E-ISSN: 2346-7290

Influences of abattoir discharges on water quality

[1]Ojekunle, O. Z*, [1]Towolawi, A. T, [2]Ojekunle, O. O, and [1]Lateef, S. T.

[1]Department of Environmental Management and Toxicology, PMB 2240, Federal University of Agriculture, Abeokuta, Ogun State.
[2]Department Forestry and Wildlife Management, PMB 2240, Federal University of Agriculture, Abeokuta, Ogun State.

*Corresponding author (Email: ojekunlezo@funaab.edu.ng, +2348039181615, taofiktowolawi@yahoo.com;)

ABSTRACT
Available ground and surface water around abattoirs within Abeokuta metropolis was assessed for their quality. Nine (four stream, three ground (borehole) and two control) water samples were randomly collected in 10 days interval from different abattoirs in April, 2019 (the month between dry and wet season) three times and analysed using standard procedures and analytical instruments. The obtained results were analysed statistically using Analysis of Variance (ANOVA) at 0.05 level of significance. Results showed that pH and Temperature were neutral and at room temperature, respectively. The order of concentrations of EC (μS/ cm), TDS, BOD, hardness and chloride (mg/ L) unlike DO followed stream > groundwater > control and varied significantly ($p < 0.05$). The heavy metals (Pb, Cu, Zn and Fe) were significantly different ($p < 0.05$) with their concentrations varying across the three sets of samples. Value of the Faecal Coliform was nil in the control samples and ≥ 10 CFU/ mL in the stream and groundwater samples. The study deduced that abattoir discharges can contaminate available water quality and pose a grievous threat to human health. The regulatory and concerned agents need to persuade personnel of the abattoir to care for the water sources around them.

Keywords: Abattoirs discharge, faecal coliform, heavy metals, pollution, Abeokuta

INTRODUCTION
Water is a free and general resource which is often subjected to abuse especially across the third world nations where information is hardly disseminated to society. Water is ubiquitous but safe and clean water is hard to come by almost in all part of the world (Omole and Longe, 2008). Water performs three roles: transporting body nutrients to other vital organs, regulating the body temperature and carrying waste out of internal body organs. Water is only second to air in its importance (Omer, 2019). Water potential, availability for human use and management cannot be underestimated anywhere. The physical hazard present in it includes VOCs, dissolved solids and suspended solids while the chemical hazard includes iron, mercury, copper, manganese, lead, cadmium, phosphate, nitrate etc. Surface and ground water are requiring proper management for being highly polluted as a result of anthropogenic activities, even if it is a controllable activity (Grownwall and Danert, 2020). In rural areas of the developing countries, potable water supply is scarce thereby making the inhabitants rely on water from streams, brooks, borehole, rivers, ponds and lakes, well and tube-wells. Groundwater unlike surface water is

characterized with better protection, excellent microbial load and quality which require little treatment (Treacy, 2019). So, the groundwater cost of treatment is cheaper than surface water and its ease of development makes it viable for potable water supply (Treacy, 2019).

The major source of water for Abeokuta residents is public water source from Ogun State Water Corporation and the water supply situation in the city seemed to be inadequate due to the continuous population and industrial growth. The poor and inadequate network has led to water shortage in some areas in Abeokuta. The major substitutes for pipe borne water are shallow hand dug wells in areas of low and average income. The principal sources and causes of groundwater pollution are municipal, industrial, agricultural and others. The activities of abattoir is another source of pollution from human activities as it deals with animal slaughtering and meat processing with potentially high negative impact on natural water which eventually pollutes the water resources and in turn the environment (Adesemoye *et al.*, 2006). Waste from abattoirs is usually multi-dimensional with diverse polluting components (Coker *et al.*, 2001; Nafarnda *et al.*, 2006). The World Bank accessed total waste produced for each slaughtered animal to be between 34 and 35 % by weight while 6 kg of manure is estimated for every 1000 kg of carcass weight and 100 kg of paunch manure (Verheijen *et al.*, 1996). Effluent from abattoirs enters the water body through a point source or nonpoint source thereby reducing dissolved oxygen in water to endanger aquatic life. The organic nutrients influx into the ground water with high microbial load which in turn causes unpleasant taste and odours in water. It is also observed that animals that graze on contaminated plants and marine lives which rely on polluted water bioaccumulate heavy metals which are transferred to human and released into the soil as natural sink and infiltrate to the nearby streams or water bodies (Masindi and Muendi, 2018).

MATERIALS AND METHODS

Study area

Abeokuta, the study area is the capital and largest city in Ogun State, Nigeria with coordinate on Latitudes 7°5'35’’ to 7°20'N and Longitudes 3°17' to 3° 27'E. Figure 1 is the map of the study area showing the sampling locations.

Samples collection and preservation

Nine (four stream, three ground- (borehole) and two control) water samples were randomly collected 10 days interval from different abattoirs in the April, 2019 (the month between dry and wet season) three times. Water samples were collected at each site into pre-cleaned plastic bottles of 2 litres capacity. The sample bottles were rinsed thoroughly with the water to be sampled at each designated station prior to collection and then filled completely to prevent loss of dissolved gases. The plastic containers were labelled with marker, packed in ice chest and transported to the laboratory. Water sample was collected at the monitoring stations with sampling container to prevent losses due to adsorption, volatilization and contamination by foreign substances for laboratory analysis. Water samples were preserved in the Departmental refrigerator. All the water samples were analysed for physical, chemical and microbial parameters.

