*International Research Journal of Environmental Sciences*_____ ISSN 2319–1414
Vol. **8(1),** 23-29, January **(2019)** *Int. Res. J. Environmental Sci.*

Evaluation of the characteristics of wastewater from slaughterhouses in South Eastern Nigeria for design of appropriate treatment system

Okoye Nelson Mbanefo[1*], Madubuike Chimaobi Nnaemeka[2], Nwuba Ifeanyi Uba[1], Orakwe Louis Chukwuemeka[1] and Ugwuishiwu Boniface O.[3]

[1]Agricultural and Bioresources Engineering Department, Nnamdi Azikiwe University, Awka, Nigeria
[2]Agricultural Engineering Department, Federal University of Technology, Owerri, Nigeria
[3]Agricultural and Bioresources Engineering Department, University of Nigeria, Nsukka, Nigeria
nelsonokoye2003@yahoo.com

Available online at: www.isca.in, www.isca.me
Received 3rd September 2018, revised 24th December 2018, accepted 18th January 2019

Abstract

*Wastewater from seven slaughterhouses was evaluated in terms of quality and quantity. Effluent Samples were obtained from the slaughterhouses outlet channels and analyzed for Temperature, Electrical Conductivity, pH, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Total Solids (TS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonium Nitrogen (NH_4-N), Nitrate Nitrogen (NO_3-N), Nitrite Nitrogen (NO_2-N), Phosphate (PO_4^{3-}). Results show that the current effluent quality from the slaughterhouses is not suitable for discharge into surface water. The physicochemical wastewater parameter values were very high such as values of 3144.8±251.07*µS/cm *for Electrical Conductivity, 1667.8±127.58mg/l for Total Dissolved Solids, 1049.3±235.75mg/l for Biochemical Oxygen Demand and 1698.9±291.91mg/l for Chemical Oxygen Demand. The study also revealed a serious water economy at the facilities.*

Keywords: Slaughterhouse, wastewater, water quality, physicochemical parameters, Anambra state.

Introduction

A leading cause of surface water and underground water pollution in Nigeria is wastewater discharge by the meat processing industry. The evidence of the toxic effect of slaughterhouse effluent on human health and the environment has made it an issue of public and scientific interest[1-4]. Considerable amounts of wastewater is discharge by the meat processing industry as a result of the significant quantity of water used for meat processing. Meat processing industry wastewater is a combination of water used for cleaning the slaughtered animal carcasses, floor, personnel and equipment[3]. The wastewater from slaughterhouses is characterized by nitrogen-rich, biodegradable materials with a high concentration of suspended and dissolved solids, fat residues, blood, intestinal contents, detergents, hair and skin residues[5]. Coker *et al* stated that "slaughterhouse wastewater is characterized by the presence of a high concentration of whole blood of the slaughtered food animals, and suspended particles of semi-digested and undigested feeds in the stomach and intestine of slaughtered and dressed food animals"[3]. One of the considerations for slaughterhouse location is proximity to surface water so as to ensure constant supply[6]. Abattoir effluent is a known source of pollution for both surface water and groundwater, with very serious environmental and health implications[7-11]. If contaminations of these magnitude continue without any mitigation, then ecosystem health will be compromised. Therefore care must be taken to ensure that wastewater from slaughterhouses is treated before discharge, so as to protect future users of these essential natural elements, and also safeguard the environment. Evaluation of the strength and quantity of effluent from a slaughterhouse is the first step in the design of an appropriate treatment system. There is a paucity of data on the quality and quantity of effluent from slaughterhouse in Nigeria. Even the few data on the strength of wastewater from slaughterhouses in the country report, in most cases, significantly different values of key physicochemical parameters. Such variations may be attributed to factors such as lack of adherence to standard sampling procedures or poor timing of sample collection. Thus there is need to compare the strength of waste streams from these facilities. The objective of this study is thus to characterise wastewater from slaughterhouses in Eastern Nigeria, by assessing the quantity and quality of the waste streams at the slaughterhouses.

Methodology

Study area: Seven slaughterhouses out of the major ones in Anambra State, South-East Nigeria, that dealt mainly on beef were selected for the wastewater characterization studies. The seven slaughterhouses were randomly selected to ensure that the major cities of the State were covered and at least two from each senatorial district. The slaughterhouses were the Umunya slaughterhouse in Oyi L.G.A; Nkwo-Nnewi slaughterhouse in Nnewi North L.G.A; Amansea slaughterhouse in Awka-North L.G.A; Eke-Ekwulobia slaughterhouse in Aguata L.G.A; Agulu slaughterhouse in Anaocha L.G.A; Eke-Awka Etiti slaughterhouse in Idemili South L.G.A; and Ochanja

slaughterhouse in Onitsha South L.G.A. They varied in size from small private facilities to large municipal ones, and they all had approval from the local government authorities. The location map of the seven slaughterhouses and their coordinates is presented in Figure-1.

