituents of the water sources and this essentially can distort the quality of water and therefore impact negatively on the health of the consumers and general economic activities going on with it [8].

Improper disposal of industrial effluents, fertilizer and pesticides which are common practices in major African Urban and Rural Centers has led to heavy contamination of available fresh water sources, thus reducing the volume of safe agriculture, domestic, irrigation and drinking water.

According to reports, contaminated water can transmit diseases such as diarrhea, cholera, dysentery, typhoid, fever and polio and also that contaminated water is estimated to have caused 502,000 diarrheal deaths each year in many developing nations such as Nigeria [9].

Environmental pollutants such as heavy metals which are primarily the results of anthropogenic activities within an environment have been an issue of serious health concern to environmental health researchers in the past five decades [6].

Heavy metals such as mercury, cadmium, lead and arsenic are harmful at low concentrations and even essential ones like copper, zinc and nickel can be toxic at high concentration in biological system. The presence of these elements in the environment has been linked with toxicity in man and aquatic organisms [10].

It is no secret that human activities have impacted negatively on natural water sources.

One of such activities is the indiscriminate location of abattoirs in residential areas in developing countries. An Abattoir is a specialized environment where animals are slaughtered and processed for their meat. It is duly approved and registered by government regulation agencies so that animals can be slaughtered and processed in a hygienic and acceptable form and also that the presentation and storage of the meat for consumption will meet the utmost standard [11]. Most abattoirs in developing countries such as Nigeria are not well developed and facilities for the handling of abattoir in developing countries such as Nigeria are not well developed and facilities for the handling of the solid waste and waste water are usually absent [12].

Abattoir wastes are usually multi-dimensional, mainly organics containing fat grease, hair, feathers, grit, flesh, dung's, undigested feed, manure, blood, bones and process water [17]. According to [13] the total amount of waste produced per animal slaughtered was approximately 35% of its weight.

[14,15] stated that abattoir effluents could significantly increase the amounts of nitrogen, phosphorus, total solids and material organisms in the receiving water body and thus deteriorates the quality of such water. In so many developing countries like Nigeria, abattoirs are mostly situated around residential areas and in most cases where shallow wells are sited close by the effluents from these abattoirs percolates in the soil and leaches into the aquifers and renders such near-by water sources unfit for human consumption. Therefore, assessing the quality of water within the vicinity of abattoirs in residential areas will help in gauging the health impacts on residents who depend solely on this near-by water sources for consumption and other domestic uses.

This is especially important because most people in developing countries like Nigeria erroneously believe that because water is potable based on physical observations, it portends no health concerns. For this reason, studies were carried out to evaluate the environmental impact of abattoir effluents discharge on the quality of well water in Abakpa, Enugu State, Nigeria.

2 MATERIALS AND METHODS

2.1 STUDY AREA

Abakpa is located in Enugu East Local Government Area of Enugu State. It is densely populated with majority of the inhabitants having as their occupation trading, farming and government services [16]. Abakpa has level lands all through and the major source of water in this area is ground water (well water). An average of eight cows and ten goats are slaughtered daily from where vendors come to purchase the meat to sell to consumers across the town and its suburbs. The sample collection points were at a distance of 5, 10 and 15m away from the abattoir. The sampling points at 5, 10 and 15m from the abattoir were denoted as S_1, S_2 and S_3 respectively. A control was chosen based primarily on its distance (140m) away from the abattoir and where no such intense anthropogenic activity such as abattoir takes place.

2.2 SAMPLE COLLECTION AND ANALYSIS

A total of twenty samples were collected five each from the sampling points and control. The water samples were collected in clean plastic bottles that were appropriately labelled and preserved in 5% HNO_3 and stored in laboratory conditions prior to analysis. The physicochemical qualities of the water samples were determined using the America Public Health Analysts (APHA) Standard methods (17). These parameters included pH, turbidity (NTU) conductivity (μS/cm), total dissolved solids, chloride (Cl^-), biological oxygen demand. (BOD) and nitrates (NO^-_3). The heavy metal analysis was carried out using hydrochrolic acid digestion. The metal ion concentrations were determined using atomic absorption spectrophotometer (Model Philips RU, 9100) with a hollow cathode lamp and a fuel rich flame (nitrous oxide and air-acetylene). The heavy metals analyzed included arsenic (As), lead (Pb), iron (Fe), copper (Cu), and zinc (Zn).