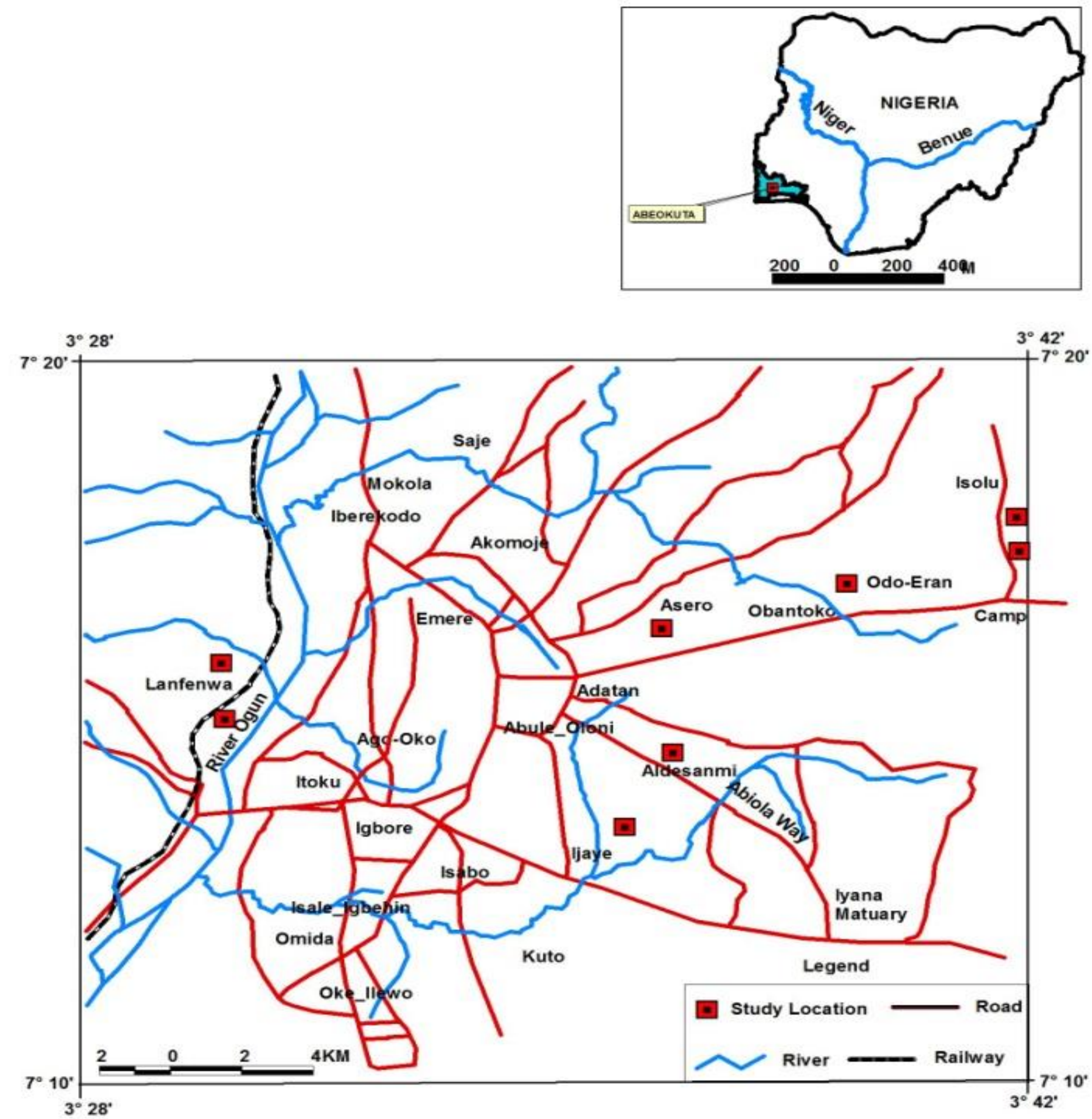

Fig 1. Map showing the sampling location of abattoir in Abeokuta, Ogun State
Source: AgroMet Cartographic Laboratory in Federal University of Agriculture, Abeokuta.

Laboratory analysis

The water quality parameters measured were pH, Temperature, Chloride (Cl_2), Dissolved Oxygen, Biochemical Oxygen Demand (BOD), Total Dissolve Solids (TDS), and Heavy Metals (Lead, Zinc, Copper, and Iron), and Microbiological load. Physical and chemical parameters were determined by conventional instrumental methods following standard analytical method (APHA

1998). The heavy metal analysis was determined according to the method of Taiwo *et al.* (2015) using Atomic Absorption Spectrophotometer (AAS) (Buck Scientific, Model 210VGP, CT, USA). Validation of the instrument (AAS) followed the method of Alves *et al.* (2009) as adopted by Aquisman *et al.* (2019).

Data handling

The data collected were subjected to descriptive and inferential statistics. The obtained values of the various water samples were then compared with drinking water thresholds of WHO (1997, 2006) standard for quality comparison.

RESULTS

Levels of physicochemical parameters in available water around abattoirs

Figures 2 to 5 indicate physicochemical parameters analysed in wastewater. The pH values were observed to be neutral while the temperature of the samples ranged between 27.8 and 28.3°C with no significant ($p > 0.05$) difference (Figure 2). The order of values of the TDS followed stream > groundwater > control water samples; the lowest and highest values were determined as 70 and 320 mg/ L in Asero control-1 and Odo-eran stream respectively. The values were significantly ($p < 0.05$) different, though below the permissible limit: < 1200 mg/ L of WHO (2006). The same trends were observed for the EC of the samples (Figure 3). Values obtained for BOD from the analysis were highest in the stream samples and lowest in the control samples. Reverse was the case for the DO contents. There were significant ($p < 0.05$) differences in their values (Figure 4). The values of DO were higher than the expected WHO value of 2.0 mg/ L. The order of the values of hardness followed stream > groundwater > control – the least and highest values were determined in Asero control 2 (90) and Lafenwa Odo-eran stream (500 mg/ L) sample respectively. All the values were significantly ($p < 0.05$) different and exceeded (except the Asero control-1) WHO permissible limit: 100 mg/ L. The determined values of total hardness could be related to the abattoir discharges. Values of the chloride contents ranged from 20 (in Asero control-2 to 72 mg/ L (in Odo-eran stream) (Figure 5) which falls significantly ($p < 0.05$) within the WHO standard: < 250 mg/ L.