Sampling and data collection: From October to December 2016, wastewater samples were collected twice a month from the seven studied slaughterhouses. The grab samples were collected from the major channels of effluent outflow using 500ml plastic containers. The containers used for sample collection were washed using non-ionic detergent and rinsed with tap water prior to usage. During sampling, in-situ measurements were first carried out, after which the plastic containers severally rinsed with the wastewater sample and filled. TDS, EC and Temperature were measured using Teika K12 digital handheld TDS-EC meter. The digital meter has a range of 0-9990ppm for TDS, 0-9990µs/cm for EC and 0.1-80^{o}C or 32.0-176.0^{o}F. NO_3^--N, NO_2^--N, and PO_4^{3-} were analyzed using the USEPA approved general purpose field test kits by Hach Company, USA[12]. BOD_5, COD, TSS and NH_4^+-N were analyzed following standard methods of APHA[13]. Average daily effluent production was estimated by dividing the water storage tank capacities by the number of days of usage. Wastewater management facilities at the slaughterhouses were evaluated in terms of presence and functionality.

Results and discussion

Quality of Wastewater from the Slaughterhouses: The variations of the mean pH, temperature and EC in the seven slaughterhouses are shown in Figure-2. The average pH varied from 6.4±0.07 at the Amansea slaughterhouse to 6.9±0.14 at the Eke-Ekwulobia slaughterhouse. The pH varied from slightly acidic to basic, with the average pH for slaughterhouses in the state of Anambra, based on this study, estimated as slightly acidic with a value of 6.7. The pH level in the wastewater from the slaughterhouses was within the Federal Environmental Protection Agency (FEPA)[14]/ World Health Organization (WHO) prescribed standards of 6.0-9.0 for effluent discharge into water bodies. The values of pH were comparable to previous ranges of 6-10 reported by for slaughterhouses in Europe[15]. A range of 7.6-8.2 was also reported for slaughterhouse wastewater samples from the Maiduguri Metropolis, Nigeria[6].

The temperature of the effluent from the slaughterhouses varied from 26-27^{o}C in the rainy season (October 2016) to 29-30^{o}C in the dry season (December 2016). The average temperature during the study period varied from 27.5°C in the Eke-Awka Etiti slaughterhouse to 28.5°C in the Ochanja slaughterhouse, as shown in Figure- 3.

The higher temperature values obtained during the dry season can be attributed to the high intensity of sunlight during the period that increased the ambient air temperature and also the effluent temperature. However, the values of effluent temperature obtained at the slaughterhouses did not exceed the <40°C recommended by FEPA. These ranges were in agreement with a similar study conducted in Nigeria, with a range of 26.6^{o}C to 29.17^{o}C[16].

The average EC values for effluent from the slaughterhouse ranged from 2588.8uS/cm in the slaughterhouse of Agulu and 3144.8uS/cm in the Eke-Awka Etiti slaughterhouse (Figure-4).

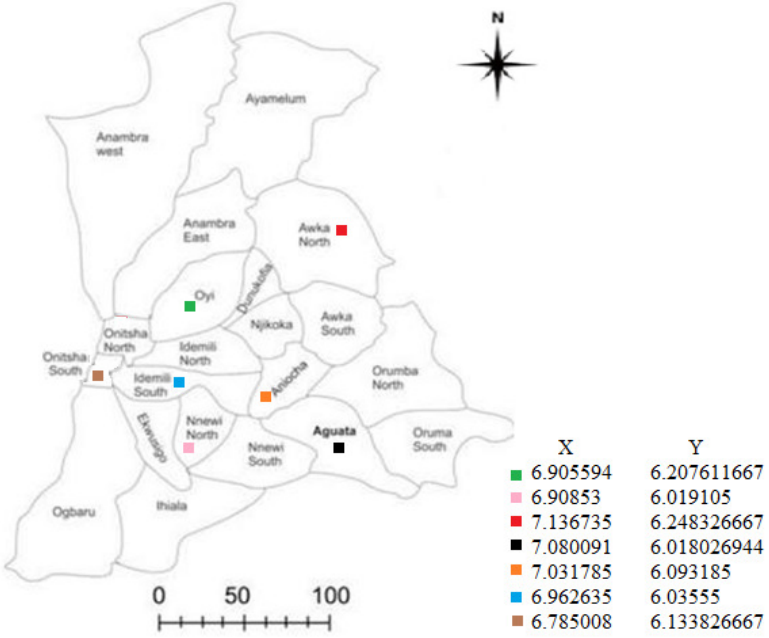

Figure-1: Map of Anambra State showing the location of the seven slaughterhouses.