2.3 STATISTICAL ANALYSIS

The data obtained were expressed in means and standard derivation and subjected to one way analysis of variance (ANOVA) using SPSS version22.0 at 5% level of confidence.

3 RESULTS AND DISCUSSION

Table 1. Physicochemical properties of the well water sampling points around Abakpa abattoir in Enugu

Sampling points / Physicochemical parameters	S_1	S_2	S_3	Control	F test P value	[9]WHO STD
pH	6.64 ± 0.11	6.82 ± 0.08	7.07 ± 0.36	6.88 ± 0.19	0.03	6.5 – 8.5
Turbidity (NTU)	6.26 ± 0.05	5.10 ± 0.07	3.64 ± 0.12	3.03 ± 0.22	0.02	5
Electrical conductivity (μS/cm)	117.32 ± 2.77	104.11 ± 0.01	96.25 ± 0.63	71.02 ± 0.46	0.02	500
Total dissolved solids (mg/l)	200.61 ± 3.14	181.52 ± 1.40	173.57 ± 1.65	116.29 ± 1.84	0.01	500
Chloride (mg/l)	53.08 ± 0.55	50.45 ± 2.73	46.18 ± 0.34	41.04 ± 0.22	0.03	250
Biological oxygen demand (mg/l)	2.88 ± 0.26	2.09 ± 0.05	1.35 ± 0.11	1.04 ± 0.17	0.02	4
Nitrate (mg/l)	29.12 ± 1.46	25.79 ± 0.67	22.14 ± 0.51	23.75 ± 1.30	0.02	50

pH: The pH of a water body serves as an index to denote the extent of pollution by acidic or basic wastes. It equally plays a significant role in determining the bacteria population growth and diversity in water bodies. Table 1 shows that the mean pH values of S_1, S_2, S_3, and control were 6.64 ± 0.11, 6.82 ± 0.08, 7.07 ± 0.36 and 6.88 ± 0.19 respectively.

The pH of sampling point, S_1 was slightly more acidic than the other studied water sampling points. This could be due to the proximity of the water samples to the abattoir, where intense effluent discharge occurs. The mean pH values of the sampling points and control were within WHO recommended permissible limit for a safe drinking water [12]. reported a higher mean pH range of 6.89 – 7.65 for ground water situated around the abattoir in Omu-Aran Nigeria. The mean pH values of the water sampling points and control were statistically significant.

Electrical Conductivity (EC): Electrical conductivity is a measure of the water's ability to conduct an electric current and is related to the amount of dissolved minerals in the water, but does not give an indication of which element is present [18].

Table 1 shows that the mean values of electrical conductivity for water sampling points S_1, S_2, S_3, and control were 117. 32 $\pm$ 2.77, 104.11 $\pm$ 1.01, 96.25 $\pm$ 0.63 and 71.02 $\pm$ /0.46 μS/cm respectively. The water samples had mean values of electrical conductivity in the following decreasing order: $S_1 > S_2 > S_3 >$ control.

The mean values of the electrical conductivity of the water samples were within WHO recommended permissible limits for a safe drinking water.

The electrical conductivity values of the water samples differed significantly at $p < 0.05$. The result of this study clearly indicates that the distance of the sampling points from the abattoir significantly influenced the level of dissolved salts present in the water samples.

According to [19], the consumption of water which has its electrical conductivity values above permissible limits over a long period of time can adversely affect the endocrine functions and cause total brain damage.

Total Dissolved Solids (TDS): According to [6] total dissolved solids of water are mainly due to vegetable decay, evaporation, disposal of effluents and chemical weathering of rocks.