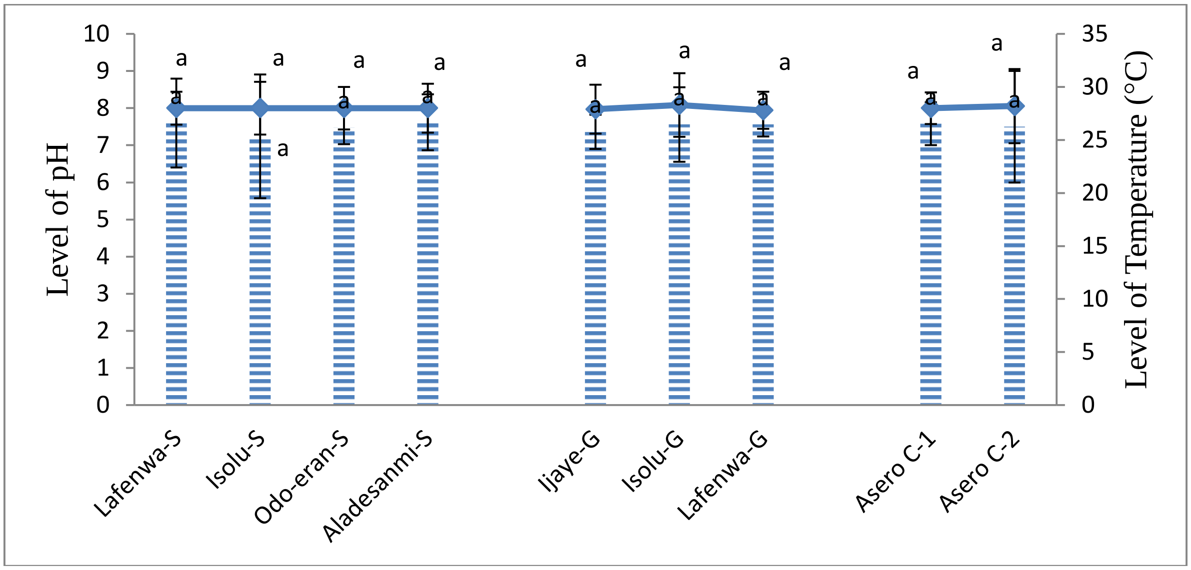

Fig. 2. The pH and Temperature (^{O}C) levels across the water samples

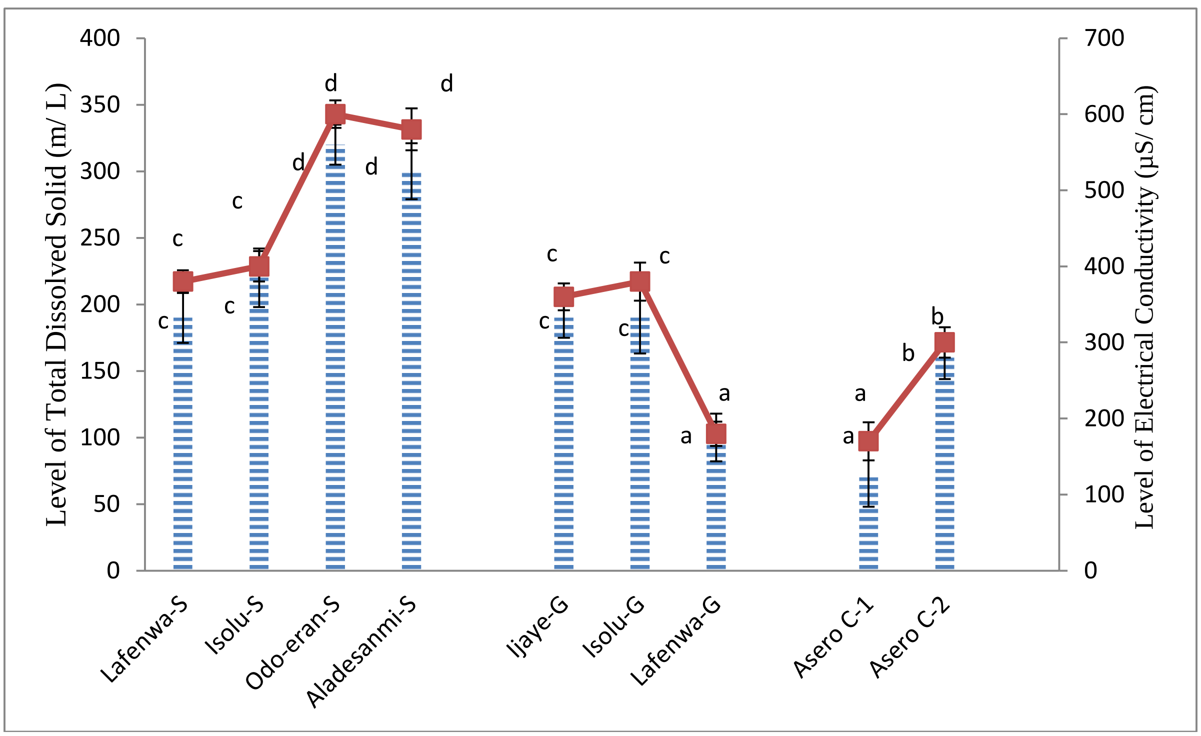

Fig. 3. The TDS (mg/ L) and EC (µS/ cm) levels across the water samples

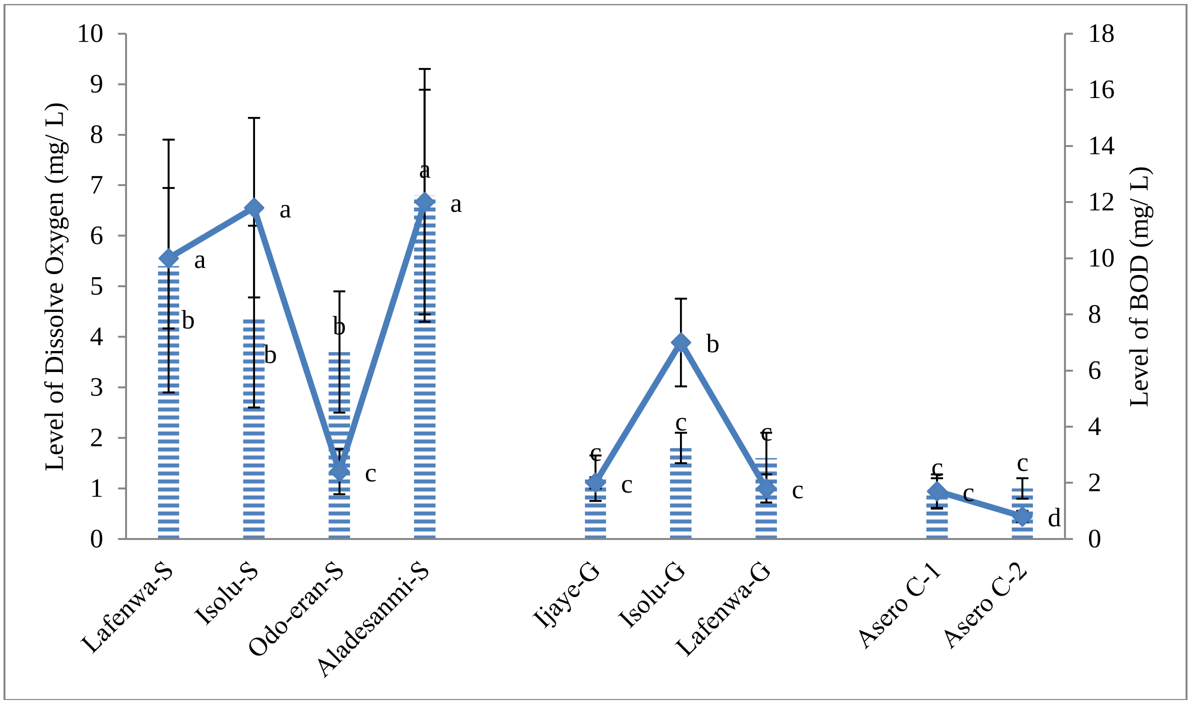

Fig. 4. The DO (mg/ L) and BOD (mg/ L) levels across the water samples

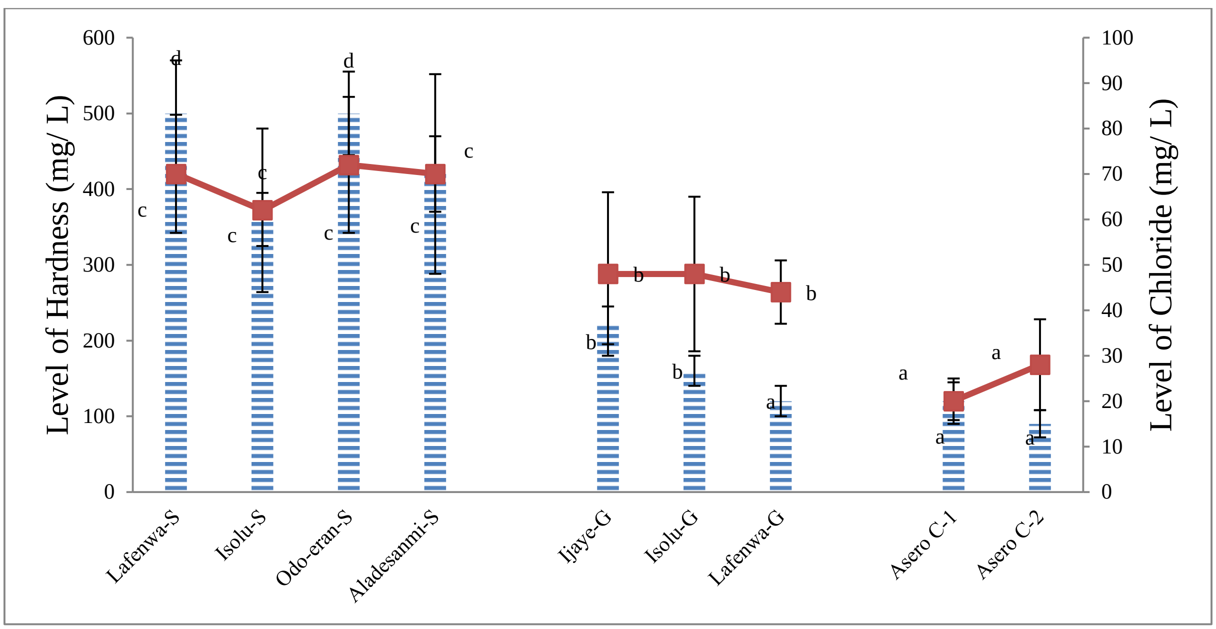

Fig. 5. The hardness (mg/ L) and chloride (mg/ L) levels across the water samples

Levels of heavy metals and microbial load in available water around abattoirs

Levels of heavy metals in the abattoir wastewater are as presented in Figures 6 and 7, while Figure 8 depicts microbial load. The obtained concentrations of Pb and Cu indicated significant ($p < 0.05$) differences but varied across the three groups of samples (stream, ground- and control samples). On the other hand, concentrations of Zn and Fe sloped significantly ($p < 0.05$) toward stream > groundwater and control samples. However, the results showed that abattoir activities could be ascertained as the source of heavy metals intrusion into the water resources. From the total faecal coliform (TFC) values obtained, the control samples had no traces unlike the stream and groundwater samples, which ranged from 10 to 30 CFU/ mL.