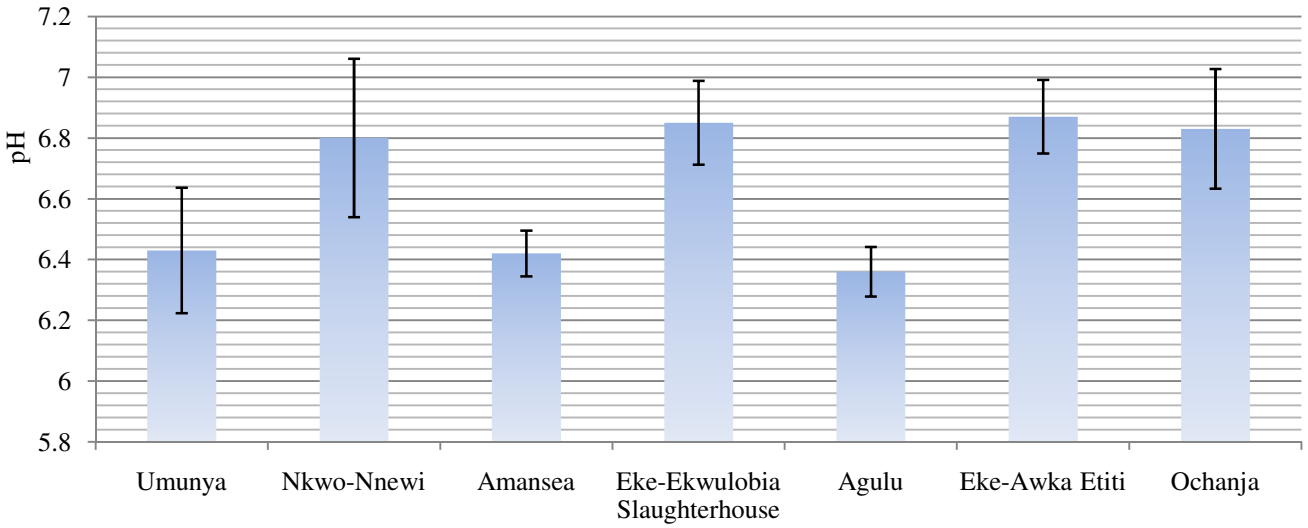

Figure-2: Variation of pH at the seven slaughterhouses.

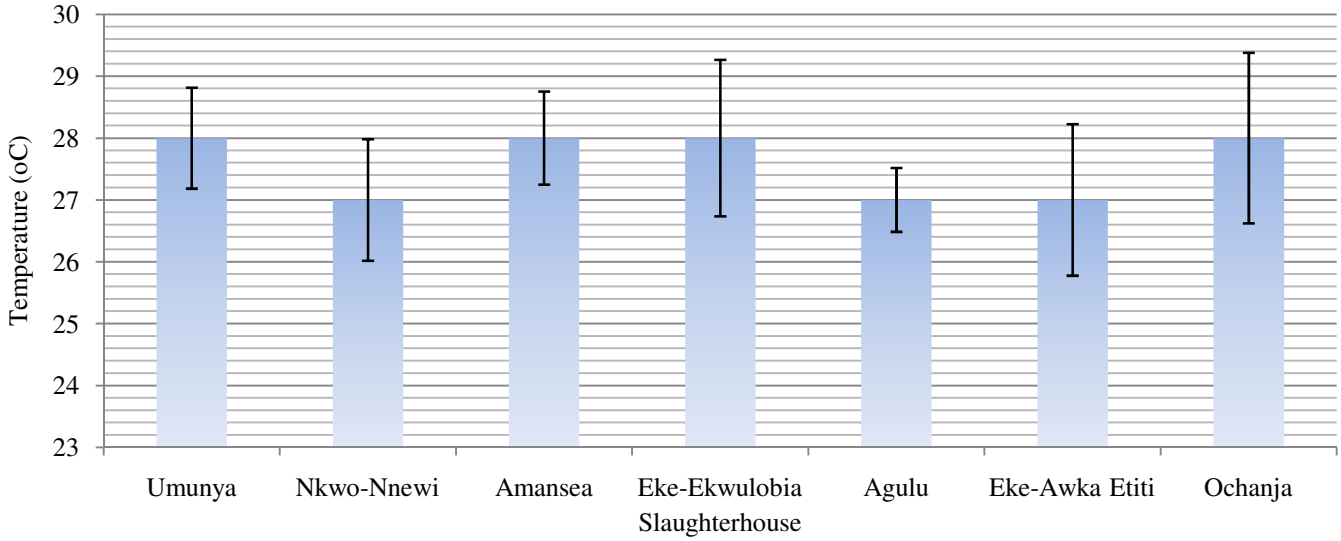

Figure-3: Variation of temperature at the seven slaughterhouses.