Table 1 shows that the mean values of total dissolved solids for S_1, S_2, S_3, and control were 200.61 $\pm$ 3.14, 181.52 $\pm$ 1.40, 173.57 $\pm$ 1.65 and 116.29 $\pm$ 1.84 mg/l respectively.

The water samples had mean values of total dissolved solids in the following decreasing order: $S_1 > S_2 > S_3 >$ control.

The mean values of the total dissolved solids in the water samples met WHO requirements for a safe drinking water.

The mean values of the TDS in the water samples were statistically significant. A high level of chlorides, sulphates and other ions increases the value of TDS in water.

According to [10] when there is excess TDS above the recommended permissible limits, taste will be impacted in the water.

[10] reported lower values for total dissolved solids in bore hole water near some abattoirs in Port Harcourt, River State than what was obtained in this study.

Chloride: [20] stated that chlorides in water are important in the detection of sewage contamination of ground water; other sources include storm water containing road salts, the use of artificial fertilizers, landfill, leachates, septic tank, waste water and animal feeds.

Table 1 shows that the mean values of chloride in water sampling points S_1, S_2, S_3, and control were 53.08 $\pm$ 0.55, 50.45 $\pm$ 2.73, 46.18 $\pm$ 0.34 and 41.04 $\pm$ 0.22 mg/l respectively.

The water samples had mean chloride values in the following decreasing order: $S_1 > S_2 > S_3 >$ control.

The result of this study indicates that the levels of chloride ions in the water samples decreased with distance suggesting therefore that water sampling point S_1 has the highest chloride values than the other samples because of its proximity to the abattoir. The mean values of chloride ions in the water samples met WHO requirements for a safe drinking water.

The mean values of chloride ions in the water samples were statistically significant and this could be as a result of the variation in the distances of the water samples from the abattoir.

[21] reported that although chloride ions are harmless at low levels but ground water with high levels of chloride ions could damage plants if used for gardening or irrigation and equally gave drinking water an unpleasant taste. It equally reported that the adverse health effects of consuming water with very high levels of chloride ions include, stomach ulcer, skin lesions and abdominal pains.

Biological Oxygen Demand (Bod): Table 1 shows that the mean values of the biological oxygen demand in the water samples S_1, S_2, S_3, and control were 2.88 $\pm$ 0.26, 2.09 $\pm$ 0.05, 1.35 $\pm$ 0.11 and 1.04 $\pm$ 0.17 mg/l respectively.

The water samples had mean values of biological oxygen demand in the following decreasing order: $S_1 > S_2 > S_3 >$ control. The mean values of biological oxygen demand in the water samples were statistically significant; the reason is as adduced for the variation of values of chloride ions in the samples. The mean values of the biological oxygen demand in the water samples met WHO requirements for a safe drinking water. Increased BOD values in water imply that the water contains a lot of organic matter. The proximity of water sampling points S_1 and S_2 could have significantly contributed to the increase in their BOD values [12]. reported higher mean range of values of 12.00 – 26.54 for BOD in ground water around the abattoir in Omu-Aran, Nigeria than what was obtained for this water samples in this study.

Nitrate: Table 1 shows that the mean values of nitrate in S_1, S_2, S_3, and control were 29.12 ± 1.46, 25.79 ± 0.67, 22.14 ± 0.51 and 23.75 ± 1.30 mg/l respectively. The mean values of nitrate in the water samples were within WHO recommended permissible limits for a safe drinking water. The water samples had mean values of nitrate in the following decreasing order: $S_1 > S_2 >$ control $> S_3$.

The result of this study shows that abattoir activities only could not have influenced the levels of nitrate in the water samples as seen for S_3 and control, indicating therefore that other anthropogenic activities within these environments could have played a significant contributory role. The mean values of nitrate in the samples differed significantly at $p < 0.05$. According to [22] high levels of nitrate in water could cause blue-eye syndrome in little children and pregnant women and equally some form of cancer in the body.