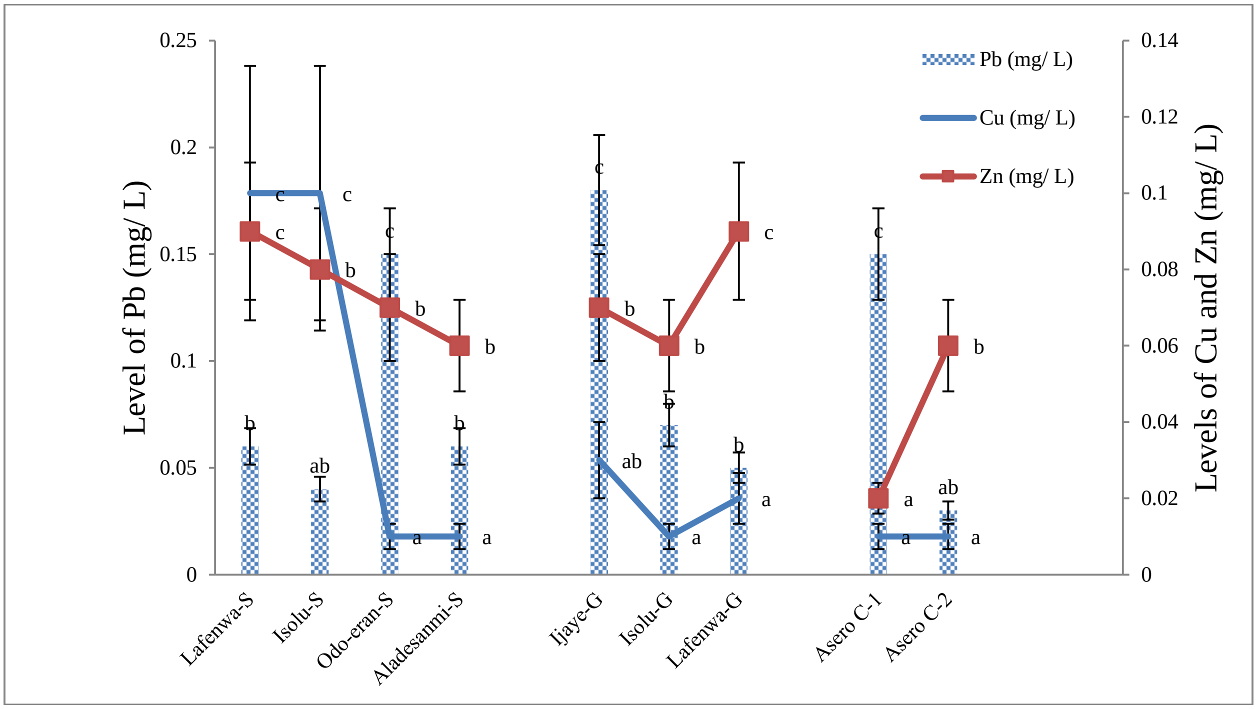

Fig. 6. The Pb, Cu and Zn levels (mg/ L) across the water samples

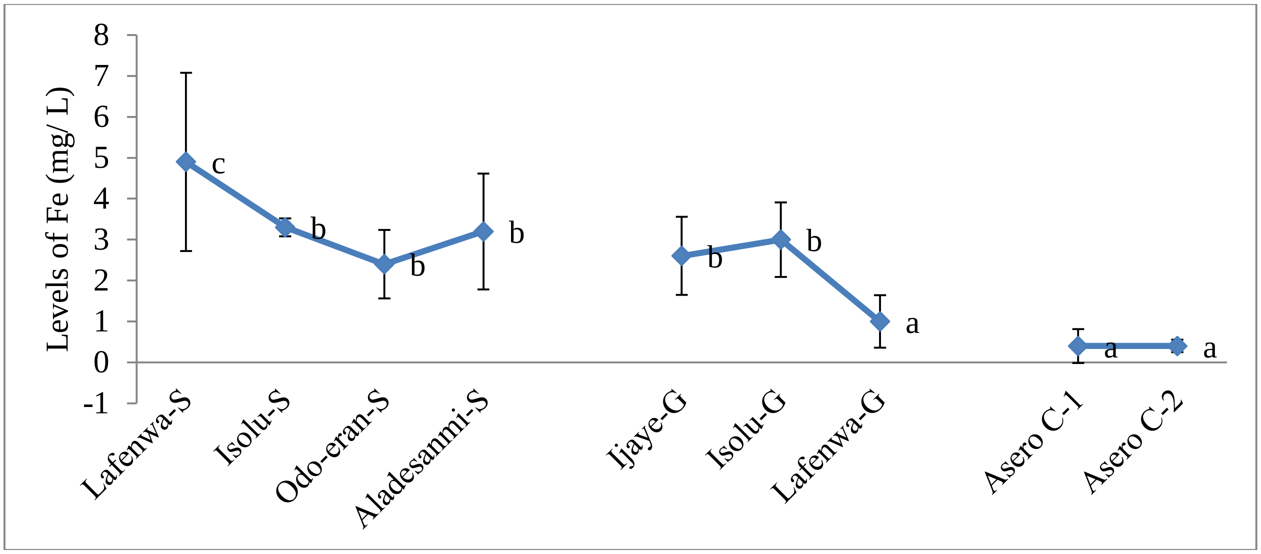

Fig. 7. The Fe levels (mg/ L) across the water samples

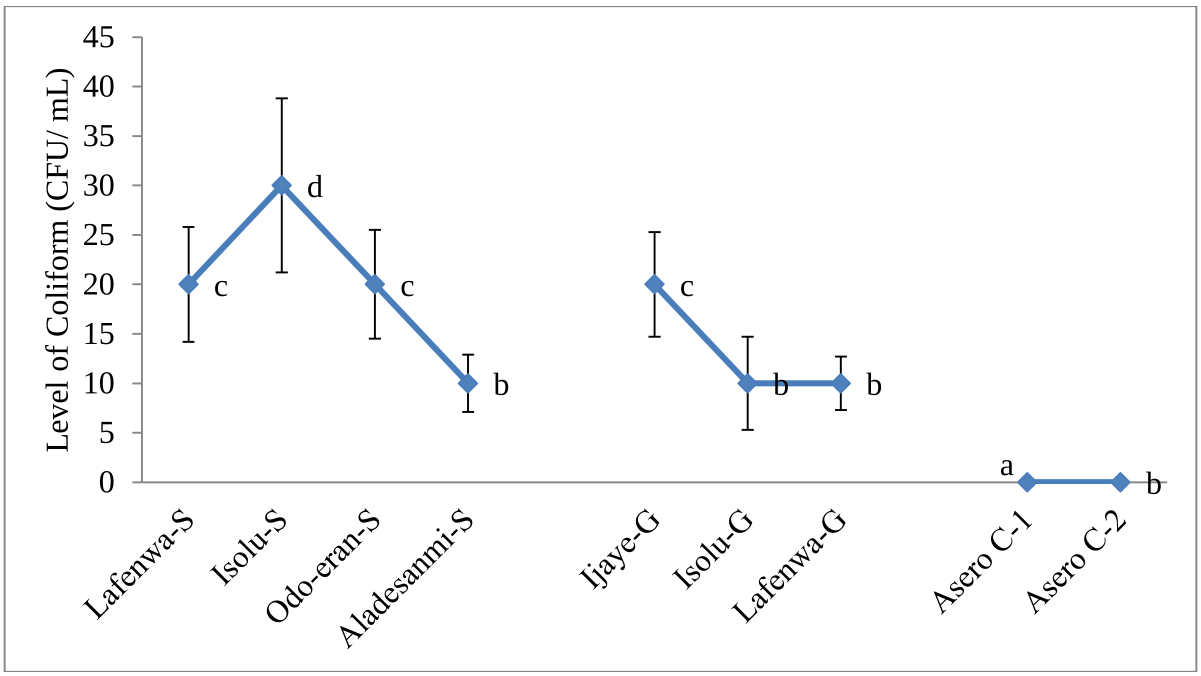

Fig. 8. The Coliform levels (CFU/ mL) across the water samples

DISCUSSION

The obtained temperature values in this study were within the WHO (2006) standard of the permissible limit: < 40°C. Temperature influences the amount of dissolved oxygen in water and affects survival of aquatic organisms which might living in the stream under the study. Results of temperature are similar with the study done by Magaji and Chup (2012) that identified most water samples in abattoir areas with temperature of 28.5 – 28.8°C. The pH played a significant role in influencing bacterial growth and diversity in water environment. The pH ranges in this study could cause health problems such as acidosis contrary to what was reported by Asamoah and Amorin (2011). The pH values in this study are within the WHO standards of 6.5-8.5 and comparable with the values (4.9 to 7.2) reported by Masse and Masse (2002) on similar study, where all water samples were slightly acidic. Some microorganisms do change the pH in their environment by producing acid or basic metabolic products as waste (Prescott *et al.*, 1999). Potassium, chlorides and sodium ions in many cases are responsible for high levels of TDS which interfere with the taste of foods and beverages, thereby making consumption of water less desirable. Some of the individual mineral salts that make up TDS pose a variety of health hazards to living organisms (Chukwu *et al.*, 2008) and indicate some degree of dissolved substances of metal origin in the water as reported by Tchounwou *et al.* (2012). Salt water intrusion could cause high significant values of TDS due to the proximity of oceans body (Oloruntola *et al.*, 2019). Water becomes undesirable with high dissolved solid contents thereby influencing health implications (Meride and Ayenew, 2016). The acceptability of water with TDS level < 1000 mg/L as set by WHO (2006) is generally potable.