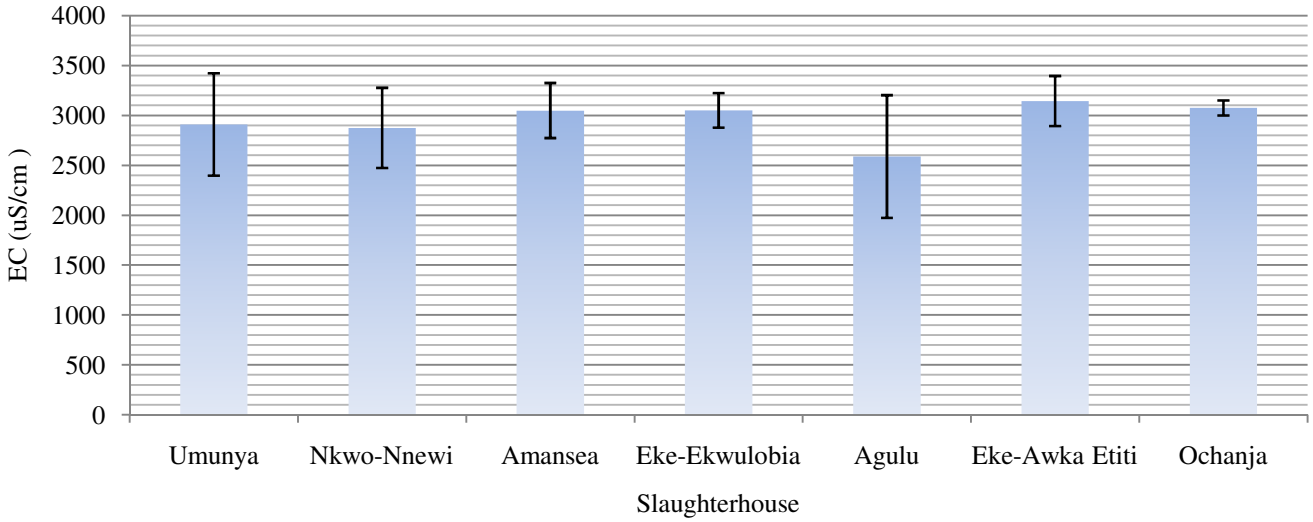

Figure-4: Variation of electrical conductivity at the seven slaughterhouses.

The EC values recorded at the slaughterhouses exceeded the limit of 1000µS/cm set by FEPA for effluent discharge. Increased EC values is likely due to the salt content of paunch manure, which is an indication of substantial dissolved ions.

Figure-5 shows the variation of TSS, TDS and TS at the studied slaughterhouses. TSS mean values varied from 460.7mg/l at the Agulu slaughterhouse to 885.8mg/l at the Ochanja slaughterhouse. The mean TSS levels at the slaughterhouses exceeded the 30mg/l benchmark set by FEPA. TDS mean values for the effluent from the slaughterhouses, which were within the 2000mg/l set limit of FEPA, varied from 1416.0mg/l at the Umunya slaughterhouse and 1667.8mg/l at the Ochanja slaughterhouse. TS mean values ranged from 2037.4mg/l at the Eke-Ekwulobia slaughterhouse and 2553.7mg/l at the Ochanja slaughterhouse. The values obtained from the study were found to be very variable when compared with similar studies. Higher values of 2114.27mg/l and 2507.93mg/l were reported during the rainy and dry seasons respectively for TDS. Also high values of 2690.67mg/l and 2133.33mg/l were reported during the rainy and dry seasons respectively for TSS[16]. Range of values reported 856.0-1080.0mg/l for TSS and 3200-3480mg/l for TDS were also reported[6]. Values of 4688.00-11053mg/l for TDS and 6348-12145mg/l for TSS were reported by Ojo and Alamuoye[17]. However, Atuanya *et al* in their study of effluent quality of government and private abattoirs in Benin City, Nigeria, reported very low TSS of 59mg/l and 6lmg/l for government and private abattoirs respectively[8]. Solid content of abattoir effluent is as a result of solid by-products such as paunch manure, blood, fats and soft tissues that are removed during cutting and this results in an aesthetically unpleasant odour.

The mean BOD and COD values obtained from the study were found to be very high. As shown in Figure-6, BOD concentrations varied from 613.7mg/l at the Agulu slaughterhouse to 1049.3mg/l at the Ochanja slaughterhouse. The mean concentrations of COD varied from 1020.7mg/l to 1698.9mg/l at Agulu and Ochanja slaughterhouses respectively. The BOD and COD benchmarks set by FEPA for effluent discharge into surface water were 50mg/l and 80mg/l respectively, which underscores the high organic load of the effluent from the study area.