Table 2. Heavy metal levels in well water sampling points around the Abakpa abattoir in Enugu State

Sampling points / Heavy metals (μg/g)	S_1	S_2	S_3	Control	F Test P value	[9]WHO STD
Zn	12.31 ± 0.22	7.04 ± 0.15	4.63 ± 0.54	2.14 ± 0.16	0.00	10
Cu	1.59 ± 0.25	1.22 ± 0.08	0.71 ± 0.20	0.38 ± 0.11	0.01	2
Fe	2.81 ± 0.06	2.35 ± 0.11	1.94 ± 0.27	1.03 ± 0.36	0.01	3
Pb	0.26 ± 0.07	0.15 ± 0.04	0.06 ± 0.02	0.08 ± 0.01	0.01	0.1
As	0.008 ± 0.001	0.006 ± 0.000	0.003 ± 0.001	0.004 ± 0.000	0.03	0.01

Zinc: Zinc is one of the most important trace elements that plays a vital role in the physiological and metabolic process of many organisms. Zinc is generally known as immune booster, however high levels of zinc causes diarrhea in man [10].

Table 2 shows that the mean levels of zinc in the water sampling points S_1, S_2, S_3, and control were 12.31 ± 0.22, 7.04 ± 0.15, 4.63 ± 0.54 and 2.14 ± 0.16 μg/g respectively.

The water samples had mean values of zinc in the following decreasing order: $S_1 > S_2 > S_3 >$ control. The levels of zinc in the water samples were statistically significant and this could be as a result of the variation in the distances of the sampling points from the abattoir. Of the four water sampling points, only S_1 had its mean levels of zinc above the WHO recommended permissible limits for a safe drinking water. This could be attributed to the proximity of the water sampling point to the abattoir where a lot of discharge of blood, animal fat, dungs, bones and undigested feed among other are daily occurrence.

[10] reported a comparable mean range of 4.4 – 9.59 μg/g for zinc in bore hole water samples near some abattoirs in Port Harcourt, Rivers State as was obtained for the metal in this study.

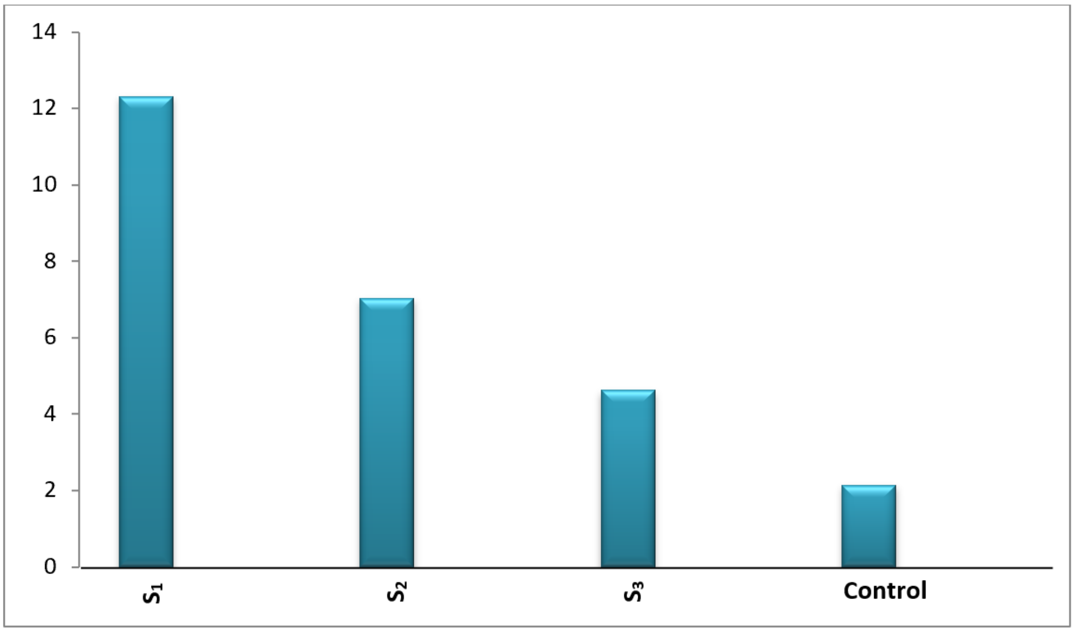

Fig. 1. Bar chart representation of the mean levels of zinc in the water sampling points

The mean values reported in this study for zinc in the control water samples were similar to that reported by [6] for zinc in borehole water samples consumed in Aba metropolis.