All the samples were within the permissible limits of EC: 900 µS/ cm (WHO, 2006). This showed that the water samples were not saline as the concentration of salts dissolved in the water might be minimal. Salt content of a water body is determined by its ability to conduct an electric current and the larger the current that can be conducted when the EC is higher in a water body. Level of EC above the standards shows there is high concentration of pollutants which could pose health risks such as endocrine dysfunction and brain damage on human if the exposure is prolonged (Jaishankar *et al.*, 2014). The EC in water has its sources from the soluble salt (NaCl and KCl) and eases electrons to flow through the ions in electrolytes (Shrestha *et al.*, 2017). All the values of BOD samples were within the permissible standard of 50 mg/L from wastewater discharges (WHO, 2006). The BOD is important as it measures water quality for microbial activities such as growth of aerobic and facultative anaerobic bacteria which influence dissolved oxygen present in any water body. The values obtained in this study, could have been as a result of abattoir waste and other activities in the area because frequency of organic material in the water sources is a function of the BOD, differed to the result of Ojekunle *et al.* (2014). Degree of pollution by organic matter is a good indicator to measure the amount of DO in any water body. The DO is also capable as self-purification capacity and destruction of organic substances of the water body, with a standard for sustaining aquatic livelihood at 5mg/L. Any concentration below this would inadvertently affect aquatic biology and life. Concentrations below 2mg/L as shown across the stream and Lafenwa groundwater samples were lower than values obtained in the previous study of Ojekunle *et al.* (2014) on similar abattoir study. The condition may lead to death of most fishes with a condition known as hypoxia, the higher the DO concentration the better the water quality (Omer, 2019). Hard water comes with increased soap usage which results in metal or soap salt residues and when they are not quickly rinsed off it could lead to contact irritation. Any likely exposure to hard water is a risk factor that could exacerbate eczema which plays an important part in the etiology of atopic eczema (Kantor and Silverberg, 2017).