The BOD and COD values from this study were comparable to the values reported in the literature such as 709mg/l-748mg/l for BOD and 340mg/l-1550mg/l for COD[6]; 135.00 ± 35.36 mg/l for BOD[17]. Also range of values reported for central abattoir in Moundou, Chad, were a BOD of between 548mg/l in December and 614mg/l in May, while COD ranged between 109 mg/l and 801mg/l[18]. The high concentration of BOD and COD obtained from this study was expected because of the poor practice of blood and solids separation observed at most of the slaughterhouses. Blood was a main component of the sampled wastewater, and it is reported that blood is a major contributor of organic load with 150000mg/l to 200000mg/l BOD and 375000mg/l COD[19]. Therefore the high values from the slaughterhouses can mainly be attributed to the blood generated through the slaughtering operations. Lower values obtained at the Agulu slaughterhouse can be attributed to the blood pit provided at the slaughter slab for blood collection.

The average ammonium nitrogen and nitrate nitrogen concentrations where high at the slaughterhouses. For NH_4-N the mean values ranged from 52mg/l at the Eke-Ekwulobia slaughterhouse to 107mg/l at the Ochanja slaughterhouse (Figure-7). NO_3-N values ranged from 34.5mg/l at the Amansea slaughterhouse to 58.5mg/l at the Ochanja slaughterhouse.

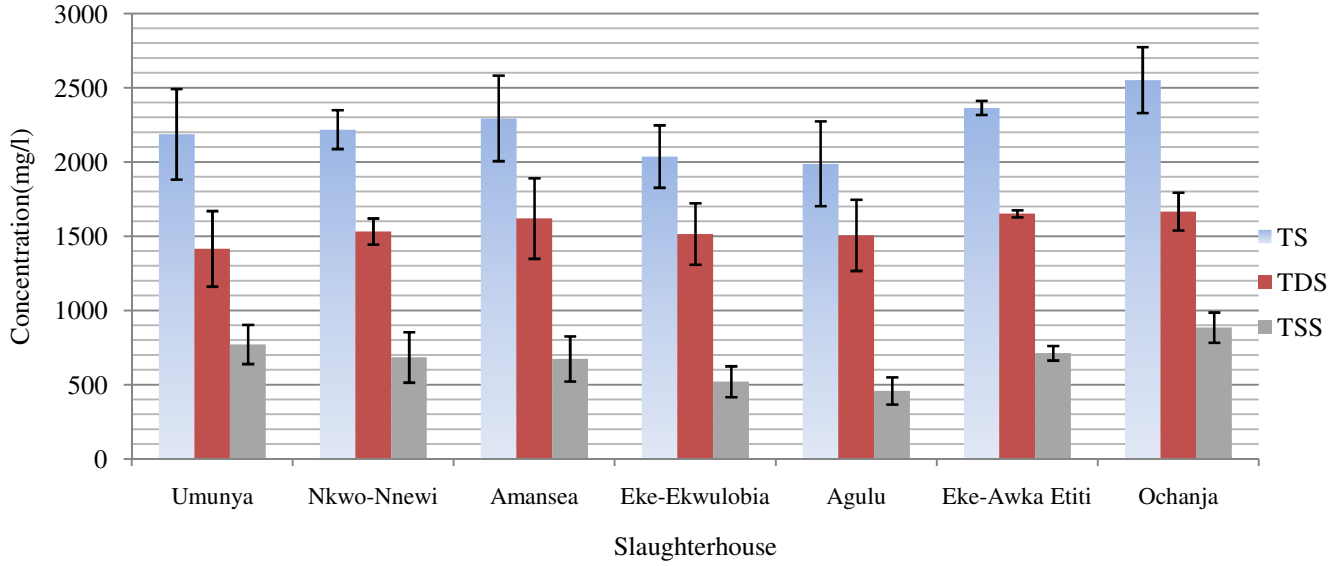

Figure-5: Variation of TSS, TDS and TS at the seven slaughterhouses.