Copper: According to [23] copper plays a crucial role in foetus formation, brain development, anti-oxidative properties and neuron message transmission.

Table 2 shows that the mean levels of Cu in the sampling points S_1, S_2, S_3, and control were 1.59 ± 0.25, 1.22 ± 0.08, 0.71 ± 0.20 and 0.38 ± 0.11 μg/g respectively. The mean levels of copper in the water samples met WHO requirements for a safe drinking water. The water samples had mean levels of copper in the following decreasing order: $S_1 > S_2 > S_3 >$ control. The levels of the metal in the water samples differed significantly at $p < 0.05$.

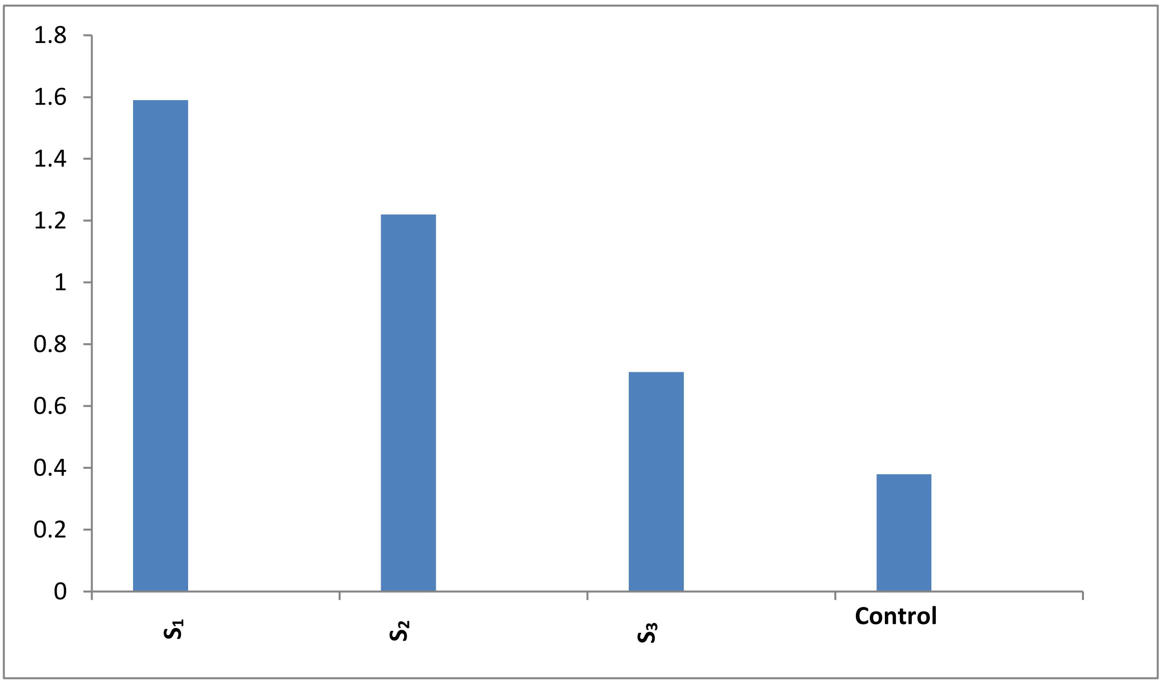

Fig. 2. Bar chart representation of the mean levels of the copper in the water sampling points

[23] stated that consumption of water with high level of copper may lead to stomach cramps, liver damage, anemia and kidney diseases.