Concentration of chloride ions could be due to diffusion of ocean water into the river from wave and tide action (Ma *et al.*, 2019). Levels of Cu determined indicated that Cu values at 78 % sampling points were below the WHO standard of 1.0 mg/ L. None of the 9 sampling points had Fe values less than its threshold: 0.3 mg/ L. Drinking water could be contaminated with potential hazard to human health when Fe content is high, when it is possible to elicit unpleasant taste with associated colouration of cooking utensils (Jain, 2018). The taste may not be noticed below 0.3 mg/ L but can develop turbidity and colouration. The determined high Fe contents may be attributed to influx of spared and washed blood that transported to the available surface- and groundwater sources. All the determined values of Zn in this study were within the permissible limit: 1.5 mg/ L and in conformity with the value reported by Masindi and Muedi (2018), who highlighted effects of high levels of Fe to include severe aesthetic, slimy coatings on plumbing, slight iron overload in sensitive human, thereby influencing possibly chronic health effects in young children and sensitive individuals in the range of 10–20 mg/L with an occasional acute toxicity towards the upper end of this range. Values of Pb were observed to be higher than the permissible limit of 0.1 mg/ L. This could be linked to dilution from the undesignated dumpsite and discharging of abattoir effluent into the water bodies.

The presence of coliform in any study reveals regrowth, possible biofilm function or contamination influenced by both sewage, natural wastes or excrete from human and animal faeces (Cabral, 2010). The presence of total coliform contributes to evidence of fresh faecal contamination which could be further probe for sources of contamination and its present could be human and animal origin (Price and Wildeboer, 2017). The recommended limit is zero for total coliform to which the control samples from Asero conformed while neither stream nor groundwater samples was observed to be free from coliform with implication of possible pollutants from defecation within and around the abattoir. The major source of surface and groundwater pollution is indiscriminate discharge of untreated abattoir effluent into water bodies resulting in serious contamination (Nafarnda *et al.*, 2012).

CONCLUSION AND RECOMMENDATIONS

The problem is aggravated by inadequate awareness, scarce financial resources, lack of wastewater treatment facilities, and the ineffective environmental laws. The concentration of the heavy metals reported in this study indicated that there was high concentration of the pollutants, taken at differently selected sampling points, which were higher than the compared permissible limits. Although some of the results like EC and TDS were slightly below the limits. The toxic level of harmful materials can aggravate due to the continuous generation of the effluents with possibility of portraying danger signals to human health and other living organisms. In no distant time, resident could begin to experience severe consequences of pollutants from abattoir activities proximal to their neighbourhood. Abattoir is prone to contaminate water sources and affect water quality due to the discharge of the effluents from animal processing onto the environment and water channels. Such discharge eventually finds its way to the available surface and ground water source. From this research, it could be inferred that the abattoir effluent from the meat production has potential and grievous impact on the water quality across the study area of Abeokuta. If habit of discharging untreated abattoir water continues, the neighbouring settlements are then prone to severe threats of water contamination.

REFERENCES

Adesemoye, A.O., Opere, B.O. and Makinde, S.C.O., 2006. Microbial content of abattoir waste water and its contaminated soil in Lagos, Nigeria. *African Journal of Biotechnology*, 5(20), 1963-1968.

Adie, G.U. and Osibanjo, O., 2007. Impact of effluent from Bodija abattoir on the physicochemical parameters of Oshunkaye Stream in Ibadan City, Nigeria. *African Journal of Biotechnology*, 6 (15), 1806-1811.

Alves, S., Correia dos Santos, M.M. and Ascensao Trancoso, M., 2009. Evaluation of measurement uncertainties for the determination of total metal content in soils by atomic absorption spectrometry, *Accreditation and Quality Assurance*, 14(2), 87-93.

APHA (American Public Health Association), 1998. Standard methods of examination of water and waste water, 20th edition, Washington DC. 1220 pp.

Aquisman, A. E., Assim, Z., Wahi, R., Kwabena, D.E. and Festus, W., 2019. Validation of the atomic absorption spectroscopy (aas) for heavy metal analysis and geochemical exploration of sediment samples from the Sebangan River. *Advances in Analytical Chemistry*, 9 (2), 23-33.

Asamoah, D. N. and Amorin, R., 2011. Assessment of the quality of bottled/sachet water in the Tarkwa-Nsuaem Municipality (TM) of Ghana. *Res. J. Appl. Sci. Eng. Technol.*, 3(5), 337-385.

Cabral, J.P., 2010. Water microbiology. Bacterial pathogens and water. *International Journal of Environmental Research and Public Health*, 7(10), 3657-3703. DOI: 10.3390/ijerph7103657.

Chukwu, O., 2008. Analysis of groundwater pollution from abattoir waste in Minna, Nigeria. *Research Journal of Diary Science*, 2(4), 74-77.

Grönwall, J. and Danert K,. 2020. Regarding Groundwater and Drinking Water Accessthrough A Human Rights Lens: Self-Supply as a Norm. *Water (MDPI)*, 12: 419: 21pp. DOI: 10.3390/w12020419.

Jain, P., 2018. Effect of cooking utensil on iron content of food. *J. Pub. Health Catalog.*, 1(4), 89-92

Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B.B. and Beeregowda, K.N., 2014. Toxicity mechanism and health effects of some heavy metals. *Interdiscip Toxicol*., 7(2), 60-72. DOI:10.2478/intox-2014-0009.

Kantor, R. and Silverberg, J.I., 2017. Environmental risk factors and their role in the management of atopic dermatitis. *Expert Rev Clin Immunol*. 13(1), 15-26. DOI:10.1080/1744666X.2016.1212660.

Ma, J., Zhou, Z., Guo, Q., Zhu, S., Dai, Y. and Shen, Q., 2019. Spatial characterization of seawater intrusion in a coastal aquifer of Northeast Liaodong Bay, China. *Sustainability (MDPI)*, 11(7013), 17pp. DOI: 10.3390/su11247013.