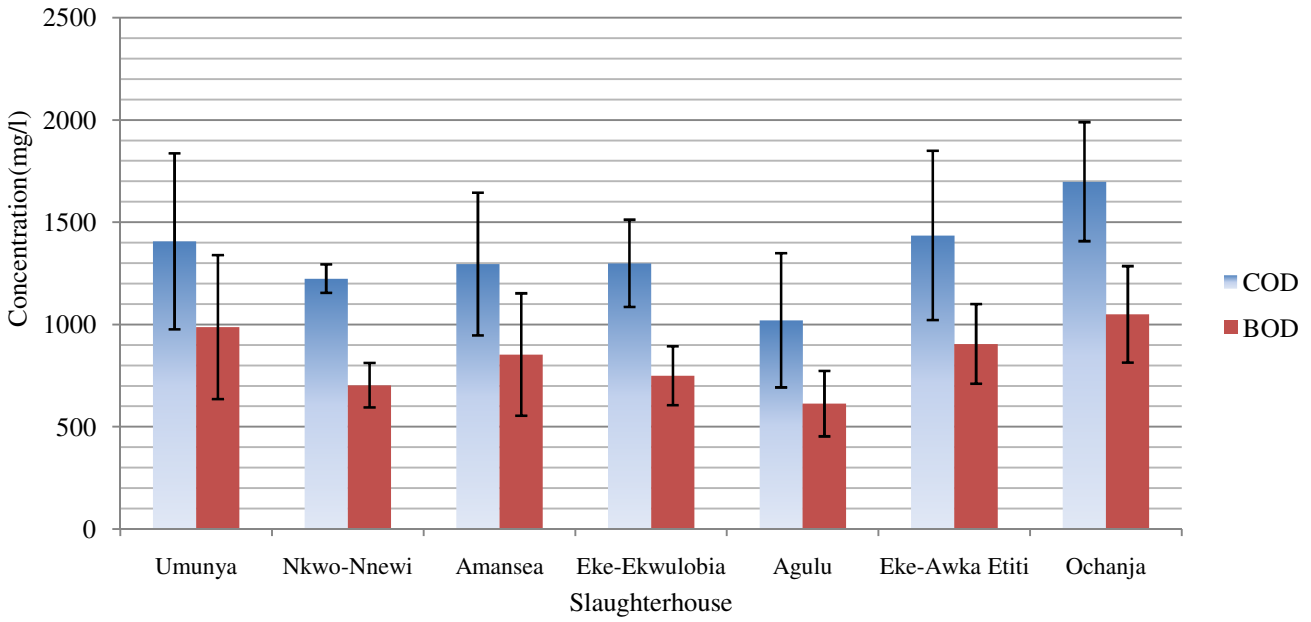

Figure-6: Variation of BOD and COD at the seven slaughterhouses.

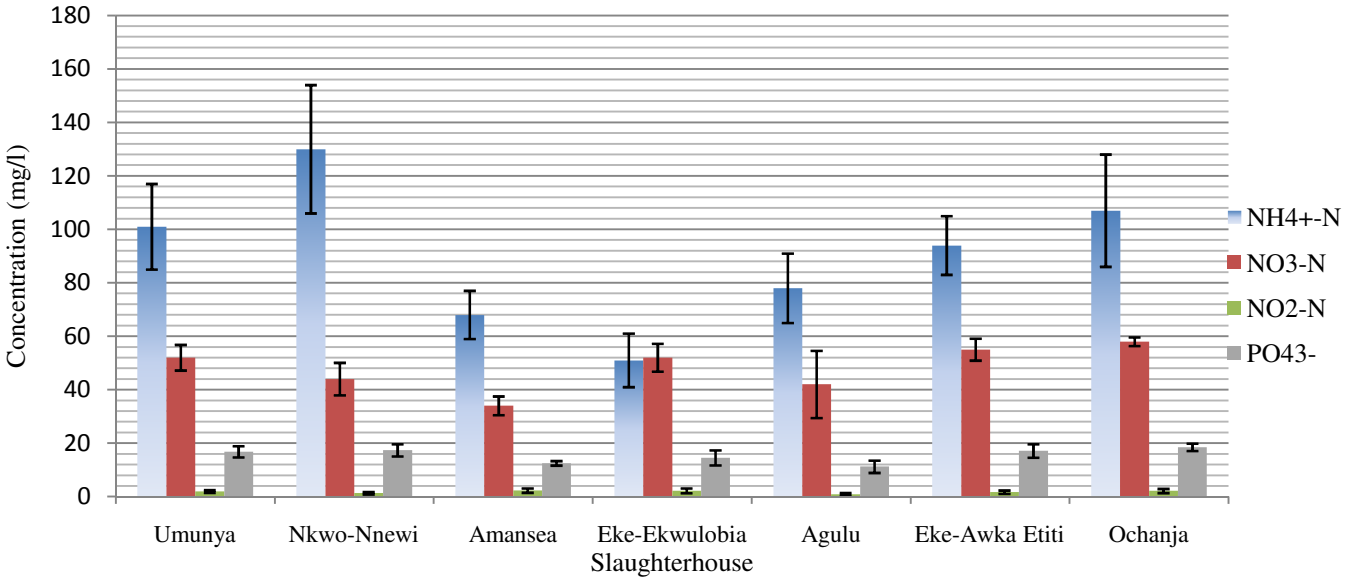

Figure-7: Variation of nutrients at the seven slaughterhouses.