Iron: Iron plays a very crucial role in haem protein synthesis. Despite being a health concern, high concentration of iron affects the quality of water, leading to bad taste, colouration of cooking utensils and food.

Table 2 shows that the mean levels of iron in samples S_1, S_2, S_3, and control were 2.81 ± 0.06, 2.35 ± 0.11, 1.94 ± 0.27 and 1.03 ± 0.36 μg/g respectively.

The mean levels of iron in the water samples were within the WHO recommended permissible limits for a safe drinking water. The levels of the metal in the water sample were statistically significant. The water samples had mean levels of iron in the following decreasing order; $S_1 > S_2 > S_3 >$ control.

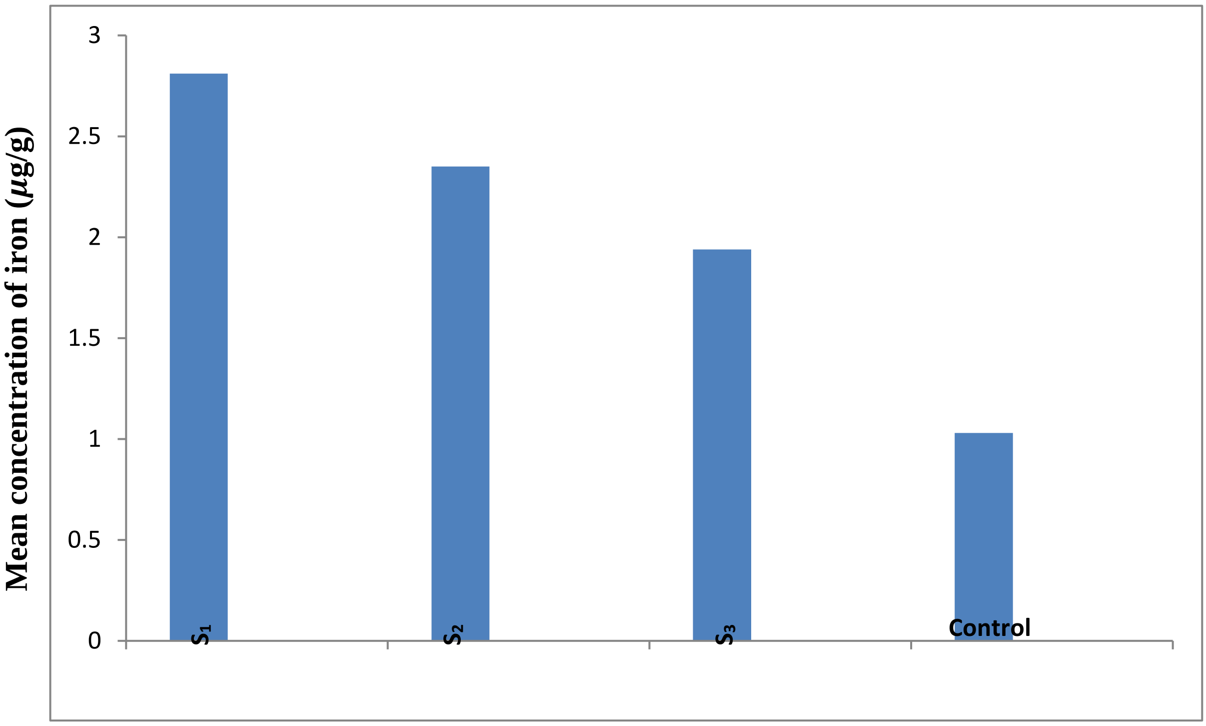

Fig. 3. Bar chart representation of the mean levels of iron in the water samples

[27] reported a higher mean range of 0.46 – 4.96μg/g for iron in ground and surface water samples around the abattoir in Abeokuta than what was obtained for the metal in this study.

Lead: Lead is the most recognized environmental pollutants. It accrues with time in bones, blood vessels and other internal organs. It can access the human body through food, water and air (WHO, 2011).