Magaji, J. Y. and Chup, C. D., 2012. The effects of abattoir waste on water quality in Gwagwalada-Abuja, Nigeria. 547pp.

Martins, O. and Awokola, O. S., 1996. Total dissolved solids of selected rivers in south western Nigeria. *Journal of Mining and Geology*, 32(2), 113-119.

Masindi, V. and Muedi, K. L., 2018. environmental contamination by heavy metals, heavy metals, Hosam, E., Saleh, M. and Aglan, R.F. IntechOpen, DOI:

10.5772/intechopen.76082. Available from: https://www.intechopen.com/books/heavy-metals/environmental-contamination-by-heavy-metals. (Accessed on 15 June 2020).

Masse, D. I. and Masse, L., 2000. Characterization of wastewater from hog slaughterhouse in eastern Canada and evaluation of their in-plant wastewater treatment systems. Agriculture and Agri-food Canada Contribution, No. 660.

Meride, Y. and Ayenew, B. 2016. Drinking water quality assessment and its effects on residents' health in Wondo genet campus, Ethiopia. *Environ Syst Res* 5**(**1), 7pp. https://doi.org/10.1186/s40068-016-0053-6.

Nafarnda, W.D., Ajayi, I.E., Shawulu, J.C., Kawe, M.S., Omeiza, G.K., Sani, N.A., Tenuche, O.Z., Dantong, D.D. and Tags, S.Z., 2012. bacteriological quality of abattoir effluents discharged into water bodies in Abuja, Nigeria. *International Scholarly Research Network (ISRN) Veterinary Science*, 2012(Article ID515689): 5pp. DOI:10.5402/2012/515689.

Nafarnda, W. D., Yayi, A. and Kubkomawa, B., 2006. Impact of abattoir waste on aquatic life: A case study of Yola abattoir. *Global J. Pure Applied Sci.*, 12, 31-33.

Ojekunle, O. Z., Ufoegbune, G. C., Oyebamiji, F. F., Sangowusi, R. O., Taiwo, A. M. and Ojekunle, V. O., 2014. Assessment of the effect of commercial activities on the surface water quality of Ogun River. *Merit Research Journal of Environmental Science and Toxciology*, 2(9), 196-204.

Oloruntola, M.O., Folorunso, A.F., Bayewu, O.O., Mosuro, G.O. and Adewale, S., 2019. Baseline evaluation of freshwater–saltwater interface in coastal aquifers of Badagry, south-western Nigeria. *Appl. Water Science*, 9, 85. https://doi.org/10.1007/s13201-019-0957-1.

Omer, N.H., 2019. water quality parameters, water quality - science, assessments and policy, Kevin Summers, IntechOpen, DOI: 10.5772/intechopen.89657. Available from: https://www.intechopen.com/books/water-quality-science-assessments-and-policy/water-quality-parameters. (Accessed on 15 June 2020).

Omole, D. O. and Longe, E. O., 2008. An assessment of the impact of abattoir effluents on river Illo, Ota, Nigeria. *Journal of Environmental Science and Technology*, 1(2): 56-64.

Prescott, L. M., Harley, J. P. and Klein, D. A., 1999. The influence of environmental factors on growth. microbiology. 4th edition. McGraw-Hill Companies, Inc.: USA; pp. 123-132.

Price, R.G. and Wildeboer, D., 2017. *E. coli* as an Indicator of Contamination and Health Risk in Environmental Waters, <i>Escherichia coli</i> - Recent Advances on Physiology, Pathogenesis and Biotechnological Applications, Amidou Samie, IntechOpen, DOI: 10.5772/67330. Available from: https://www.intechopen.com/books/-i-escherichia-coli-i-recent-advances-on-physiology-pathogenesis-and-biotechnological-applications/-i-e-coli-i-as-an-indicator-of-contamination-and-health-risk-in-environmental-waters (Accessed on 15 September 2020).

Shrestha, A.K., Basnet, N., Bohora, C.K. and Khadka, P., 2017. Variation of electrical conductivity of the different sources of water with temperature and concentration of electrolyte solution NaCl. *International Journal of Recent Research and Review,* X (3), 24-26.

Taiwo, A.M., Towolawi, A.T., Olanigan, A.A., Olujimi, O.O. and Arowolo, T.A. 2015. Comparative Assessment of Groundwater Quality in Rural and Urban Areas of Nigeria, Research and Practices in Water Quality, Teang Shui Lee, IntechOpen, DOI: 10.5772/59669. Available from: https://www.intechopen.com/books/research-and-practices-in-water-quality/comparative-assessment-of-groundwater-quality-in-rural-and-urban-areas-of-nigeria.

Tchounwou, P.B., Yedjou, C.G., Patlolla, A.K. and Sutton, D.J., 2012. Heavy metal toxicity and the environment. *Exp Suppl*., 101: 133-164. DOI: 10.1007/978-3-7643-8340-4_6.

Treacy, J., 2019. Drinking water treatment and challenges in developing countries, the relevance of hygiene to health in developing countries, Natasha Potgieter and Afsatou Ndama Traore Hoffman, IntechOpen, DOI: 10.5772/intechopen.80780. Available from: https://www.intechopen.com/books/the-relevance-of-hygiene-to-health-in-developing-countries/drinking-water-treatment-and-challenges-in-developing-countries. (Accessed on 15 June 2020).

Verheijen, L., Wiersema, L. W. D., Hulshoff, P. and DeWit, J., 1996. Management of wastes from animal product processing, International Agriculture Center, Wageningen, The Netherlands. www.unesco.org/water/wwap>abattoirs [Accessed on 29 May, 2019].

WHO (World Health Organisation), 1997. International standard for drinking water quality. Geneva: Switzerland.

WHO (World Health Organisation) 2006. Guidelines for drinking water quality: First addendum to 3^{rd} edition. Geneva: Switzerland.