The NH_4-N values recorded at the slaughterhouses were higher than FEPA limits of 10mg/l and the NO_3-N values also higher than the 20mg/l benchmark. These results were contrary to the reported range of 408.46±3.50mg/l in effluents from the slaughter slab and 445.23±2.25mg/l in drainages within the slaughterhouse for NO_3-N[17]. Also much higher NO_3-N values of 216.33-252mg/l have been reported[16]. However, much similar results of 38-62mg/l have also been reported for NO_3-N[6]. Concentration of NO_3-N for effluent from central abattoir, Chad ranged between 33.67mg/l in December and 53.1mg/l in May[18]. The high NH_4-N and NO_3-N concentrations can be attributed to the richness of effluents in urine and organic matter. The levels of NH_4-N and NO_3-N in the slaughterhouse wastewater shows that the wastewater can be treated by biological processes. The mean NO_2-N concentrations were low at the slaughterhouses ranging from 0.84mg/l at the Agulu slaughterhouse and 2.27mg/l at the Amansea slaughterhouse. Instability of nitrite ion (NO^-_2) due to oxidation reactions, and also the fact that NO_2^- values are most often lower that the other forms of nitrogen related to it, which are NH_4^+ and NO_3^-, were the reasons for the low NO_2-N values obtained[20]. PO_4^{3-} mean values of the slaughterhouse effluents ranged from 11.2mg/l at the Agulu slaughterhouse to 18.5mg/l at the Ochanja slaughterhouse as shown in Figure-7. The concentrations recorded at the seven

slaughterhouses exceeded the 5mg/l benchmark set by FEPA for effluent discharge into surface water. PO_4^{3-} levels obtained in the study was comparable to the reported values of 11-20mg/l[6], but was not parallel with other works in the literature such as values of 51.49±3.31mg/l[17] and 24.5-32mg/l[8] respectively. In Canada, higher phosphate values of 86mg/l for beef slaughterhouse, 35mg/l for pork, 34mg/l and 77mg/l for poultry and mixed use slaughterhouses respectively were reported[21]. The lower PO_4^{3-} levels may be as a result of lack of use of detergents in cleaning the slaughter slab and equipment, as most of the butchers at the slaughterhouses washed their equipment with only water. High nutrient concentration in discharged wastewater is known to eutrophication in water bodies as a result of oxygen depletion due to excessive algae growth and mineralization of dead algae.

Quantity of wastewater generated at the slaughterhouses: The estimated average daily wastewater generation at the seven slaughterhouses from October 2016 to December 2016, assuming 80% of the water input is discharged as wastewater[22], is shown in Table-1. Wastewater production was highest in the Ochanja slaughterhouse, with a production of 4.48m^3/d, and a wastewater production of 0.16m^3/d from the Agulu slaughterhouse was lowest. The variation in wastewater production in the slaughterhouses was expected because the wastewater production is directly proportional to the number of animals that are processed in a slaughterhouse.

Table-1: Estimated average daily water usage at the slaughterhouses.

Slaughterhouse	Water Input (m^3/d)	Wastewater Production (m^3/d)
Umunya	4.20	3.36
Nkwo-Nnewi	1.30	1.04
Amansea	2.30	1.84
Eke-Ekwulobia	0.60	0.48
Agulu	0.20	0.16
Eke-Awka Etiti	2.50	2.0
Ochanja	5.60	4.48

The average volume of water per head in the seven slaughterhouses was estimated at: 0.06m^3 at the Eke-Ekwulobia slaughterhouse; 0.02m^3 in the Agulu slaughterhouse; 0.08m^3 in the Amansea slaughterhouse; 0.06m^3 in the Eke-Awka Etiti slaughterhouse; 0.1m^3 in the Nkwo-Nnewi slaughterhouse; 0.05m^3 in the Umunya slaughterhouse and 0.06m^3 in the Ochanja slaughterhouse. The average volume per head of the seven slaughterhouses was thus estimated at 0.061m^3. This is much lower than the benchmark of 0.7 to 1.0m^3 per cow set by UK Environment Agency[23]. The low water consumption can be attributed to the lack of portable water supply in most slaughterhouses. There was a serious water rationing in the facilities, which reportedly translates into an increased concentration of pollutant. The low volume per head can also be due to the fact that no further processing is carried out in the slaughterhouses, except slaughtering, eviscreation and splitting into manageable sizes for easy transport to the different markets where further cutting is carried out. Other processes known to have contributed to water consumption, such as evaporative cooling of animals to be slaughtered to prevent hyperthermia, pre-eviscreation washing, carcass washing, etc. were not carried out in the slaughterhouses.

Conclusion

Wastewater from slaughterhouses in the study area are very strong in terms of their physicochemical properties, with most values exceeding the set standards for effluent discharge into the environment. Almost all the major slaughterhouses in south eastern Nigeria lacked the facilities and operational procedures to support products of standard quality. Solid and liquid waste management at the slaughterhouses were poor. This corroborated the assertion that the operation of slaughterhouses in Nigeria now constitutes national embarrassment due to the poor handling of generated wastes[24]. Slaughterhouses in the region urgently need effluent treatment facilities to reduce the associated environmental and health hazards.

References

1. Sangodoyin A.Y. and Agbawhe O.M. (1992). Environmental study on surface and groundwater pollutants from abattoir effluents. *Bioresource Technology*, 41, 193-200.

2. World Bank (1998). Pollution Prevention and Abatement Handbook, Toward Cleaner Production. The World Bank Group in Collaboration with UNEP and UNIDO, IBRD/The World.