Lead aside being a carcinogen, also negatively affects the central nervous system and could lead to delayed mental development in children [23].

Table 2 shows that the mean levels of lead in the water sampling points S_1, S_2, S_3, and control were 0.26 ± 0.07, 0.15 ± 0.04, 0.06 ± 0.02 and $0.08 \pm 0.01 \mu$g/g respectively. The water samples had mean values of lead in the following decreasing order: $S_1 > S_2 >$ control $> S_3$.

Of the four studied water samples, only water sampling point S_1 and S_2 had their mean pb values above the WHO recommended permissible limits for a safe drinking water. There was significance between the levels of Pb in water sampling points S_1, S_2, S_3, and control. It can be equally stated that the result of Table 2 shows that the contamination of the well water around the abattoir with Pb could not have only come from the effluent discharges, therefore other contamination sources could have arisen from other anthropogenic activities within the studied environments as evidenced in the values obtained for Pb in sample S_3 and control.

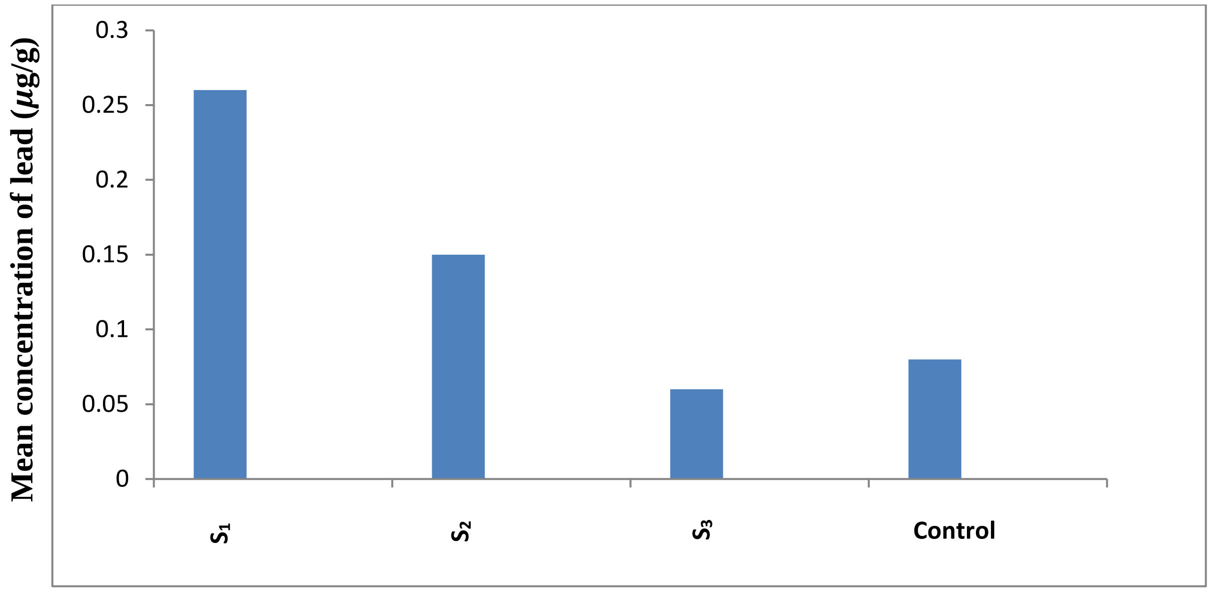

Fig. 4. Bar chart representation of the mean levels of lead in the water samples

Arsenic: Arsenic is a poison even at a very low level of exposure. The numerous signs of arsenic toxicity include, peripheral vascular diseases, hyper and hypo pigmentation, skin lesions, impaired intellectual development in children, lung diseases, reproductive disorders and various types of cancer [23]

Table 2 shows that the mean levels of arsenic in the water sampling points S_1, S_2, S_3, and control were, 0.008 ± 0.001, 0.006 ± 0.000, 0.003 ± 0.001 and 0.004 ± 0.000 μg/g respectively.