3. Coker A.O., Olugasa B.O. and Adeyemi A.O. (2001). Abattoir wastewater quality in South Western Nigeria. Proceedings of the 27th WEDC Conference. Lusaca, Zambia, 329-331.

4. Osibanjo O. and Adie G.U. (2007). Impact of effluent from Bodija abattoir on the physicochemical parameters of Osunkaye stream in Ibadan City, Nigeria. *Afri. J. Biotech*., 6(15), 1806-1811.

5. Ojo J.O. (2014). Environmental impact assessment of effluents from Oko-Oba Municipal abattoir at Agege, Lagos State, Nigeria. *Global Advanced Research Journal of Agricultural Science,* 3(10), 317-320. (ISSN: 2315-5094).

6. Akan J.C., Abdulrahman F.I. and Yusuf E. (2010). Physical and chemical parameters in Abattoir wastewater sample,

Maiduguri metropolis, Nigeria. *The Pacific Journal of Science and Technology*, 11(1), 640-648.

7. Ubwa S.T., Atoo G.H., Offem J.O., Abah J. and Asemave K. (2013). An assessment of surface water pollution status around Gboko abattoir. *African Journal of Pure and Applied Chemistry,* 7(3), 131-138. http://www.academic journals.org/ AJPAC.

8. Atuanya E.I., Nwogu N.A. and Akpor E.A. (2012). Effluent qualities of government and private abattoirs and their effects on Ikpoba River, Benin City, Edo State, Nigeria. *Advances in Biological Research,* 6(5), 196-201.

9. Adeyemi-Ale O.A. (2014). Impact of Abattoir Effluent on the Physico-Chemical Parameters of Gbagi Stream (Odo-Eran), Ibadan, Nigeria. *Ilorin Journal of Science*, ILJS-14-022, 1(1), 100-109.

10. Adegbola A.A. and Adewoye A.O. (2012). On investigating pollution of groundwater from Atenda Abattoir wastes, Ogbomoso, Nigeria. *International Journal of Engineering and Technology,* 2(9), 1569-1585.

11. 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.

12. USEPA (2016). Approved General-Purpose Methods | CWA Methods | US EPA. <http://water.epa.gov/cwa-methods> Retrieved 23/05/2016.

13. APHA (1998). Standard Methods for the Examination of Water and Wastewater. 20th edn ed. Washington DC, USA: American Public Health Association, American water Works Association and Water Environment Federation.

14. FEPA (1991). National interim guidelines and standards for industrial effluent, gaseous emissions and hazardous wastes. *Abuja, Nigeria,* 33-63.

15. Mittal G.S. (2004). Characterization of the effluent wastewater from abattoirs for land application. *Journal of Food Reviews International*, Taylor & Francis group, 20(3), 229-256.

16. Ekanem K.V., Chukwuma G.O. and Ubah J.I. (2016). Determination of the physicochemical characteristics of effluent discharged from Karu abattoir. *International Journal of Science and Technology,* 5(2).

17. Ojo J.O. and Alamuoye O.F. (2015). Bacteriological and physicochemical characteristics of abattoir effluents from Ado-Ekiti municipal abattoir Ekiti State, Nigeria. *Sch. Acad. J. Biosci.,* 3(10), 838-841.

18. Tidjanihisseine A., Kamga R. and Tchadanaye N.M. (2016). Physicochemical evaluation of wastewater from abattoir, brewery, soap and oil factories, at Moundou City in Southern Chad. *Journal of Engineering Research and Applications,* 6(1), (Part-2), 19-30.

19. Tritt W.P. and Schuchardt F. (1992). Materials flow and possibilities of treating liquid and solid wastes from slaughterhouses in Germany. *Bioresource Technology,* 41(3), 235-245.

20. Noukeu N.A., Gouado I., Priso R.J., Ndongo D., Taffouo V.D., Dibong S.D. and Ekodeck G.E. (2016). Characterization of effluent from food processing industries and stillage treatment trial with Eichhorniacrassipes (Mart.) and Panicum maximum (Jacq.). *Water Resources and Industry,* 16, 1-18.

21. Wu P.F. and Mittal G.S. (2011). Characterization of provincial inspected slaughterhouse wastewater in Ontario, Canada. *Canadian Biosystems Engineering,* 54, 6.9-6.18.

22. Johns M.R. (1995). Developments in wastewater treatment in the meat processing industry: A review. *Bioresource Technology* 54, 203-216.

23. Environment Agency (2008). Guiding small businesses through environmental regulations. Available online at: http://www.netregs.gov.uk/netregs/sectors/ (Assessed 24/07/2015 at 15.30)

24. Adeyemo O.K. (2002). Unhygienic operation of a city abattoir in south western Nigeria: Environmental implication. *Afri. Jour. of Envir. Ass. and Manag.,* 4(1), 23-28.