The mean levels of arsenic in the water samples met WHO requirements for a safe drinking water. The water samples had mean levels of arsenic in the following decreasing order: $S_1 > S_2 >$ control $> S_3$.

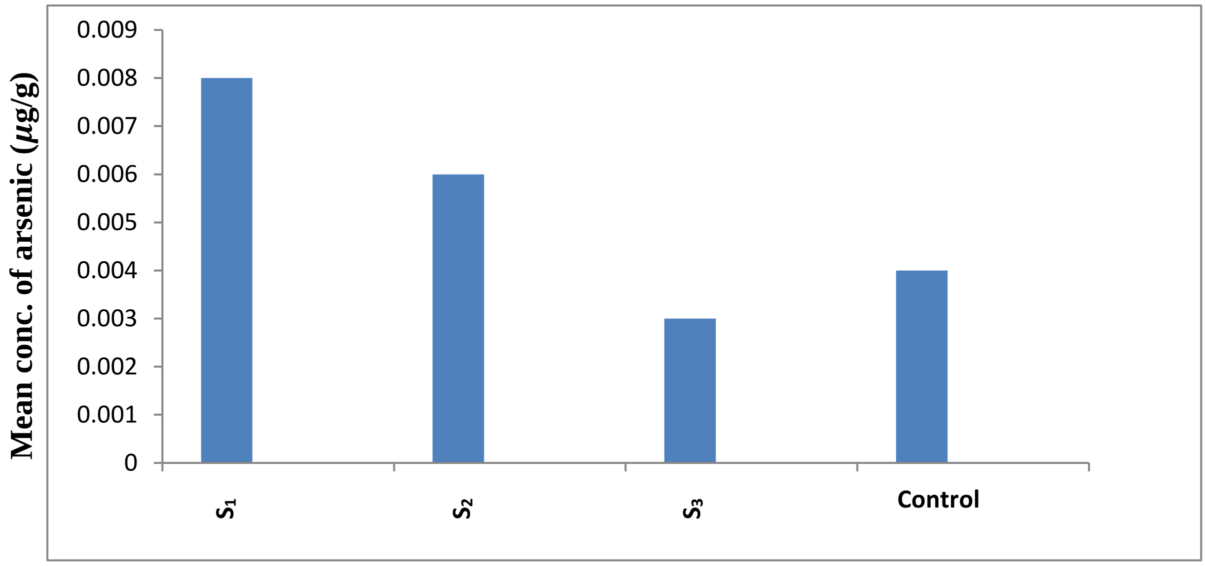

Fig. 5. Bar chart representation of the mean levels of arsenic in the water samples

The levels of arsenic in the studied water samples differed significantly at $p < 0.05$.

[10] reported a higher mean range of 0.15 – 0.37 $\mu g l g$ for arsenic in borehole water samples near some abattoirs in Port Harcourt, Rivers State than obtained for the metal in this study.

4 CONCLUSION

Except for the turbidity of the water sampling point S_1, all the other studied physicochemical parameters (pH, electrical conductivity, total dissolved solids, chloride, biological oxygen demand and nitrate) of the water samples met WHO requirements for a safe drinking water.

Of the five analyzed heavy metals, only zinc in sampling point S_1 and Pb in water sampling points S_1 and S_2 exceeded the WHO recommended permissible limits,

The levels of the physicochemical parameters and heavy metals in the water samples differed significantly.

Distance played a significant role in the levels of the studied physicochemical parameters and heavy metals in the water samples.

For instance, water sampling points S_1 and S_2 consistently exhibited higher levels for all the studied physicochemical parameters and heavy metals than the other water samples (S_3 and control).

The study therefore reveals that situating abattoirs within residential areas significantly affects the quality of water available for consumption within such environments.

It therefore recommends that environmental health agencies should be live to their responsibilities and ensure that strict recommended guidelines are kept and adhered to in sitting abattoirs in human environments so as to safe guard the health of the people from any water disease related epidemic.

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